Advances in Production Management Systems:
Artificial Intelligence for Sustainable and Resilient Production Systems

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IFIP WG 5.7 International Conference, APMS 2021

Nantes, France, September 5 – September 9, 2021

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APMS 2021 Conference | Artificial Intelligence for Sustainable and Resilient Production Systems
Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Preface

The scientific and industrial relevance of the development of sustainable and resilient production systems lies in ensuring future-proof manufacturing and service systems, including their supply chains and logistics networks. “Sustainability” and “Resilience” are essential requirements for competitive manufacturing and service provisioning now and will be in the future. Industry 4.0 technologies, such as artificial intelligence; decision aid models; additive and hybrid manufacturing; augmented, virtual, and mixed reality; industrial, collaborative, mobile, and software robots; advanced simulations and digital twins; as well as smart sensors and intelligent industrial networks are key enablers for building new digital and smart capabilities in emerging cyber-physical production systems in support of more efficient and effective operations planning and control. These allow manufacturers and service providers to explore more sustainable and resilient business and operating models. By making innovative use of the aforementioned technologies and their enabled capabilities, they can pursue the triple bottom line of economic, environmental, and social sustainability. Furthermore, industrial companies are able to withstand and quickly recover from disruptions that pose threats to their operational continuity. This is in the face of disrupted, complex, turbulent, and uncertain business environments, like the one triggered by the COVID-19 pandemic, or environmental pressures calling for decoupling economic growth from resource use and emissions.

The International Conference on Advances in Production Management Systems 2021 (APMS 2021) in Nantes, France, brought together leading international experts on manufacturing, service, supply, and logistics systems from academia, industry, and government to discuss pressing issues and research opportunities mostly in smart manufacturing and cyber-physical production systems; service systems design, engineering, and management; digital lean operations management; and resilient supply chain management in the Industry 4.0 era, with particular focus on artificial intelligence-enabled solutions.

Under the second year of influence of the COVID-19 pandemic, the event was organised as online conference sessions. A large international panel of experts (497 from 50 countries with an average of 3.2 reviews per paper) reviewed all the papers and selected the best 378 ones (70% of the submitted contributions) to be included in these international conference proceedings. The topics of interest in APMS 2021 included more particularly artificial intelligence techniques, decision aid and new and renewed paradigms for sustainable and resilient production systems at four-wall factory and value chain levels, comprising their associated models, frameworks, methods, tools, and technologies for smart and sustainable manufacturing and service systems as well as resilient digital supply chains. As usually for the APMS conference, the Programme Committee was particularly attentive to the cutting-edge problems in production management and quality of the papers, and especially on the applicability of the contributions in the industry and services.

The APMS 2021 conference proceedings are organized into five volumes covering a large spectre of research concerning the global topic of the conference: “Artificial Intelligence for Sustainable and Resilient Production Systems”.
The conference was supported by the International Federation of Information Processing (IFIP), which is celebrating its 60th Anniversary, and was co-organized by the IFIP Working Group 5.7 on Advances in Production Management Systems; IMT Atlantique, Campus Nantes as well as Centrale Nantes; University of Nantes; Rennes Business School; and Audecia Business School.

It was also supported by three leading journals in the discipline: Production Planning & Control (PPC), the International Journal of Production Research (IJPR), and the International Journal of Product Lifecycle Management (IJPLM).

Special attention has been given to the International Journal of Production Research on the occasion of its 60th Anniversary. Since its foundation in 1961, IJPR has become one of the flagship journals of our profession. It was the first international journal to bring together papers on all aspects of production research: product/process engineering, production system design and management, operations management, and logistics. Many exceptional scientific results have been published in the journal.

We would like to thank all contributing authors for their high-quality work and for their willingness to share their research findings with the APMS community. We are also grateful to the members of the IFIP Working Group 5.7, the Program Committee members, and the Scientific Committee members, and Special Sessions organizers for their support in the organisation of the conference program. Concerning the number of papers, special thanks have to be given to the local colleagues who managed the reviewing process as well as the preparation of the conference program and proceedings, particularly Hicham Haddou Ben Derbal and Maria-Isabel Estrepo-Ruiz from IMT Atlantique.

September 2021
Alexandre Dolgui
Alain Bernard
David Lemoine
Gregor von Cieminski
David Romero

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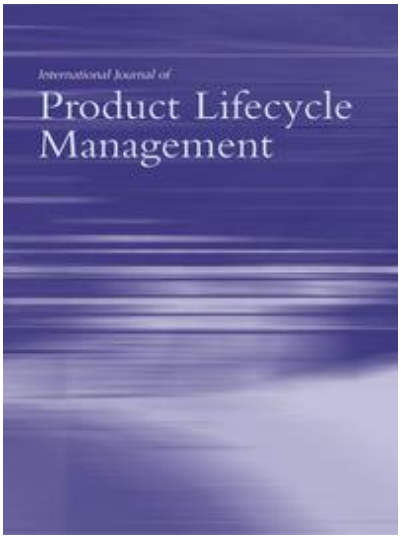

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

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Keynote Speakers

Dr. Hoda ElMaraghy

C.M., O.ONT,FRSC, FIVA, FCAE, FCIRP, FCSME, FSME, PEng
Distinguished University Professor,
Director, Intelligent Manufacturing Systems (IMS) Centre,
Department of Mechanical, Automotive and Materials Engineering,
University of Windsor, Canada

"Manufacturing Systems Resilience, Sustainability and Intelligent Adaptation"

Abstract: Innovation and transformative changes in products, manufacturing technologies, business strategies and manufacturing paradigms have profoundly changed the manufacturing systems. The shift to economically and environmentally sustainable manufacturing systems and using smart technologies for better support and complimentary collaboration between humans and machines is discussed. A vision for future intelligent adaptation and resilience of manufacturing systems in the face of change and disruptions is elaborated and its enablers are outlined. Perspectives and insights on related future research and role of humans in manufacturing systems are offered.

Biography:

Hoda ElMaraghy is a Distinguished University Professor and founding Director of the Intelligent Manufacturing Systems (IMS) Center at the University of Windsor where she became the first woman Dean of Engineering in Canada. She is member of the Order of Canada (O.C.) and the Order of Ontario (O.Ont.) for outstanding achievements and contributions to knowledge and industrial advancement. Professor ElMaraghy is a renowned scholar and research innovator, an inspiring educator, leader and role model, whose seminal contributions have been recognized nationally and internationally with numerous prestigious awards and accolades. Dr. ElMaraghy held Tier I Canada Research Chair in Manufacturing Systems for 14 years. She received an Honorary Doctorate from Chalmers University in Sweden. Her current research includes manufacturing systems paradigms; evolution and co-evolution/ co-development of products and manufacturing systems using principles of natural evolution. She supervised more than 100 researchers and has more than 500 publications. She delivered numerous keynote papers and serves on several scientific journals' editorial boards. Dr. ElMaraghy is a Fellow of the Royal Society of Canada (RSC), Royal Swedish Academy of Engineering Sciences (IVA), International Academy of Production Engineering (CIRP), Canadian Academy of Engineering (CAE), Canadian Society of Mechanical Engineers (CSME) and Society of Manufacturing Engineers (SME).

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Dr. Oleg Gusikhin

PhD, Technical Leader
Ford Global Data Insight & Analytics
Ford Motor Company, USA

"Managing Supply Chain Disruptions in the Automotive Industry"

Abstract: The presentation reviews several models to support the decisions in supply chain disruption management that are based on the automotive industry experience with COVID-19 impact. As the pandemic created waves of facility closures around the globe, it posed the significant challenges in planning the restart of the operations. The integration of the supply chain risk model, based on the time-to-survive and time-to-recover concepts, with epidemic prediction can provide insights into company recovery plans. Optimization models are created to seek the recovery plans that maximize margins and the robustness to the prediction error. The supply chain disruption response is closely related to product complexity management as material shortages require the allocation of limited supply between different models. The holistic optimization of supply chain and product complexity to minimize company financial impact is presented. During the COVID-19 pandemic, severe shortages of emergency medical and personal protective equipment have been observed. Many commercial companies, including automotive, stepped in to address these shortages repurposing their manufacturing and supply chain capacities. Capitalizing on the lessons learned, the opportunities for contingency planning for combined adaptation of healthcare and commercial supply chains for a pandemic response are discussed.

Biography:

Dr. Oleg Gusikhin is a Technical Leader at Ford Global Data, Insight and Analytics (GDI&A) Organization. Before joining GDI&A, he was the Manager and Technical Leader of the Advanced Connected Services and Mobility Applications Department at Ford Research & Advanced Engineering. He received his Ph.D. from the St. Petersburg Institute of Informatics and Automation of the Russian Academy of Sciences, MS in Electrical Engineering from St. Petersburg State Technical University, and an MBA from the Ross Business School at the University of Michigan. For over 20 years, he has been working at Ford Motor Company in different functional areas. During his tenure at Ford, Dr. Gusikhin has been involved in the design and implementation of advanced information technology and intelligent control for manufacturing and vehicle systems. Dr. Gusikhin is a Fellow of INFORMS and a Certified Fellow in Production and Inventory Management by American Production and Inventory Control Society. He is a recipient of two Henry Ford Technology Awards, 2014 INFORMS Daniel H. Wagner Prize and 2009 Institute of Industrial Engineers Transactions Best Application Paper Prize in Scheduling and Logistics. He is an Industry Vice-Chair of IFAC TC 5.2 Technical Committee "Manufacturing Modeling for Management and Control," and a Lecturer in the Industrial and Operations Engineering department at the University of Michigan.

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Prof. Dr. Dr. habil. Dmitry Ivanov

Professor of Supply Chain and Operations Management
Department of Business and Economics
Berlin School of Economics and Law, Berlin, Germany

"Ripple Effect, Viability, and Reconfigurable Supply Chains"

Abstract: In this talk, we discuss fundamental theoretical constructs and practical applications to engineer and manage disruption-resistant supply chain networks to mitigate the ripple effects in the context of the COVID-19 pandemic. We collate and review the existing knowledge in modeling the ripple effect in supply chains at different pandemic stages. Subsequently, we debate about extensions of the existing theories and practices of supply chain resilience towards viability. We present the Viable Supply Chain model and associated concepts of structure dynamics control, intertwined supply networks, and reconfigurable supply chains. Finally, we discuss the role of digital supply chain twins and platforms in managing resilience and viability at the times of super disruptions, and project the lessons learned during the COVID-19 pandemic on possible future stressors to supply chains such as climate change challenges.

Biography:

Prof. Dr. Dr. habil. Dmitry Ivanov is professor for Supply Chain and Operations Management, deputy director and executive board member of Institute for Logistics (IfL) at Berlin School of Economics and Law (Germany). His main research interests and results span the ripple effect in supply chains, supply chain resilience and viability, smart manufacturing and Industry 4.0, and digital supply chain twins.
He gained Dr., Dr. Sc., and Dr. habil. degrees and won several research excellence awards. His research record counts around 350 publications, with more than 100 papers in prestigious academic journals and the leading books "Global Supply Chain and Operations Management" (three editions), "Introduction to Supply Chain Resilience", "Structural Dynamics and Resilience in Supply Chain Risk Management", "Scheduling in Industry 4.0 and Cloud Manufacturing" and "Handbook of Ripple Effects in the Supply Chain". He serves to international research community by leading working groups, tracks and sessions on the Supply Chain Resilience and Digital Supply Chain. He delivered invited plenary, keynote and panel talks at the conferences of INFORMS, IFPR, DSI, and IFAC. He co-edits International Journal of Integrated Supply Management and is an associate editor of the International Journal of Production Research, International Transactions in Operational Research, and International Journal of Systems Science, and guest editor in many international journals. He is Chairman of IFAC TC 5.2 "Manufacturing Modeling for Management and Control" and has been General Conference Chair of 9th IFAC MIM 2019 conference as well as IPC and advisory board member of over 60 international conferences.

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Prof. Andrew Kusiak

PhD, Professor of Mechanical and Industrial Engineering
Director of the Intelligent Systems Laboratory
University of Iowa, Iowa City, Iowa, USA

"Digital Manufacturing"

Abstract: Digitization is profoundly impacting manufacturing enterprises. Two extreme enterprise architectures are emerging, open and integrated. The open architecture benefits from digitization of enterprise processes, supported by resource sharing and sustainability initiatives. The integrated architecture internalizes the benefits of digitization to maintain competitive advantage of an enterprise. Digitization as an enabler of cloud representation of enterprises of any size, from small to large, calls for modeling.

Model-based system engineering offers methodologies of interest to digital manufacturing. Applications of model-based system engineering in building enterprise models are presented. The opportunities and challenges of enterprise modeling are discussed. Building digital models is elaborate and could be expensive. Insights into autonomous building of such models are provided. Future developments in digital manufacturing are presented.

Biography:

Dr. Andrew Kusiak is a Professor in the Department of Mechanical and Industrial Engineering at The University of Iowa, Iowa City and Director of the Intelligent Systems Laboratory. He has chaired two departments, Industrial Engineering (1988-95) and Mechanical and Industrial Engineering (2010-15). His current research interests include applications of computational intelligence and big data in automation, manufacturing, product development, renewable energy, sustainability, and healthcare. He has published numerous books and hundreds of technical papers in journals sponsored by professional societies, such as the Association for the Advancement of Artificial Intelligence, the American Society of Mechanical Engineers, Institute of Industrial Engineers, Institute of Electrical and Electronics Engineers, Nature, and other societies. He speaks frequently at international meetings, conducts professional seminars, and consults for industrial corporations. Dr. Kusiak has served in elected professional society positions as well as various editorial boards of over fifty journals, including five different IEEE Transactions.

Besides his academic appointment at the University of Iowa, his past academic appointments, include the Technical University of Nova Scotia (now Dalhousie University) and the University of Manitoba in Canada. He has held distinguished research professorships at the Huazhong University of Science and Technology (China), University of Hong Kong (SAR), and King Abdulaziz University (Saudi Arabia) as well as visiting positions at the University of Lyon, Institut National Polytechnique de Grenoble, University of Nancy (France), and the University of Montreal (Canada). His graduate students have assumed prominent positions in academia and industry. Dr. Kusiak has co-advised PhD students at the University on Munich (Germany) and Institut National Polytechnique de Grenoble (France). His lab has hosted numerus visitors from different countries. Professor Kusiak is a Fellow of the Institute of Industrial and Systems Engineers and the Editor-in-Chief of the Journal of Intelligent Manufacturing.

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Prof. Mikhail Y. Kovalyov

PhD, DSc, Professor, United Institute of Informatics Problems
Corresponding Member of National Academy of Sciences of Belarus, Minsk, Belarus

"Workforce decisions in the design, reconfiguration and operation of manufacturing systems"

Abstract: While manufacturing systems become more and more automated and robotized, full automation and robotization is unlikely to be achieved in the near future in many industries. Besides, many robot's characteristics are similar to those of a human operator. We shall consider decision aspects of the workforce employment in the design, reconfiguration and operation of various manufacturing systems, analyse the relevant literature and determine the current research trends. The core object of this presentation is a generic manufacturing problem involving the workforce decisions. It can be formulated as follows. There is an existing manufacturing system or a manufacturing system to be designed. A physical layout and a working equipment can be given, or they have to be decided within the same manufacturing system type. The traditional manufacturing types are dedicated manufacturing systems, mixed and multi-model assembly lines, flexible manufacturing systems, cellular and seru manufacturing systems and reconfigurable manufacturing systems. If the equipment decision depends on the product demand, then it is a part of the system reconfiguration. The incoming sequences of (blank) product units can be repetitive or not, and they can be specified or decided. Each product unit requires a set of tasks to be performed by the system. A technological process is given which describes relations between the tasks in space and time. Each task can require additional resources, which can be homogeneous or non-homogeneous, resumable or non-resumable, discrete or continuous, constrained or unconstrained, associated with a cost and/or a priority, etc. Workforce is one of the resources. Its specificity is that it is discrete, dynamic, constrained, high-cost and high-priority. The workforce is usually categorized into utility, temporary, walking, single-skilled, multi-skilled (cross-trained) workers, and bucket brigades. The most general decision problem is to determine a physical layout of the production system, a tooling equipment, a product flow, an assignment of the tasks to the working equipment, and an allocation of the additional resources so that one or several criteria are addressed. The decisions can be dynamic, that is, time dependent. The traditional criteria are minimizing the maximum cycle time or maximizing the system productivity in the case of repetitive production, minimizing a function of product completion times in the in case of non-repetitive production, and minimizing the costs of the main equipment and the additional resources. The traditional criteria associated with the workforce are minimizing the maximum number of workers in each production cycle, minimizing the labour costs, minimizing the ergonomic risks, minimizing the maximum workload, maximizing the work variability, and minimizing the maximum or total travelling distance of the workers.

Biography:

Professor Mikhail Y. Kovalyov is a deputy general director for research of the United Institute of Informatics Problems (Minsk, Belarus) and corresponding member of the National Academy of Sciences of Belarus. He contributed to the theory of fully polynomial time approximation schemes, scheduling, production research, computational complexity, algorithm design, logistics, bio-informatics. He published in top Operational Research, Computer Science and Industrial Research journals. He is involved in the editorial work of the journals Computers and Operations Research, European Journal of Operational Research, INFORMS Journal on Computing, Omega and Journal of Scheduling.

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Mr Johan Pretorius
Aerosud Group IT Leader
Strategist at MWorx™
South Africa

"Stabilise, Automate, Innovate and Accelerate"

Abstract: Speed and agility have become the new benchmark for businesses. Any business successfully achieving this will gain the competitive edge. The challenge however is the high barriers to entry due the cost of suitable solutions, the associated cost and resources required to implement. For this reason, a new innovative solution is needed to compete and stay relevant. The Manufacturing Worx (MWorx™) platform is a secure and controlled collaborative environment, guided by global quality management systems standards such as AS9100, ISO 19443 and ISO 13485 etc. Implemented successfully it will be a key element for any manufacturing organisation who wants to participate in the integrated world of the future.

Biography:

Johan Pretorius is the Aerosud Group IT Leader and Strategist with 20+ years of information and communication technology experience. He has an in-depth understanding of Digital Transformation in the manufacturing industry and the approach needed to unlock business value. He is a committed change agent and business agility coach.

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Conference Agenda

APMS 2021 International Conference Advances in Production Management Systems

Date: Monday, 06/Sept/2021

10:15am - 11:00am	Opening ceremony						
11:00am - 1:00pm	Artificial Intelligence Based Optimization Techniques for Demand-Driven Manufacturing	Hybrid Approaches for Production Planning and Scheduling	Low-Code and Model-Driven Engineering for Production System	Metaheuristics for production systems	Regular session : New approaches for routing problem solving	System Identification for Manufacturing Control Applications	The Future of Lean Thinking and Practice
1:00pm - 2:00pm	Break						
2:00pm - 4:00pm	Intelligent Systems for Manufacturing Planning and Control in the Industry 4.0.	Learning and Robust Decision Support Systems for Agile Manufacturing environments	Lean and Six Sigma in Services Healthcare	Modern Analytics and New AI-based Smart Techniques for Replenishment and Production Planning under Uncertainty	Meta-Heuristics and Optimization Techniques for Energy-Oriented Manufacturing Systems	New trends and challenges in Reconfigurable, Flexible or Agile Production System	Regular session : Optimization of production and transportation systems
4:00pm - 4:15pm	Break						
4:15pm - 5:00pm	Dr. Hoda ElMaraghy : Manufacturing Systems Resilience, Sustainability and Intelligent Adaptation						
5:00pm - 5:15pm	Break						
5:15pm - 7:15pm	Digital Transformation of SME Manufacturers: The Crucial Role of Standard	Digital Transformations Towards Supply Chain Resiliency	Engineering of Smart-Product-Service-Systems of the Future	Lean and Six Sigma in Services Healthcare	Production Management in Food Supply Chains	Regular session : Frameworks and conceptual modelling for systems and services efficiency	Sustainability in Production Planning and Lot-Sizing
7:15pm - 7:30pm	Break						
7:30pm - 8:15pm	Prof. Andrew Kusiak : Digital Manufacturing						

APMS 2021 Conference

Artificial Intelligence for Sustainable and Resilient Production Systems

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Date: Tuesday, 07/Sept/2021

11:00am - 11:45am	Prof. Mikhail Y. Kovalyov : Workforce decisions in the design, reconfiguration and operation of manufacturing systems							
11:45am - 12:00pm	Break							
12:00pm - 2:00pm	Finance-Driven Supply Chain	Gastronomic Service System Design	Modern scheduling and applications in industry 4.0	Regular Session : Green production and circularity concepts	Regular session : Optimization of supply chain agility and reconfigurability	System Identification for Manufacturing Control Applications	The Future of Lean Thinking and Practice	
2:00pm - 3:00pm	Break							
3:00pm - 5:00pm	Intelligent Systems for Manufacturing Planning and Control in the Industry 4.0.	Learning and Robust Decision Support Systems for Agile Manufacturing environments	Lean and Six Sigma in Services Healthcare	Modern Analytics and New AI-based Smart Techniques for Replenishment and Production Planning under Uncertainty	Modern scheduling and applications in industry 4.0	New trends and challenges in Reconfigurable, Flexible or Agile Production System	Regular Session : Advanced modelling approaches	
5:00pm - 5:15pm	Break							
5:15pm - 6:00pm	Plenary panel : Women in Production Management							
6:00pm - 6:15pm	Break							
6:15pm - 8:15pm	Autonomous Robots in Delivery Logistics	Digital Transformation Approaches in Production Management	Digital Transformations Towards Supply Chain Resiliency	Engineering of Smart-Product-Service-Systems of the Future	Lean and Six Sigma in Services Healthcare	Production Management in Food Supply Chains	Recent Advances in Sustainable Manufacturing	

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Date: Wednesday, 08/Sept/2021

11:00am - 11:45am	Mr Johan Pretorius : Stabilise, Automate, Innovate and Accelerate						
11:45am - 12:00pm	Break						
12:00pm - 2:00pm	Regular Session : Improvement models and methods for green and innovative systems	Regular Session : AI-based approaches for quality and performance improvement of production systems	Regular Session : Classification and data management methods	Supply Chain Risk Management under Coronavirus	System Identification for Manufacturing Control Applications	Smart and sustainable production and supply chains	The Future of Lean Thinking and Practice
2:00pm - 3:00pm	Break						
3:00pm - 5:00pm	Intelligent Systems for Manufacturing Planning and Control in the Industry 4.0.	New trends and challenges in Reconfigurable, Flexible or Agile Production System	Regular Session : Supply chain and routing management	Regular Session : Robotics and Human aspects	Regular Session : Simulation and optimization of systems performances	Regular Session : Risk and performance management of supply chains	Smart and sustainable production and supply chains
5:00pm - 5:15pm	Break						
5:15pm - 6:00pm	Dr. Oleg Gusikhin : Managing Supply Chain Disruptions in the Automotive Industry						
6:00pm - 6:15pm	Break						
6:15pm - 8:15pm	AI for Resilience in Global Supply Chain Networks in the Context of Pandemic Disruptions	Data-based services as key enablers for Smart Products, Manufacturing and Assembly	Digital Transformation Approaches in Production Management	Digital twins in companies first developments and future challenges	Human-centered Artificial Intelligence in Smart Manufacturing for the Operator 4.0	Serious Games Analytics: Improving Games and Learning Support	Smart Methods and Techniques for Sustainable Supply Chain Management

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Date: Thursday, 09/Sept/2021

11:00am - 11:45am	Prof. Dr. Dr. habil. Dmitry Ivanov : Ripple Effect, Viability, and Reconfigurable Supply Chains							
11:45am - 12:00pm	Break							
12:00pm - 2:00pm	Blockchain in the Operations and Supply Chain Management	Data-driven methods for Supply Chain optimization	Digital twins based on systems engineering and semantic modeling	Regular session : Maintenance improvement and lifecycle management	Regular session : Additive Manufacturing and mass customization	Robotics Technologies for Control, Smart Manufacturing and Logistics	Smart Supply Chain and Production in Society 5.0 Era	Workshop on circular and efficient industrial systems - Sharing lessons learnt from case studies
2:00pm - 3:00pm	Break							
3:00pm - 5:00pm	Data-Driven Platforms and Applications in Production and Logistics: Digital Twins and AI for Sustainability	Operations Management in Engineer-to-Order Manufacturing	Product and Asset Life Cycle Management for Smart and Sustainable Manufacturing Systems	Regular session : Improvement of design and operation of manufacturing systems	Regular session : Crossdock and transportation issues	Regular session : Maintenance improvement and lifecycle management	The New Digital Lean Manufacturing Paradigm	The Role of Emerging Technologies in Disaster Relief Operations: Lessons from COVID-19
5:00pm - 5:15pm	Break							
5:15pm - 6:00pm	Plenary panel : Towards Resilient Production Management Systems: Workforce, Shopfloor, and Supply Chain Perspectives							
6:00pm - 6:45pm	IJPR 60th Anniversary							
6:45pm - 7:15pm	Closing ceremony							

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Presentations

Artificial Intelligence Based Optimization Techniques for Demand-Driven Manufacturing

Time: Monday, 06/Sept/2021: 11:00am - 1:00pm

Long term demand forecasting system for demand driven manufacturing

Rita Sleiman, Kim-Phuc Tran, Sébastien Thomassey

Univ. Lille, ENSAIT, GEMTEX, France

Demand-Driven Manufacturing (DDM) is the solution that most companies are heading to in our days. Although this strategy consists of producing goods based on what consumers demand, companies should also rely on accurate forecasting systems to prepare their production chain for such an operation by supplying enough raw material, increasing production capacity to fit the desired demand, etc… However, due to the fact that most companies have been relying on massive production, most sales forecasting systems usually used rely on sales data of previous years that, not only contain the actual demand, but takes into consideration the marketing strategy effects like massive promotions. Hence, the resulting forecasts do not mainly reflect consumers' demand. For this reason, a switch to demand forecasting, instead of sales forecasting, is essential to ensure a good transition to DDM. This paper proposes an artificial intelligence based demand forecasting system that aims to determine "potential sales", mainly reflecting consumers' demand, by correcting historical sales data from external variables' effects. A comparison with other sales forecasting models is performed and validated on real data of a French fashion retailer. Results show that the proposed system is both robust and accurate, and it outperforms all the other models in terms of forecasting errors.

Data-driven approach for Credit Card FraudDetection with Autoencoder and One-ClassClassification techniques

Abdoul-Fatao Ouedraogo[1], Cédric Heuchenne[2,1], Quoc-Thông Nguyen[3], Hien Tran[1]

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With the development of e-commerce, payment by credit card has become an essential means for the purchases of goods and services online. Especially, the Manufacturing Sector faces a high risk of fraud online payment. Its high turnover is the reason making this sector is lucrative with fraud. This gave rise to fraudulent activity on the accounts of private users, banks, and other services. For this reason, in recent years, many studies have been carried out using machine learning techniques to detect and block fraudulent transactions. This article aims to present a new approach based on real-time data combining two methods for the detection of credit card fraud. We first use the variational autoencoder(VAE) to obtain representations of normal transactions, and then we train a support vector data description (SVDD) model with these representations. The advantage of the representation learned automatically by the variational autoencoder is that it makes the data smoother, which makes it possible to increase the detection performance of one-class classification methods. The performance evaluation of the proposed model is done on real data from European credit cardholders. Our experiments show that our approach has obtained good results with a very high fraud detection rate.

FBD_Bmodel Digital Platform: a web-based application for demand driven fashion supply chain

Sébastien Thomassey, Xianyi Zeng1

GEMTEX / ENSAIT, France

The new consumption behaviors and environmental awareness are pushing the textile apparel industry to profound transformations. Co-design and pro-duction on demand are two success factors for this paradigm shift but re-quire efficient and practical tools for companies. In this context, the Europe-an H2020 FBD_BModel project provides to practitioners a suitable digital platform. More specifically for the supply chain management, efficient and well-known algorithms are implemented in an user-friendly web-based appli-cation composed of two modules. The first module aims at selecting suppli-ers with multi criteria decision making techniques. This is particularly im-portant to deal with a huge variety of products and a large number of small factories with their own features. The second modules proposes a genetic al-gorithm-based optimization for order scheduling and supplier allocation. In a demand driven strategy, this task is crucial to reach the requirements in terms of cost and lead time. This paper provides a brief description of the methods implemented in the web-based application. A numerical example, based on real data of the industrial partners of the FBD_Bmodel project, shows the results obtained with the proposed solution

Goods and Activities Tracking Through Supply Chain Network Using Machine Learning Models

Lahcen Tamym[1], Ahmed Nait Sidi Moh[2], Lyes Benyoucef[3], Moulay Driss El Ouadghiri[1]

[1]Moulay Ismail University, IA Laboratory, Meknes, Morocco; [2]Picardie Jules Verne University (PJVU), LTI Laboratory, Saint Quentin, France; [3]Aix-Marseille University, University of Toulon, CNRS, LIS, Marseille, France

End-consumers satisfaction with the higher efficiency and reliability of the products and services provided by the enterprises is a highly important factor in their competitiveness. However, providing efficient tracking and tracing of shipped products enhance customer loyalty and the enterprise image. Satisfied customers are one of the enterprise's greatest assets. In doing so, we are mainly interested in detection of fraudulent transactions and late delivery of orders, as well as tracking commodities and related supply chain costs over different countries. Two datasetes are used for model training and validation: DataCo Supply Chain Dataset and SCMS Delivery History Dataset. A case study is worked out, and the finding results are compared to some related works in the literature. The obtained results show the added value of our proposed models.

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A model for a multi-level disassembly system under random disassembly lead times

Ilhem SLAMA[1], Oussama Ben-Ammar[2], Alexandre Dolgui[3]

[1]IMT Atlantique, France; [2]Mines Saint-Etienne, France; [3]IMT Atlantique, France

This paper deals with the problem of planned disassembly lead time calculation in a Reverse Material Requirement Planning (RMRP) environment under stochastic disassembly lead times. A multi-level disassembly system with one type of end-of-life (EoL) product and several types of components at each level is considered for the first time in the disassembly planning problem under uncertainty. The paper presents a mathematical model with corresponding proofs. The objective of the proposed model is to minimize the total expected costs composed of the sum of holding and backlog costs. Some advantages of the proposed model and perspectives of this research are discussed.

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HAP: Hybrid Approaches for Production Planning and Scheduling

Time: Monday, 06/Sept/2021: 11:00am - 1:00pm

Tactical planning and predictive maintenance: towards an integrated model based on epsilon-reliability

David Lemoine[1], Bruno Castanier[2]

[1]IMT Atlantique / LS2N UMR CNRS 6004; [2]Université d'Angers / LARIS EA7315

Elaborating some Master Scheduling Programs to maximize the customer product demands in respect to the different logistics costs and optimizing maintenance policies are classically addressed independently by two scientific communities whose interests may in some cases diverge. The objective of this paper is to build, based on recent contributions from the field of maintenance optimization, an integrated optimization approach for tactical production plans and maintenance decisions. This goal of integrating as much information as possible into more holistic approaches and more relevant decisions is clearly one of the challenges that can be found in the precepts of the ``Industry of the Future". In this paper, we propose, through a modeling of the effects of the degradation of the production system on its production efficiency, to show a benefit of the simultaneous consideration of both concerns. Feasibility criteria are also proposed to ensure the robustness of the plans then produced against the hazards of degradation and failure of the production system.

Hybridization of mixed-integer linear program and discrete event systems for robust scheduling on parallel machines

Alexis Aubry[1], Pascale Marangé[1], David Lemoine[2], Sara Himmiche[1], Sylvie Norre[3]

[1]Université de Lorraine, CNRS, CRAN; [2]IMT-Atlantique, LS2N UMR 6004; [3]Clermont Auvergne University, LIMOS UMR 6158

This paper proposes an approach for robust scheduling on parallel machines. This approach is based on a combination of robust mathematical and discrete event systems models which are iteratively called in order to converge towards a schedule with the required robustness level defined by the decision maker. Experimentations on a small instance (10 jobs and 2 unrelated machines) and a more complex one (30 jobs and 6 uniform machines) show that this approach permits to converge quickly to a robust schedule even if the probability distribution associated to the uncertainties are not symmetrical. The approach achieves a better rate of convergence than those of the literature's methods.

An unrelated parallel machines rescheduling problem: an industrial case study

Alice Berthier, Alice Yalaoui, Hicham Chehade, Farouk Yalaoui, Lionel Amodeo, Christian Bouillot

University of Technology of Troyes, France

This study tackles an unrelated parallel machines rescheduling problem. Sequence and machine dependent setup times and limited resources are taken into consideration. The study focuses on the objective of proposing an efficient and stable rescheduling solution. The resolution approach is explained and illustrated. Different indicators to optimize the rescheduling planning are tested and results are analyzed. The problem is inspired from a concrete case of textile industry.

Scheduling of parallel 3D-printing machines with incompatible job families: A Matheuristic algorithm

Mohammad Rohaninejad[1], Zdeněk Hanzálek[1], Reza Tavakkoli-Moghaddam[2]

[1]Industrial Informatics Department, Czech Institute of Informatics Robotics and Cybernetics, Czech Technical University in Prague, Prague, Czech Republic; [2]School of Industrial Engineering, College of Engineering, University of Tehran, Tehran, Iran

Additive manufacturing (AM) is a promising technology for the rapid prototyping and production of highly customized products. The scheduling of AM machines has an essential role in increasing profitability and has recently received a great deal of attention. This paper investigates the scheduling of batch processing of parallel 3d-printing machines to minimize the total weighted tardiness. Accordingly, a mathematical model is proposed to formulate the problem considering the sequence-dependent setup time and incompatible job families, where jobs of different families are processed with different materials and desired quality. Due to the high complexity of the problem, an efficient matheuristic algorithm is presented based on the hybridization of a genetic algorithm and a local search method based on mixed integer programming (MIP). Computational results show that the proposed approach is efficient and promising to solve the problem.

An Iterated Greedy Matheuristic for Scheduling in Steelmaking-Continuous Casting Process

Juntaek Hong, Kwansoo Lee, Kangbok Lee, Kyungduk Moon

Pohang University of Science and Technology, Korea, Republic of (South Korea)

The steelmaking-continuous casting (SCC) is a bottleneck process in the steel production.

Due to elevated product variety and environmental restrictions on the steelmaking industry, efficient operation of the SCC has become more crucial. This paper considers an SCC scheduling problem to minimize the weighted sum of total waiting time, total earliness, and total tardiness while satisfying the maximum waiting time and the continuous casting constraints. We propose a generic mixed integer linear programming (MILP) model that can express various SCC scheduling requirements. Using the MILP model, we develop an iterated greedy matheuristic inspired by the iterated greedy method. An initial SCC schedule is constructed by solving small MILP models one after another. Then, it is improved by solving a series of small MILP models representing the destruction and construction of the prior schedule. Through a numerical experiment, we show that the proposed algorithm can obtain efficient solutions in a short time and outperforms an NSGA-II algorithm for most test cases of practical size.

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Low-Code and Model-Driven Engineering for Production System

Time: Monday, 06/Sept/2021: 11:00am - 1:00pm

Towards Development Platforms for Digital Twins: A Model-Driven Low-Code Approach

Judith Michael[1], Andreas Wortmann[2]

[1]RWTH aachen University, Germany; [2]University of Stuttgart, Germany

Digital Twins in smart manufacturing must be highly adaptable for different challenges, environments, and system states. In practice, there is a need for enabling the configuration of Digital Twins by domain experts. Low-code approaches seem to be a meaningful solution for configuration purposes but often lack extension options. We propose a model-driven low-code approach for the configuration and reconfiguration of Digital Twins using language plugins. This approach uses model-driven software engineering and software language engineering methods to derive a configurable digital twin implementation. Moreover, we discuss some remaining challenges such as interoperability, language modularity, evolution, integration of assistive services, collaborative development, and web-based debugging.

Towards Twin-Driven Engineering: Overview of the State-of-the-Art and Research Directions

Massimo Tisi[1], Hugo Bruneliere[1], Juan de Lara[2], Davide Di Ruscio[3], Dimitris Kolovos[4]

[1]IMT Atlantique, LS2N (UMR CNRS 6004), France; [2]Universidad Autónoma de Madrid, Spain; [3]University of L'Aquila, Italy; [4]University of York, United Kingdom

Cyber-Physical System (CPS) are complex physical systems interacting with a considerable number of distributed computing elements for monitoring, control and management. They are currently becoming larger as Cyber-Physical Systems of Systems (CPSoS), since many industrial companies are transitioning their complex systems of systems to software-intensive solutions in different domains such as production or manufacturing. Following the development and dissemination of DevOps approaches in the Software Engineering world, we propose the Twin-Driven Engineering (TDE) paradigm as a way to upgrade the role of Digital Twins (DT) to become a central point in all the engineering activities on the CPSoS, from design to decommissioning. Since CPSoS can be highly heterogeneous, we rather target the support for producing and maintaining a single integrated virtual representation of the CPSoS (i.e. a System of Twins) on which it is possible to perform global reasoning, analysis and verification. However, such a new paradigm comes with several open research challenges. We provide an overview of the state-of-the-art in key areas related to TDE. We identify under-investigated problems in related work and outline corresponding research directions.

A Low-Code Development Environment to Orchestrate Model Management Services

Arsene Indamutsa, Davide Di Ruscio, Alfonso Pierantonio

University of L'Aquila, Italy

The current digital transformation in production systems has positioned model-driven engineering (MDE) as a promising development solution to leverage models as first-class entities and support complex systems' development through dedicated abstractions. Models are specified through domain-specific languages and consumed by dedicated model management services, which implement automation and analysis services. Achieving complex model-driven tasks that involve several model management services and multiple model repositories can be a difficult and error-prone task. For instance, modelers have to identify the proper atomic operations among available services, connect to remote model repositories, and figure out their composition to satisfy the final goal. Different composition proposals have been introduced in MDE even though a satisfactory solution is still missing. In this paper, we propose a low-code development environment to support citizen developers to plan, organize, specify and execute model management workflows underpinning the development of complex systems. Thus, developers are relieved from managing low-level details, e.g., related to the discovery, orchestration, and integration of the needed model management services.

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Metaheuristics for production systems

Time: Monday, 06/Sept/2021: 11:00am - 1:00pm

Comparison of metaheuristics and exact method for the dynamic line rebalancing problem

M.-Lounes BENTAHA[1], Salma El Abdellaoui[2]

[1]University of Lyon, France; [2]OMP France

Assembly lines are the most widely used systems for industrial mass production. A main objective in such a system is to ensure a workload balancing among its workstations and optimize it at the operational level. However, this balancing is affected by various disturbances which induce delays and then generate additional costs and deteriorate the performance of the assembly line. To remedy the negative effects of such disturbances, methods allowing real-time rebalancing are needed. The problem is known as the dynamic rebalancing of assembly lines. This work proposes a comparative study of three metaheuristics performances in solving this problem, namely: Iterated Local Search, Genetic Algorithm and Filters Beam Search-Ant Colony Optimization. The choice of these metaheuristics is motivated by their reputation for quickly and efficiently solving assembly line balancing problems. An exact method, whose performance is compared to the three selected metaheuristics, is also considered. The four approaches are applied to instances of industrial size and complexity known in the assembly line balancing literature. This benchmark data set guarantees coverage of almost all cases that an industrial could encounter. Obtained results showed the metaheuristics efficiency in solving large instances and that the exact method is recommended for small ones. Efficiency is measured here in terms of resolution speed (few seconds are required) and the quality of returned rebalancing solution. A rebalancing solution is of good quality if its cycle time is less than or equal to the initial line takt time.

A Distributed Model for Manufacturing Scheduling: Approaching the EDGE

Pedro Miguel Fernandes Coelho, Cristovão Silva

Univ Coimbra, CEMMPRE, Department of Mechanical Engineering

Manufacturing scheduling has a crucial role in a company's performance. It's a hard optimization problem and due to the latest manufacturing trends, it is becoming even more complex. Metaheuristics are promising methods to solve those real-world problems. The latest distributed/parallel computing advances may support the increase of computational power needed to get efficient schedules a suitable time period. In the last years, the Industrial Internet has also known some advances as the emergence of the Edge computing paradigm that increased the computational processing power near the factory floor. This work presents strategies to implement a distributed metaheuristic for manufacturing scheduling on the Edge. Under the scheduling problem context, the physical platform and the programming environment are examined. Based on an evolutionary metaheuristic (genetic algorithm), a model is developed, following strategies that take advantage of the Edge layer of the Industrial Internet. The generic algorithm steps are described for future deployment and validation.

Multi-objective genetic algorithm to reduce setup waste in a single machine with coupled-tasks scheduling problem

Corentin Le Hesran, Anne-Laure Ladier, Valérie Botta-Genoulaz

Univ Lyon, INSA Lyon, UCBL, Univ Lumière Lyon 2, DISP, EA4570, 69621 Villeurbanne, France

This article studies a single-machine scheduling problem involving coupled-tasks and hard due dates. A genetic algorithm based on the Non-dominated Sorting Genetic Algorithm (NSGA) II model is proposed to carry out a bi-objective optimization of both holding cost and setup-related waste generation. Results show that the multi-objective genetic algorithm outperforms the previous approaches regarding both computation time and objective functions, showing that a reduction of setups of 36% is possible at the expense of an 11% increase in inventory with acceptable computation times. It also highlights the importance of multi-objective optimization for decision-making in case of conflicting objective functions.

Tabu search algorithm for single and multi-model line Balancing problems

Mohamed Amine Abdeljaouad[1], Nathalie Klement[2]

[1]Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), France; [2]Arts et Métiers Institute of Technology, LISPEN, HESAM Université, Lille, France

This paper deals with the assembly line balancing issue. The considered objective is to minimize the weighted sum of products' cycle times. The originality of this objective is that it is the generalization of the cycle time minimization used in single-model lines (SALBP) to the multi-model case (MALBP). An optimization algorithm made of a heuristic and a tabu-search method is presented and evaluated through an experimental study carried out on several and various randomly generated instances for both the single and multi-product cases. The returned solutions are compared to optimal solutions given by a mathematical model from the literature and to a proposed lower bound inspired from the classical SALBP bound. The results show that the algorithm is high performing as the average relative gap between them is quite low for both problems.

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Scheduling jobs on unrelated machines with job splitting and setup resource constraints for weaving in textile manufacturing

IOANNIS MOURTOS, STAVROS VATIKIOTIS, GEORGIOS ZOIS

Athens University of Economics and Business, Greece

This work considers the production scheduling of the weaving process in a real-life textile industry, where a set of jobs - linked to the production of a fabric type and accompanied by a quantity - arrive over time and have to be processed (woven) by a set of parallel unrelated machines (looms) with respect to their strict deadlines (delivery dates), under the goal of makespan minimization. A number of critical job and machine properties demonstrate the challenging nature of weaving scheduling, i.e., a) job splitting: each order's quantity is allowed to be split and processed on multiple machines simultaneously, b)sequence-dependent setup times: the setup time between any two orders j and k is different than setup time between jobs k and j on the same machine and c) setup resource constraints: the number of setups that can be performed simultaneously on different machines is restricted due to a limited number of setup workers. We propose a MILP formulation that captures the entire weaving process. To handle large real instances,while also speeding up an exact solver on smaller ones, we propose two heuristics that perform job-splitting and assignment of jobs to machines either greedily or by using a relaxed version of our MILP model, respectively. We evaluate the impact of our approach on real datasets under user-imposed time limits and resources (machines, workers) availability.

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Regular session: New approaches for routing problem solving

Time: Monday, 06/Sept/2021: 11:00am - 1:00pm

The Implementation of Eulerian Coverings of a Graph for Solving Routing Problems

Tatiana Makarovskikh

South Ural State University, Russian Federation

In terms of graph theory, the urban transport network can be adequately represented as a graph. All crossroads in the city are considered to be the vertices of the graph, and streets are the edges. Using this model, one can set and effectively solve many routing problems: (1)~constructing the routes between given starting and ending points, satisfying the rules of the road (allowed turns at crossroads and a given sequence of driving through the streets), (2)~finding the way, passing through all the streets of the city in accordance with the rules of the road and a given sequence of turns at crossroads (an algorithm for constructing an permissible Eulerian chain), (3)~constructing a minimal cardinality set of routes running through all the streets of the city (Eulerian cover of any graph with permissible chains). The paper provides a formalization of these problems and effective algorithms for solving them.

An Exact Method for a Green Vehicle Routing Problem with Traffic Congestion

Hongyuan Luo, Mahjoub Dridi, Olivier Grunder

Nanomedicine Lab, Univ. Bourgogne Franche-Comté, UTBM, France

This paper addresses a time-dependent green vehicle routing problem (TDGVRP) with the consideration of traffic congestion. In this work, the objective is to optimize the vehicle routing plan, with the goal of reducing carbon emissions, which has linear relationship with fuel consumption of vehicles. To deal with traffic congestion, travel time are considered to be time-dependent. We propose a branch-and-price (BAP) algorithm to precisely solve this problem. A tailored labeling algorithm is designed for solving the pricing sub-problem. Computational experiments demonstrate the effectiveness of the proposed BAP algorithm.

Investigating Alternative Routes for Employee Shuttle Services Arising in a Textile Company: A Comparative Study

İbrahim Miraç ELİGÜZEL, Nur Sena YAĞBASAN, Eren ÖZCEYLAN

Gaziantep University, Turkey

For the big companies, picking up a number of employees from various places (residential areas or common places) within a neighborhood and brought to the factory should be a challenging task. Potential improvements for this constantly repeated service planning may result in cost and total traveled distance reduction. To search and provide the aforementioned potential savings, three different scenarios with three different bus capacities are generated for a textile company in this paper. In the first scenario that is also the current application of the company, an integer programming model for the capacitated vehicle routing problem (CVRP) is applied. In this scenario, shuttle buses with a certain capacity are routed by picking up the employees from their homes. In the second scenario, the employees are clustered (cluster size is equal to the vehicle capacity) using P-median model to minimize the total walking distance of employees to the meeting point, then the shuttle buses are routed by visiting the clustered zones (meeting points). In the last scenario, the employees are clustered using K-means model and then, shuttle buses transport workers to factory from the center points of each cluster. Three scenarios with different bus capacities (20, 30 and 50 people) are applied to a textile company (the depot) that includes 1,361 employees. The models are run using Gurobi 9.1.1 with Python 3.8 and the results are discussed. According to the results, second and third scenarios reduce the total traveled distance by 46.90% and 44.10% (averagely) compared to the first scenario, respectively.

Two variants of bi-objective Vehicle Routing Problem in Home (Health)-care fields

Salma HADJ TAIEB[1], Taicir MOALLA LOUKIL[1], Abderrahman EL MHAMEDI[2], Yasmina HANI[2]

[1]FSEGS, Tunisia; [2]PARIS8, France

In this research paper, we consider two bi-objectives Vehicle Routing Problem with Time windows, temporal dependency, multiple structures and multiple specialities (VRPPTW-TD-2MS and VRPBTW-TD-2MS), in Home Health Care service field. In this context, patients are not in a single structure any more, but rather at home. As a result, the problem is no longer limited to the care organization, but also to the construction of tours for the caregivers, the delivery of medicines, and the equipment needed for care. According to our knowledge, our work is different from those made in the literature. Our problem consists to determine the caregivers' tours while optimizing bi-objective function which aims to minimize the total traveling time and the total negative preference or the maximal difference workload of caregivers under set of constraints such as time window, synchronization, precedence and disjuction constraints with multiple structures and multiples skills. A benchmark of instances are considered from literature. Cplex is defined to solve our problems to obtain optimal/feasible solutions.

Inventory routing problem with transshipment and substitution for blood products using the case of the Belgian blood distribution

Christine Di Martinelly[1,2], Nadine Meskens[3,4], Fouad Riane[5,6,7], Imane Hssini[4]

[1]IESEG School of Management; [2]LEM-CNRS (UMR 9221); [3]Université Catholique de Louvain; [4]Louvain School of Management, Lourim; [5]Ecole Centrale de Casablanca; [6]LGI CentraleSupélec Paris Saclay University; [7]FST Settat, Hassan Premier University

In this paper, we deal with a blood supply chain management problem. We focus in particular on blood distribution routes design and optimization. Blood is a scarce and perishable product, made of multiple components, each with specific compatibility rules. We would like to investigate the impact of compatible products substitution and transshipment between hospitals on blood demand satisfaction. We use the case of the blood supply chain in Belgium as an application. We model the case as an Inventory Routing Problem with transshipment and substitution for perishable products in a capacity constrained environment. We implement the model and conduct experimentations to evaluate the contribution of both transshipment and substitution with regards to shortages and distribution and inventory costs reduction. In a capacity constrained environment, at equivalent cost, mismatching/substitution is preferred to transshipment to satisfy the demand and avoid backorders.

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System Identification for Manufacturing Control Applications

Time: Monday, 06/Sept/2021: 11:00am - 1:00pm

Management Projects for Digital Ecosystems of Automotive Enterprises: Truck Sharing

Natalia Bakhtadze[1], Denis Elpashev[1], Alexandre Suleykin[1], Rustem Sabitov[2], Gulnara Smirnova[2], Mikhail Kuchinskii[3], Shamil Sabitov[4]

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The paper offers an approach to the development of a truck sharing management system for a digital ecosystem, which comprises a automobile plant, auto parts suppliers, customers and service centers. The management is based on predictive associative search models. To improve the efficiency of the situational management based on situational awareness, quantum clustering algorithms are used.

Multi-Step Problem of Inventory Control with Returns

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A new model of inventory control with returns is considered, when it is possible for consumers to return (under certain conditions) the products they have pur-chased. It proved to be that the optimal inventory control strategy in such a sys-tem turns out to be four-level.

Price-to-Quality Ratio Dependent Demand: Keeping the Intensity of Demand Constant

Anna Kitaeva[1], Natalia Stepanova[2], Alexandra Zhukovskaya[3]

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We consider a deterministic model of an inventory system that consists of a sin-gle type of perishable product, which is periodically replenished, and a demand depends on price-to-quality ratio (PQR). The product quality decays linearly over time. To keep an intensity of the demand constant we change the price propor-tionally to the decreasing quality of the product. Exponential and linear depend-ences of the demand's intensity of PQR are considered and optimal values of lot size and PQR maximizing the profit per unit time are obtained.

Identification of Integrated Rating Mechanisms on Complete Data Sets

Nikolay Korgin, Vladimir Sergeev

V.A. Trapeznikov Institute of Control Sciences of RAS, Moscow, Russia

An approach to the selection of structure for integrated rating mechanism to be identified given complete learning dataset is suggested. Theoretical assertions and derived from them constructive algorithm for full binary tree selection are described. Challenges for ex-tension of the approach suggested to incomplete data sets are outlined.

Resolution Estimates for Selected Coordinate Descent: Identification of Seismic Structure in the Area of Geothermal Plants

Tatyana Smaglichenko[1], Alexander Smaglichenko[2]

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The coordinate descent method is a traditional inverse solver to optimization problems. In modern sectors of production research: in computer graphics, computer tomography, a theory of pattern recognition various algorithms of the coordinate descent have been applied. In this paper, we investigate the novel algorithm of selected coordinate descent and outline the difference between this algorithm and the classical coordinate descent. The solution selection is performed owing to the search of the maximum among values of the specific parameter. The maximum indicates a single direction, which is responsible for the minimum of the function in the least square sense. We develop the technique for defining the explicit expression for the resolution measure of the linear systems, which are solved using the proposed algorithm. The algorithm and its resolution tool are applied to seismic observations collected in the area of the Krafla and Theistareykir geothermal power plants, northern Iceland. The result confirms that the distinctive feature of the algorithm is its effectiveness when simple large-size structures are retrieved. The analysis of the resolution parameter values shows that the calculation of this parameter might be helpful to recognize the true structure.

APMS 2021 Conference | Artificial Intelligence for Sustainable and Resilient Production Systems

Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

The Future of Lean Thinking and Practice

Time: Monday, 06/Sept/2021: 11:00am - 1:00pm

Towards an Economic Theory of Lean

Eivind Reke[1], Daryl Powell[2], Kodo Yokozawa[3]

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Abstract. For more than 40 years, researchers have studied the operations man-agement practices of Toyota and their application in different companies and in-dustries, most notably under the heading of lean operations. Even though lean has become an integral part of the operations management curriculum and cor-porations such as Danaher have embraced it as their "way of doing business", lean has yet to truly breach the executive echelons of most firms and as such fails to reach its true potential as an alternative, people-centric, and sustainable busi-ness model. To address this gap, we have carried out an extensive literature search on the subject and conducted several interviews with CXO level execu-tives from lean firms. Our findings point us in the direction of an underlying economic theory of lean, based on the business model and associated practices of the Toyota Motor Corporation, and a further three exemplary case companies which have adapted some or all of these practices under the guise of lean produc-tion.

Reshaping the concepts of Job Enrichment and Job Enlargement: the impacts of Lean and Industry 4.0

Alexandra Lagorio, Chiara Cimini, Paolo Gaiardelli

University of Bergamo, Italy

The latest innovations in the manufacturing technologies significantly affected the roles of workers, both concerning task variety and required skills. Consequently, in a highly digitalised context, operators and managers are facing increasingly job enlargement and job enrichment requirements in order to perform new and different activities and functions. This paper aims at exploring how the concepts of job enrichment and job enlargement have been evolving over time, through a systematic review of the literature. From the analysis, it emerged that the concepts have been enriched with broader meanings according to the two different production paradigms, in particular with the introduction of Lean Manufacturing principles up to the introduction of the Industry 4.0. The study highlights that if the lean principles strongly promoted the idea of enlarging and enriching the workers' activities to promote their involvement and motivation, supporting leadership attitude and soft skills, additionally the Industry 4.0 significantly affected an enlargement of tasks in space and time, requiring enriched technical skills to manage complex digitized processes.

Realizing value opportunities for a Circular Economy: Integrating Extended Value Stream Mapping and Value Uncaptured Framework

Nina Pereira Kvadsheim[1], Bella B Nujen[2], Daryl Powell[3], Eivind Reke[3]

[1]Møreforsking AS, Norway; [2]Faculty of International Business, Norwegian University of Science and Technology; [3]SINTEF Manufacturing, Norway

A shift to a Circular Economy (CE) requires more than the implementation of new processes and activities. It also requires identification of new opportunities to create and capture value by analyzing value captured and uncaptured across the product life cycle. However, previous studies focusing on value captured and un-captured have consistently employed the value uncaptured (VU) framework in isolation. Hence, this study combines the VU framework with extended value stream mapping (EVSM), to identify waste and value improvement opportunities with 'high' circularity. Based on an in-depth case study of a firm that produces patient simulators, both approaches have been applied. The findings of the current study prove the effectiveness of integrating EVSM and the VU framework when firms are to evaluate the possibilities for realizing value opportunities for a CE

An Enhanced Data-Driven Algorithm for Shifting Bottleneck Detection

Christoph Roser[1], Mukund Subramaniyan[2], Anders Skoogh[2], Björn Johansson[2]

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Bottleneck detection is vital for improving production capacity or reducing production time. Many different methods exist, although only a few of them can detect shifting bottlenecks. The active period method is based on the longest uninterrupted active time of a process, but the analytical algorithm is difficult to program requiring different self-iterating loops. Hence a simpler matrix-based algorithm was developed. This paper presents an improvement over the original algorithm with respect to accuracy.

More checks for less waste in the lamination process of a shipbuilding company pursuing Lean Thinking

Inês Freitas, Isabelle Leão, João Eduardo Marinho, Leonor Pacheco, Margarida Gonçalves, Maria João Castro, Pedro Duarte Silva, Rafael Moreira, Anabela Alves

University of Minho, Portugal

Lean Thinking is a management philosophy that aims to do more with less through a process of continuous improvement. By employing Lean Thinking principles, the project presented in this article aimed to obtain improvements in the boats' hulls and decks lamination process of a shipbuilding company. After analyzing the current process, some problems were identified. To solve these problems, suggestions were developed, such as the use of checklists, the introduction of quality checkpoints along the production line, and a VBA tool for the correct management of the dies. Through the implementation of the suggested proposals, it was expected a decrease in the number of defects and a reduction of the bottleneck cycle time from 90 to 20 minutes. Interesting findings of this project were that the improvements implied more quality checkpoints in the process, which seems contradictory as checkpoints are considered as non-value activities. This was a remarkable lesson learned by the team of Industrial Engineering and Management students that developed this project in the context of Project-Based Learning active methodology.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Intelligent Systems for Manufacturing Planning and Control in the Industry 4.0.

Time: Monday, 06/Sept/2021: 2:00pm - 4:00pm

A smart contracts and tokenization enabled permissioned blockchain framework for the Food Supply Chain

Monica Sharma[1], Akshay Patidar[1], Rajeev Agrawal[1], Kuldeep Singh Sangwan[2]

[1]Malaviya National Institute of Technology, India; [2]Birla Institute of Technology and Science Pilani Campus, India

The food supply chain is gaining a lot of attention these days. Due to the relativity of the food supply chain with human health directly, focusing on its problems and issues has become the need of the hour. Several issues like food safety, food contamination, and adulteration, food losses are some of the issues. Among these issues, food losses are critically important as they affect sustainable development as well. Among the several critical causes of this food loss problem, handling losses are most important and are very less studied. Handling losses are important as the causes of these losses are controllable and can be easily mitigated with the help of science and technology. This research is an effort in the defined direction. With the help of technology like blockchain and its capabilities, the authors in this study developed a framework for the food supply chain that if implemented can help in reducing handling losses.

Opportunities of Blockchain Traceability Data for Environmental Impact Assessment in a Context of Sustainable Production

Vincent Carrières[1,2], Andrée-Anne Lemieux[3], Robert Pellerin[1]

[1]Ecole Polytechnique de Montréal, Montréal, Canada; [2]Arts et Métiers, Paris, France; [3]Institut Français de la Mode, Paris, France

Supply chains face various challenges for collecting reliable, transparent, and up-to-date data due to their increased complexity and globalization. This threatens their sustainability and limits the efficiency of environmental impact assessment of products with Life Cycle Assessment (LCA) methodology. This paper explores the opportunities, limitations, and research paths for assessing products' environmental impact using blockchain-based traceability data based on a literature review. Results showed that blockchains are mainly used for product traceability and several models and frameworks were pro-posed for the integration of blockchain-based LCA systems. However, the maturity of blockchain technology and supply chain organization are the prevalent barriers to implementing these systems.

Manufacturing strategy dimensions as I4.0 performance antecedents in developing economies

Amit Kumar Gupta, Narain Gupta

Management Development Institute Gurgaon, India

The challenge with technology implementation in today's world is the industrial workforce's acceptance, awareness, and cost implications. This also requires old systems to be obsolete and complete staff training on the new system change. This research aimed to understand the readiness, acceptance, and implementation of the concept of I4.0 and performance in the Indian industrial sector for achieving a business edge. In addition, the paper strives to analyze the impact of dimensions of manufacturing strategy (i.e., cost, delivery, flexibility, and quality) on I4.0 performance. The conceptual framework was developed under the lenses of dynamic capability theory [1–3].

The survey method was used to collect the perception data from middle to above middle executives. To test the hypotheses, CB-SEM measurement and path models were developed using the IBM- AMOS 25. A random sampling using an in-person survey and an online sample collection method was used to obtain the sample data. A total of 232 valid sample data were eventually analyzed out of the total collected 273 datasets to check the reliability of our hypothesis. The results showed that quality and the delivery performance had a strong positive relationship with industry 4.0 supplier performance (i4.0SP) while cost and flexibility performance failed to improve i4.0SP significantly. Academically this research contributes to the literature of industry 4.0 and dynamic capability theory. The findings of this research give clear directions to the manufacturing organizations of the developing nations to focus their efforts towards inbound logistics to improve the i4.0SP.

Design of a Li-Fi Transceiver for Distributed Factory Planning Applications

Vasu Dev Mukku[1], Sebastian Lang[1,2], Tobias Reggelin[1], Paul Reichardt[1]

[1]OVGU, Germany; [2]Fraunhofer Institute for Factory Operation and Automation IFF, Germany

Light-Fidelity (Li-Fi) is a wireless communication technology, which uses light as the medium of communication. In this paper, we discuss Li-Fi as a communication strategy for building dynamic factory layouts. Advantages of Li-Fi are the low energy consumption, the straightforward implementation, the cost-efficient maintenance and the easy identification of factory layouts. This paper focuses on designing a customized Li-Fi transceiver, which provides point-to-point and full-duplex communication within an Industry 4.0 learning factory. Furthermore, we propose a conceptual model for the adaption of Li-Fi communication in distributed factory planning applications. Finally, we describe the prototypical implementation of the proposed conceptual model. The primary scientific contribution of this paper is to present the reliability of a custom-designed four-way Li-Fi transceiver inside an industry 4.0 learning laboratory.

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Comparison between product and process oriented Zero-Defect Manufacturing (ZDM) approaches

Foivos Psarommatis, Dimitris Kiritsis

École polytechnique fédérale de Lausanne, Switzerland

Contemporary manufacturing companies pay a lot of attention to product qual-ity as this aspect affects directly their competitiveness, productivity and the reputation of the company. Traditional quality improvement methods such as Six Sigma, Lean etc. seems unable to cope with the market's quality standards. Contemporary technological advancements allowed the successful implemen-tation of Zero Defect Manufacturing (ZDM) which is replacing traditional quality improvement methods. According to a recent review article ZDM can be implemented in two ways the product oriented and the process oriented ap-proach, but there is no clear understanding of the advantages and disad-vantages of each approach. The current research proposes a methodology for quantifying the performance of each approach. To accomplish that a set of ZDM parameters is defined to describe the problem and the proposed method-ology is applied on a specific industrial use case in order to enumerate the ZDM parameters. The results from the application of the proposed methodolo-gy will assist manufacturers and researchers to select the most suitable ap-proach to their specific case in order to achieve sustainable manufacturing. The results showed that the performance of either product or process oriented approach is heavily depending on the input parameters and use case.

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Learning and Robust Decision Support Systems for Agile Manufacturing environments

Time: Monday, 06/Sept/2021: 2:00pm - 4:00pm

Resilient Project Scheduling Using Artificial Intelligence: a Conceptual Framework

Sarra Dahmani[1], Oussama Ben-Ammar[2], Aïda Jebali[1]

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This paper explores the role that Artificial Intelligence (AI) can play in building resilient project schedules. Based on a literature review and brainstorming sessions, we introduce a conceptual framework that details how AI-enabled predictive and prescriptive analytics can be leveraged to improve project schedule resilience. The latter

specifies the potential of AI to make use of historical and real-time data to better contain the effect of disruptions on project schedules.

Knowledge graphs in digital twins for AI in production

Pieter Lietaert, Bart Meyers, Johan Van Noten, Joren Sips, Klaas Gadeyne

Flanders Make, Belgium

AI is increasingly penetrating the production industry. Today, however, AI is still used in a limited way in a production environment, often focusing on a sin-gle production step and using out-of-the-box AI algorithms. AI models that use information spanning a complete production line and even larger parts of the product lifecycle could add significant value for production companies. In this paper, we suggest a digital twin architecture to support the complete AI lifecycle (discovering correlations, learning, deploying and validating), based on a knowledge graph that centralizes all information. We show how this digital twin could ease information access to different heterogenous data sources and pose opportunities for a wider application of AI in production industry. We illustrate this approach using a simplified industrial example of a compressor housing production, leading to preliminary results that show how a data scientist can ef-ficiently access, through the knowledge graph, all necessary data for the crea-tion of an AI model.

Decision Support on the Shop Floor Using Digital Twins: Architecture and Functional Components for Simulation-Based Assistance

Franz Georg Listl[1,2], Jan Fischer[2], Roland Rosen[2], Annelie Sohr[2], Jan Christoph Wehrstedt[2], Michael Weyrich[1]

[1]Institute of Automation and Software Engineering, University of Stuttgart, Germany; [2]Siemens AG, Germany

Increased flexibility and improved resilience in production and manufacturing processes are goals that are becoming more and more important in the context of Industry 4.0 and from the experience of the Covid-19 pandemic. At the same time, efficient operation of production must be guaranteed to achieve economic as well as ecological objectives. Intelligent assistance systems follow the idea to support stakeholders of production systems in their decisions and can thus be useful applications for helping to master the various challenges and to meet these goals. In this paper, we describe functional components of these decision support systems: data provision and data extraction, knowledge base, simulation models, model execution and analytics, and application and user interaction. We show the underlying technologies and illustrate why these assistant systems are valuable for several stakeholders.

Worker in the loop: a framework for enabling Human-Robot collaborative assembly

Eleni Tzavara, Panagiotis Angelakis, George Veloudis, Christos Gkournelos, Sotiris Makris

LMS-University of Patras, Greece

Industry has taken a big leap forward by placing a human in the center of interest by turning the working areas into a collaborative environment between operators and robots. In this environment, human behavior is a major uncertainty factor that can affect operator's safety and execution status. Furthermore, the creation of a digital twin including the whole workstation area, the operators and the procedures that take part in there, is a way to design and integrate collaborative systems using a virtual space. This paper aims to overview the current state of the technological trends in human detection, human task monitoring and digital twin integration. Also, the design of the upcoming solution of a case study from the automotive industry will be represented.

A taxonomy for resistance concepts in manufacturing networks

Ferdinand Deitermann, Thomas Friedli

University of St. Gallen, Switzerland

Manufacturing networks - global production networks and international manufacturing networks - are exposed to an increase in uncertainty, which can cause disturbances. To cope with these disturbances, scholars presented different concepts, such as robustness, resilience, responsiveness, flexibility, changeability, adaptability, and agility. However, these terms are not clearly and concisely defined and lack a common understanding. With this study, we intend to address this issue and contribute to a better understanding and differentiation. We develop a taxonomy with descriptive dimensions and characteristics for the different resistance concepts for manufacturing net-works, which will provide a tool to better understand the differences and commonalities between them. It is a vital first step that creates a common ground for further investigations. Practitioners can use the taxonomy to build a sound understanding and improve their manufacturing network.

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Lean and Six Sigma in Services Healthcare

Time: Monday, 06/Sept/2021: 2:00pm - 4:00pm

Lean Healthcare and Fast Track in Emergency - Systematic Integrative Review

Sandra Maria do Amaral Chaves[1], Robisom Damasceno Calado[1], Olavo de Oliveira Braga Neto[2], Sara Avelar Coelho[1], Alexandre Beraldi Santos[1], Saulo Cabral Bourguignon[1]

[1]Universidade Federal Fluminense; [2]Ministério da Saúde - DAHU, SAES

Abstract: The aim of this study was to investigate the theoretical methodological framework of Lean Thinking with the application of Fast Track in emergency ser-vices with overcrowding. The systematic integrative review method was used with the following guiding question: What is the principle of Lean Thinking relat-ed to the application of Fast Track in overcrowded emergency services? De-scriptors were used: “emergency department”, “lean”, “overcrowding” in the ba-ses: Web of Science, PubMed, and Scopus. Articles were selected using PRISMA® and a matrix was created with three categories of analysis units to classify and discuss the results, concluding with the presentation of the review. Of the 268 records collected, 14 articles were selected in which the Fast Track consists of a fast flow that favors the application of the principle of continuous and essential flow in overcrowded emergency services, as it aims to reduce the length of stay of patients from less acuity. It was identified that: the theoretical methodological framework demands more in-depth studies; and that, Fast Track is an approach that helps to reduce overcrowding in emergency services is associat-ed with the Continuous Flow principle. It is concluded that the Fast-track service in the Emergency environment reduced the waiting time, which resulted in im-provements in the flow of care and increased patient satisfaction.

Information, Communication and Knowledge for Lean Healthcare Management Guidelines, A Literature Revision

Christiane Barbosa[1], Adalberto Lima[1], Alberto Sobrinho[1], Robisom Calado[2], Sandro Lordelo[1]

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The objective is to identify the management of information, communication and knowledge in Emergency Care Units (ECU). The method was a lexical and semantic analysis using VOSViewer, categorization of the results for a qualitative and cross analysis of the approaches on the subject. With the results of the practical application of the Lean Project in the ECU in 50 units it was possible to establish criteria and a parameter for knowledge management in this health area. The results categorize the publications in four central themes in healthcare: leadership and governance; quality in health; technology and information; Lean. The information flow is presented as a means, not an end activity and this is confirmed when the articles limit themselves to highlight the means of communication, applications or devices used for the dissemination of information, with- out further deepening of steps such as data collection, validation and valuation of information in health environments. The human factor is the main agent of change because it needs clarity that the use of information and communication technologies do not make its nal activity impossible, but it is a facilitating, agile and effective tool in the conduct of their work activities.

HFMEA-Fuzzy Model for Lean Waste Assessment in Health Care Units: Proposal and utilization cases

Harvey José Santos Ribeiro Cosenza[1], Nilra do Amaral Mendes Silva[1], Olavo de Oliveira Braga Neto[2], Luis Fernando Torres[3], Robisom Damasceno Calado[1]

[1]Federal Fluminense University, Brazil; [2]Ministry of Health – Secretariat of Specialized Health Care – Department of Hospi-tal, Home and Emergency Care; [3]Campinas State University SP, BR

The management of risks and failures in health systems is considered one of the most efficient solutions for providing care to patients. In practice, this activity also makes it possible to join new corporate opportunities, because it allows preventive measures resulting from social, scientific, and technological developments to be constantly evolving throughout the organization. The aim of the article is to present an applica-tion of the failure modes and their health effects analysis model (HFMEA) integrated with Fuzzy logic in three Emergency Care Units (UPAs) in Brazil. This mapping model analyzes and analyzes how failures occurred in the supply chain of UPAs. The meth-odology used included dividing the study into 4 stages, which were used to prepare the proposed model through the evaluation of failure modes integrated with Fuzzy logic. This work reports as one of the roots of the problems in the studied UPAs: the predominance of processing and creativity waste. These, associated with the factor Management and Leadership for a Lean environment, demonstrate that failures in leadership are linked to the dissatisfaction of management support professionals. In addition, a hierarchical analysis of the failure probabilities and evaluation of the eight Lean wastes found in the UPAs was presented.

Motivators to application of DMAIC in patient care processes

Milena Estanislau Diniz Mansur dos Reis[1], Luis Enrique Valdiviezo Viera[2], Laryssa Carvalho de Amaral[2], José Rodrigues de Farias Filho[2], Adriana Melo Teixeira[3], Robisom Damasceno Calado[2]

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Six Sigma comprises DMAIC which is a methodology that has attracted the at-tention of researchers in the field of Healthcare. This study aims to understand the motivators to apply DMAIC in process in the context of Six Sigma and Lean Six Sigma to be implemented in processes focused on direct patient care. The article covers literature on DMAIC from 1997 to October 2020. For such a purpose, a systematic literature review has been carried out based on empirical studies in Hospitals and Emergency units. A total of 21 articles were reviewed, and the top-ic Motivators were addressed in this article with the aim of performing DMAIC through Six Sigma/Lean Six Sigma. Based on the analyzed articles, the most fre-quent motivator to implement Six Sigma/Lean Six Sigma DMAIC in organiza-tions lies in reducing process time (such as length of stay) and improving the quality of service. It was also noticed that DMAIC has been used in several health services, such as patient discharge and surgeries (femur surgeries, for in-stance). An application of DMAIC in 50 emergency care units (UPAs) corroborated the main motivators indicated in the literature.

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Evaluation of Fast-Track Implementation on Emergency Department: A Literature Review

Luis Enrique Valdiviezo Viera[1], Milena Estanislau Diniz Mansur Reis[2], Sandra Maria do Amaral Chaves[1], Robisom Damasceno Calado[1], Saulo Cabral Bourguignon[1], Sandro Alberto Vianna Lordelo[1]

[1]Federal Fluminense University, Brazil; [2]Federal University of Rio de Janeiro, Brazil

The fast-track is an important strategy for the management and control of over-crowding, which is increasingly used in hospital emergency services. This review article aims to identify the main approaches and criteria for analyzing and decid-ing on the implementation of the fast-track strategy in Emergency Department. The bibliographic review considered articles published in the Scopus and Med-Line databases during the period 2010 and 2020. In general, the bibliographic re-search showed: the relative scarcity of scientific communication, regarding the implementation of fast-track strategies in hospital management systems; the di-versity of the implantation purposes; the preference for modeling and simulation techniques; the difficulty of ex-ante and ex-post evaluation from a social perspec-tive. The evaluation of the effectiveness of the implementation of fast-track strate-gies, when operational criteria are used, are based on quantitative models and techniques. In Brazil, the efficient management of Emergency Care Units, UPAs 24-hour, is essential because the UPAs are a fundamental part of the Brazilian health system.

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Modern Analytics and New AI-based Smart Techniques for Replenishment and Production Planning under Uncertainty

Time: Monday, 06/Sept/2021: 2:00pm - 4:00pm

Multi-period Multi-sourcing Supply Planning with Stochastic Lead-times, Quantity-dependent Pricing, and Delivery Flexibility Costs

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This work studies the problem of multi-period multi-sourcing supply planning with stochastic lead-times, quantity-dependent pricing, and delivery flexibility costs. We present a problem formulation that takes also into account holding and backlog costs and finite capacities of suppliers. The objective is to minimize the expected total cost while respecting suppliers' capacity constraints and satisfying customer demand. In this paper, the proposed stochastic integer linear program is detailed and the first results of experiments are presented and discussed.

Tool for nervousness analysis in a rolling planning environment via historical data

Khellaf Walid[1], Lamothe Jacques[2], Guillaume Romain[3]

[1]IRIT, IMT Mines Albi-Carmaux; [2]IMT Mines Albi-Carmaux; [3]IRIT, University of Toulouse Jean Jaures

This paper analyses the modifications of plans exchanged between supply chain actors in a tactical planning rolling horizon process. A particular focus is on the changes of planned quantities in order to respond to fluctuating demand or to adapt to internal contingencies of the organization. They create instability and nervousness in the planning system. This paper presents a data-driven study to compare the behavior of planning decision makers in a context of certain and uncertain demand. We show through simulation and statistical analysis the effect of decision characteristics of one actor on the system nervousness and the resulting uncertainty for the other actors.

A Preliminary Overview of Ramp-up Management Practices in Crisis Context

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Production ramp-up is a key stage in the product life cycle since it can determine whether a product's launch into the market or the increase of production capacity succeeds or fails. Ramp-up as a phase of value creation, begins with the comple-tion of a product's design and ends with the reach of maximum production capac-ity. In today's world, there is a significant advance in technology but simultane-ously there is an increasing uncertainty as we have experienced with the Covid-19 crisis. Within this context, the importance of ramp-up management become more than ever evident. Whilst some products like face masks saw their demand increase drastically, some other companies had to shut off their production or switch to manufacture new products like hand sanitizers. Hence, it is critical to-day to have a successful ramp-up management in order to predict and meet cli-ents' demand in terms of quality and quantity. This paper aims to provide a set of guidelines for ramp-up management considering crisis context. The paper relies on an exploratory research coupling literature analysis and interviews among practitioners. The insights drawn from the literature and from the interviews are expected to provide decision makers with valuable guidance with regard to ramp-up management.

Inventory and Commitment Decisions for On-demand Warehousing System

JUNHYEOK LEE[1], JUNSEOK PARK[1], ILKYEONG MOON[1,2]

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The on-demand warehousing system is a service that makes a connection between e-commerce sellers and warehouse providers who have excess capacity for sharing warehouse spaces. The e-commerce sellers can create a distribution network strategy and manage the varying demands of customers by utilizing this system. In this study, we focused on inventory and commitment decisions that impacted the use of shared warehouses from the standpoint of e-commerce sellers. We proposed a mathematical model, which incorporated inventory and commitment decisions to maximize total profits. A small-scale experiment was conducted, and the result showed that the commitment decisions could affect total profits of e-commerce sellers considerably.

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Meta-Heuristics and Optimization Techniques for Energy-Oriented Manufacturing Systems

Time: Monday, 06/Sept/2021: 2:00pm - 4:00pm

Single machine Order Acceptance Scheduling with periodic energy consumption limits

Mariam Bouzid, Oussama Masmoudi, Alice Yalaoui

Computer Laboratory and Digital Society (LIST3N), France

This work presents an Order Acceptance Scheduling (OAS) problem with the introduction of energy consumption limits at each period of the planning horizon. The objective is to maximize total profit of accepted orders while considering energy usage over time, in accordance with imposed deadlines. A time-indexed formulation is presented to tackle the investigated problem.

A MILP Model for Energy-Efficient Job Shop Scheduling Problem and Transport Resources

S. Mahdi Homayouni[1], Dalila B.M.M. Fontes[1,2]

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This work addresses the energy-efficient job shop scheduling problem and transport resources with speed scalable machines and vehicles which is a recent extension of the classical job shop problem. In the environment under consideration, the speed with which machines process production operations and the speed with which vehicles transport jobs are also to be decided. Therefore, the scheduler can control both the completion times and the total energy consumption. We propose a mixed-integer linear programming model that can be efficiently solved to optimality for small-sized problem instances.

Developing a bi-objective model to configure a scalable manufacturing line considering energy consumption

Atefeh Jamiri, Mehdi Mahmoodjanloo, Armand BABOLI

INSA Lyon- LIRIS Laboratory, France

Today, due to intense global competition, manufacturing systems need to be highly responsive and adaptive to fulfill market demand fluctuations and personalized production. Reconfigurable manufacturing system (RMS) is one of the main paradigms which has been introduced to overcome the dynamic nature of today's industry. In addition, RMSs are also a basis to develop new generation of sustainable production systems. This paper addresses the prob-lem of designing a scalable manufacturing line for a part family considering both cost- and energy-effectiveness criteria. Hence, a bi-objective mathemat-ical programming model is proposed. The main decision is to configuration and/or reconfiguration of production line by adding a set of new machines from a list of candidate reconfigurable machine tools (RMTs) and/or trans-forming them among the stages to fulfill anticipated demands in the periods of a time horizon. A numerical example is solved to illustrate the validation of the model. CPLEX is utilized to implement an augmented epsilon con-straint method to extract Pareto front. The results show that different strate-gies in configuration the production line have significant impact on cost- and energy-effectiveness criteria.

Designing Bioenergy Supply Chains under Social Sustainability Constraints

Sobhan Razm[1], Ramzi Hammami[2], Alexandre Dolgui[1], Nadjib Brahimi[2]

[1]IMT Atlantique, France; [2]Rennes School of Business, France

Using renewable energy, a clean alternative to fossil fuel, has become very attractive. It has environmental advantages and leads to regional development. This study proposes designing bioenergy supply chains under social concerns. Unemployment rate, and rate of vulnerability to the variation in the markets in an economic crisis, are considered as social concerns.

The areas that are mostly exposed to these social issues are chosen as initial suggested locations for installing the biorefineries. Installing biorefinery can generate jobs for the people of these areas. This leads to the sustainable development in the areas. The applicability of the developed model is shown through a case study. The results demonstrate that the proposed approach leads to generation of a large number of job positions which is an important impact on the social sustainability of these regions.

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New trends and challenges in Reconfigurable, Flexible or Agile Production System

Time: Monday, 06/Sept/2021: 2:00pm - 4:00pm

Changeable Manufacturing: A Comparative Study of Requirements and Potentials in Two Industrial Cases

Stefan Kjeldgaard, Alessia Napoleone, Ann-Louise Andersen, Thomas Ditlev Brunoe, Kjeld Nielsen

Aalborg University, Denmark

Today's global manufacturing environment is characterized by intense competition in dynamic and uncertain markets. Consequently, manufacturers are required to accommodate a higher variety of products with frequent new introductions and shorter life-cycles in a rapid and cost-efficient way, to sustain competitiveness. In light of these requirements, changeable manufacturing systems appear promising. However, empirically founded research is limited in regard to how different requirements lead to different applications and resulting potentials in various industrial settings. Therefore, this paper presents a comparative study of requirements, enablers, and potentials of changeability in two industrial cases (i) a Danish manufacturer of capital goods for the energy sector, (ii) a Danish manufacturer of sporting goods for the maritime sector. The objective of the paper, is to generate insights which can support various industrial settings in the transition towards changeable manufacturing. Findings include: (i) in high-volume contexts, reconfigurability is suitable to accommodate a production mix with increasing dimensions of parts, with potential to improve equipment utilization to reduce capital expenses (ii) in global manufacturing contexts, reconfigurability is suitable to accommodate frequent changes of production location, with potential to improve demand proximity to gain a competitive advantage.

Integrated Workforce Allocation and Scheduling in a Reconfigurable Manufacturing System Considering Cloud Manufacturing

Behdin Vahedi Nouri[1], Reza Tavakkoli-Moghaddam[1], Zdenek Hanzalek[2], Alexandre Dolgui[3]

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The reconfigurable manufacturing system (RMS) has been acknowledged as an effective manufacturing paradigm to tackle high volatility in demand types and amounts. However, the reconfiguration needs an amount of time and leads to some level of resource wastage. Accordingly, a high frequency in the system's reconfiguration may have a negative impact on its performance. In this regard, this paper investigates the advantage of using cloud manufacturing (CMfg) re-sources in enhancing the performance of an RMS system. A novel mathematical model is developed for the integrated workforce allocation and production scheduling problem utilizing the CMfg under a non-permutation flow shop set-ting. This model simultaneously makes decisions on the utilization of the CMfg capacity for performing some jobs, and for the remaining jobs, determination of machines' configurations for each job, scheduling of the jobs on the machines, and allocation of operators to machines as well. This model aims to minimize the sum of job processing costs, overtime costs, and the cost of utilizing the CMfg resources. Finally, a computational experiment is conducted, which shows a promising improvement in the total cost of the production system by utilizing the CMfg capacity.

Impact of Different Financial Evaluation Parameters for Reconfigurable Manufacturing System Investments

Thomas Ditlev Brunoe, Alessia Napoleone, Ann-Louise Andersen, Kjeld Nielsen

Aalborg University, Denmark

The need for frequently adapting manufacturing systems to dynamic market demand, short product lifecycles, technology evolution, and sustainability requirements is increasingly challenging manufacturing companies. To this end, Reconfigurable Manufacturing Systems (RMSs) are relevant, however, still far from their wide implementation in industry. In this regard, a main barrier to the intro-duction of reconfigurability is the justification of investments in developing and purchasing reconfigurable systems and equipment. Often such reconfigurable systems have high initial investments that provide returns in the mid/long-term, while at the same time being subject to and dependent on high uncertainty in product and market evolutions. Thus, uncertainty in different aspects of demand and the time-horizon of evaluations are main aspects in evaluating the financial benefits of reconfigurability. Therefore, this paper investigates how different choices of financial evaluation parameters affect the financial feasibility of reconfigurable manufacturing compared to more traditional manufacturing concepts. The findings of the paper provide valuable insights on how practitioners should proceed in adequately capturing the value of reconfigurability during investment decisions.

An Industry-Applicable Screening Tool for the Clarification of Changeability Requirements

Alessia Napoleone, Ann-Louise Andersen, Thomas Ditlev Brunoe, Kjeld Nielsen

Aalborg University, Denmark

Manufacturing companies need changeability in order to adapt to change drivers, such as unpredictable market demand and increasingly relevant sustainability requirements. Specific change drivers determine different change-ability requirements, thus leading to the need for different changeability enablers. Therefore, before starting the identification and design of changeability enablers, companies should effectively identify their changeability requirements. In this study, an industry-applicable screening tool for the clarification of changeability requirements is proposed. The tool allows companies to discern whether they need flexibility or reconfigurability enablers. The tool has been validated with industry experts and is ready to be disseminated in industry.

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Economic Design of Matrix-structured Manufacturing Systems

Patrick Schumacher, Christian Weckenborg, Thomas S. Spengler

Technische Universität Braunschweig, Institute of Automotive Management and Industrial Production, Chair of Production and Logistics, Germany

Due to increasing product variety and uncertain demand for highly individualized products, a rising need for flexibility of manufacturing systems can be observed. In this context, the concept of matrix-structured manufacturing systems (MMS) has attracted increasing consideration. MMS aim to achieve high operational flex-ibility by implementing a flexible product flow between stations with automated guided vehicles and by providing redundant resources for each operation, thus eliminating constant cycle times and the serial arrangement of stations. This paper investigates the design of MMS pursuing an economic objective. We formulate a mixed-integer linear program for the design of MMS. Introducing a numerical example, we illustrate the effectiveness of our approach and derive future re-search opportunities.

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Regular session: Optimization of production and transportation systems

Time: Monday, 06/Sept/2021: 2:00pm - 4:00pm

Interactive Design Optimization of Layout Problems

Xiaoxiao Song[1], Emilie Poirson[1], Yannick Ravaut[2], Fouad Bennis[1]

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Layout optimization plays an important role in the field of industrial engineering. The layout problem presented here involves the real and virtual rectangular components. The real components can be the devices or buildings depending on the application. The space of accessibility associated with the real component is virtual, which allows the user to access the real component in reality, such as facility maintenance. However, most of the layout problems are NP hard. The great complexity of layout problems increase the difficulty in finding a feasible layout design in a reasonable time. To resolve these problems, we propose a hybrid constructive placing strategy which makes the search of feasible designs easier. The multi-objective application presented in this study demonstrates the effectiveness and portability of the method. Since the number of optimal layout designs can be very large, a cluster approach is followed to group all similar solutions. First, the notion of pairwise similarity indicator is introduced to analyze the similarity among the optimized layout designs. Second, the visualization of the hierarchical clustering of similarity matrix is customized. Then for each design, the user can interact with it by locally modifying the position or rotation of the component. The interactivity helps the user evaluate performance of the designs and preferable results are typically achieved.

A Fast and Efficient Fluid Relaxation Algorithm for Large-Scale Re-entrant Flexible Job Shop Scheduling

Linshan Ding, Zailin Guan, Zhengmin Zhang

Huazhong University of Science and Technology, Wuhan, China

In this paper, we study a large-scale re-entrant flexible job shop scheduling problem (FJSP) with the objective of makespan minimization. In the pro-posed problem, machine quantities, job types, and processes of jobs are known in advance. At least one machine is available for each process. The large production demand for each type of jobs leads to a large-scale manu-facture feature in this problem. To address the problem, we first establish a fluid model for the large-scale re-entrant FJSP. Then, we design a priority update rule to improve the assignment of jobs and machines. We finally pro-pose a fast and efficient fluid relaxation algorithm (FRA) to solve the large-scale re-entrant FJSP through the relaxation fluid optimal solution. Numerical results show that the FRA is asymptotically optimal with the increase of the problem scale. The scale of problems has little effect on the FRA's solving speed. Therefore, we conclude the FRA is suitable for solving the large-scale re-entrant FJSP.

Straight and U-shaped assembly lines in Industry 4.0 era: factors influencing their implementation

Marco Simonetto, Fabio Sgarbossa

Norwegian University of Science and Technology (NTNU), Norway

The increasing of products variety is moving companies in rethinking the configuration of their Assembly Systems (ASs). An AS is where the products are being configured in their different variants and its configuration needs to be chosen in order to handle such high variety. Two of the most common configurations are the straight-line and the U-shaped line. In this paper, we want to first determine and define, through a narrative literature research, which are the factors that are relevant in order to compare these two AS configurations. Additionally, with the advent of Industry 4.0 (I4.0) technologies it is possible that these new technologies have an impact on these factors. For these reasons, we investigated how I4.0 technologies impact these factors. The seven factors here defined open the opportunity for future research challenges.

Math Modeling to simultaneously make overtime and transportation decisions

Gursel Suer, Busra Cakmak

Ohio University, United States of America

The objective focuses on scheduling jobs to cells considering different transportation modes and overtime options. All jobs are scheduled and late jobs are not allowed. Three transportation modes are proposed: rail, ground, and air. Weekday and weekend overtime is allowed with different time additions. The profit for a scenario is calculated by subtracting production, transportation and overtime costs from revenue. A mathe-matical model is proposed to solve the problem. Lot splitting is allowed. The problem is more complex than usual scheduling problems in that we need to decide additional capacity requirements and transportation mode decisions at the same time we make scheduling decisions. Overtime option can be used but it brings additional costs to a company. Another potential solution approach is to continue using the available capaci-ty in regular time but then rush the product to the customers by using faster transporta-tion methods. Obviously, faster transportation methods are also costlier. The proposed mathematical model solves this problem where decisions about regular time produc-tion, overtime production, and transportation modes are simultaneously made to max-imize the overall profit. The results from different experiments are also reported.

Identification of superior improvement trajectories for production lines via simulation-based optimization with reinforcement learning

Günther Schuh, Andreas Gützlaff, Matthias Schmidhuber, Jan Maetschke, Max Barkhausen, Narendiran Sivanesan

WZL of RWTH Aachen University, Germany

An increasing variety of products contributes to the challenge of efficient manufacturing on production lines, e.g. in the Fast Moving Consumer Goods (FMCG) sector. Due to the complexity and multitude of adjustment levers, the identification of economic actions for improvement is challenging. Reinforcement learning offers a way to deal with such complex problems with little problem-specific adaptation. This paper presents a method for decision support for economic productivity improvement of production lines. A combination of discrete event simulation and reinforcement learning is used to identify efficient, sequential trajectories of improvements. The approach is validated with a fill-and-pack line of the FMCG industry.

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Digital Transformation of SME Manufacturers: The Crucial Role of Standard

Time: Monday, 06/Sept/2021: 5:15pm - 7:15pm

Proposing a Gamified Solution for SMEs' Use of Messaging Technology in Smart Manufacturing

Makenzie Keepers[1], Peter Denno[2], Thorsten Wuest[1]

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Small- and medium- sized enterprises (SMEs) face exceptional challenges in implementing smart manufacturing solutions. Specifically, SMEs often struggle with understanding advanced technologies well enough to implement them and reap the benefits. In this paper, we discuss one specific instance of this problem, namely implementation of data standards for effective business-to-business communications. We propose a possible solution to aid in lowering barriers for SMEs to access and apply technologies for data standardization, a vital part of effective business-to-business communications. Our solution takes a gamified approach by working to conceptualize the SMEs' data into a story with fill-in-the-blanks, similar to a Mad LibTM. We believe that the development and implementation of this tool would provide numerous benefits including, but not limited to, boosting morale, making new technology and standards more approachable, and improving the learning experience.

Developing Digital Supply Network's Visibility Towards Transparency and Predictability

Andreas M. Radke[1], Thorsten Wuest[2], David Romero[3]

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Despite advances in Industry 4.0 technologies, supply chains have fallen short in enabling agile supply chain responsiveness. Conceptually, the enablers of connectivity, visibility, and transparency are well defined, yet their operationalization remains a challenge. In this paper, we analyse a successful case study in the domestic electrical machinery industry and derive from it a proposal for data integration lifecycle phases and socio-technical domains to structure the challenges that need to be overcome as a prerequisite for digital supply networks' visibility towards transparency and predictability.

Analyzing the Impact Level of SMEs features over Digital Transformation: A case study

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Digital Transformation (DT) represents a real challenge for companies worldwide, not only because of its complexity due to technology's fast evolution, but also because of the lack of appropriate guidance. Available approaches are judged generic as they do not take into account the specific context of companies. In this sense, this work explores the influence of context in DT success and introduces a performance indicator to measure the impact of the company features that represent its specific context on the dimensions involved in a DT. As the second phase in a research project aimed to build a quantitative model that explains this relationship, this paper focuses on the application of the Impact Level (IL) factor in a real case scenario. The goal is to validate a previous theoretical analysis and also to identify changes in the results with a different characterization of company features. Relevant findings confirm the critical importance of Culture (f3) and R&D investment (f9) for DT success, but many differences arise from the comparative analysis that reveals the DT process as highly contextual. Future work will be focused on translating the insights of both studies into a quantitative model that pre-sents the IL as an aggregator but also with the possibility to provide enough detail for better decision-making during the DT process.

Strategic roadmapping towards Industry 4.0 for manufacturing SMEs

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In recent years, there is a growing focus on the role of small and medium-sized enterprises (SMEs), and their development towards Industry 4.0. One way of supporting SMEs in this effort, is by utilizing the method of strategic roadmapping. This article presents a) a theoretical framework for the use of strategic roadmapping towards industry 4.0, and b) insights from a validation of the framework in four pilots - Norwegian manufacturing companies.

The framework offers a systemic view of the company by focusing on five dimensions: business and strategy, product, customers and suppliers, production processes, and factory and infrastructure. Simultaneously, the frame-work offers a stepwise method to look at these five dimensions from a strategic perspective in a holistic way. The empirical data from the pilot companies offer insights on how the companies take up the strategic roadmapping method into their strategic operations, as well as which topics related to Industry 4.0 get integrated into their future vision, strategies and plans. The results indicate that the use of the strategic roadmapping method supports companies in seeing diverse routes towards Industry 4.0 and provides support in prioritizing relevant projects and activities.

Lean first … then digitalize: a standard approach for Industry 4.0 implementation in SMEs

Daryl Powell[1,2], Richard Morgan[3], Graham Howe[3]

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The digitalization of manufacturing is the essence of Industry 4.0 realiza-tion. Many large manufacturers have developed ambitious digitalization strategies, and most have taken the first steps towards digital transformation. Unfortunately, the same cannot be said for small and medium-sized enter-prises (SMEs). At the same time, SMEs contribute on average with more than 50% of the value to the economy in the European Union and with al-most 100 million employees, represent approximately 70% of the European workforce. This makes the onset of Industry 4.0 and the accompanying digi-talization of manufacturing a fundamental challenge for most SMEs, many of which already struggle to remain competitive in a rapidly evolving busi-ness climate. As such, in this paper, we aim to present an SME-friendly ap-proach to Industry 4.0 implementation. We share practical insights from three SME case studies that enable us to propose the lean first … then digi-talize approach to Industry 4.0 implementation in SMEs.

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Digital Transformations Towards Supply Chain Resiliency

Time: Monday, 06/Sept/2021: 5:15pm - 7:15pm

Liner Ship Freight Revenue and Fleet Deployment for Single Service

Jasashwi Mandal[1], Adrijit Goswami[1], Nishikant Mishra[2], Manoj Kumar Tiwari[1,3]

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For single-liner ship service, this study optimizes containerized cargo revenue minus ship operating costs. The decisions to optimize the ship fleet and shipment plan are included in this proposed model. This optimization problem is formulated as a mixed-integer non-linear programming model and solved it using LINGO. The proposed model is applied to a liner service route provided in the computational study and the results are analyzed in case of different scenarios of container shipment demand and different freight rates.

Cash-flow Bullwhip Effect in the Semiconductor Industry: An Empirical Investigation

Chintan Patil, Vittaldas Prabhu

Harold and Inge Marcus Department of Industrial and Manufacturing Engineering, The Pennsylvania State University, United States of America

Cash flow bullwhip effect (CFB) is the amplification of working capital variance along a supply chain. High CFB is a sign of inefficient working capital (WC) management and can lead to a significant reduction in financial resilience. CFB can be used as a measure of a company's ability to manage operational risks and corresponding resilience. We investigate the existence of CFB and the traditional bullwhip effect (BWE) in a sample of 238 semiconductor companies over 2010-Q1 to 2020-Q4. These companies' average CFB and BWE are 3.95 and 2.77, respectively. We find that CFB and BWE of a semiconductor company are negatively associated with company size, degree of seasonality in demand, and company's payment policy conservativeness; and positively associated with procurement and payment lead times.

Smart Integration of Blockchain in Air Cargo Handling for Profit Maximization

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Transportation and logistics management are critical to the economic growth of a country. Smart transportation is becoming possible thanks to the advancement of Internet of Things devices. To decrease the vulnerability of digitized systems from cyber-attacks, Blockchain has recently become one of the most commonly adopted technologies for free, decentralized, and trustworthy intelligent transportation networks. By analyzing the potential application of Blockchain technologies in the smart transportation of cargo by air, this study hopes to contribute to the area of logistics management. For efficient and safe air cargo movement, we propose a distributed Blockchain layered framework that helps in transforming air logistics operations in national and international trades and we validated our framework by mathematically comparing the cost with and without the implementation of Blockchain.

Digitization of Real-Time Predictive Maintenance for High Speed Machine Equipment

Rony Mitra[1], Mayank Shukla[2], Adrijit Goswami[1], Manoj Kumar Tiwari[2,3]

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In the recent decade, state-of-the-art techniques of maintenance in manufacturing firms have evolved. Redefining itself to come up with a whole new perspective by including a regime of digitization. From inter-compatibility to intra-network communication between hardware to highly interactive user interfaces have made the managing of necessary procedures extremely transparent. Even complex inclusions are easy to monitor following the current trends and digital transformation. Data generated through sources is big and unmanageable with a lack of filtering technologies to identify useful processable content. The proposed framework helps notify end-users by monitoring and identifying certain user-based settings and business functions. Suggested findings used machine learning (ML) algorithms surpass any previous claimed results. The modeling approach ensures consistent and reliable performance. Inclusive integration of notifying tools into trending smart devices has been tested and validated in this study. The coupling of multidiscipline open-source web-based technologies with minimum expense has been in focus for designing such applications. The best-identified set of tools that help enable the management of workflow multitasks, and their semantic arrangement through the latest state-of-the-art and scientific tools for generic work environments is covered in this study.

A Framework Integrating Internet of Things and Blockchain in Clinical Trials Reverse Supply Chain

Yvonne Badulescu, Naoufel Cheikhrouhou

Geneva School of Business Administration, University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Efficiency and resilience of the clinical trials supply chain are of particular prevalence in the current global context. The unique characteristic of the reverse logistics flow in the supply chains for clinical trials is the foundation for the digital transformation framework presented in this paper. This paper proposes a novel framework that integrates internet of things (IoT) and blockchain technology for the reverse logistics supply chain for clinical trials. The framework is implemented in a Contract Research Organisation operating clinical trials in Europe and North Africa and results are discussed. The main contribution of the proposed novel framework is the integration and interaction of both IoT and blockchain in a reverse logistics process.

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Engineering of Smart-Product-Service-Systems of the Future

Time: Monday, 06/Sept/2021: 5:15pm - 7:15pm

From Qualitative to Quantitative Data Valuation in Manufacturing Companies

Hannah Stein[1,2], Lennard Holst[3], Volker Stich[3], Wolfgang Maass[1,2]

[1]Saarland University, Germany; [2]German Research Center for Artificial Intelligence, Germany; [3]Institute for Industrial Management (FIR) at RWTH Aachen University, Germany

Since data becomes more and more important in industrial context, the question arises on how data-driven added value can be measured consist-ently and comprehensively by manufacturing companies. Currently, at-tempts on data valuation are primarily taking place on internal company level and qualitative scale. This leads to inconclusive results and unused opportunities in data monetization. Existing approaches in theory to de-termine quantitative data value are seldom used and less sophisticated. Although quantitative valuation frameworks could enable entities to trans-fer data valuation from an internal to an external level to take account of progress in digital transformation into external reporting. This paper con-tributes to data value assessment by presenting a four-part valuation framework that specifies how to transfer internal, qualitative to external, quantitative data valuation. The proposed framework builds on insights de-rived from practice-oriented action research. The framework is finally tested with a machine tool manufacturer using a single case study approach. Plac-ing value on data will contribute to management's capability to manage data as well as to realize data-driven benefits and revenue.

Integrating Failure Mode, Effect and Criticality Analysis in the Overall Equipment Effectiveness framework to set a digital servitized machinery: an application case

Claudio Sassanelli, Anna De Carolis, Sergio Terzi

Politecnico di Milano, Italy

Digital transformation and servitization have been merging in a coalescing par-adigm called Digital Servitization, changing not only companies' business mod-el but also their portfolio and thus their business. This hybrid paradigm is in-creasingly overwhelming manufacturing companies, compelling them to change their business model and provide more complex solutions to survive. Indeed, first a business model shift is needed (bringing to cope with organization-al/managerial aspects), and then a suitable new technology stack has to be im-plemented. In the extant literature it is not clear how companies can define which are the improvements to implement on Smart Connected PSSs. These modifications on the physical products, if flanked by a concurrent definition and structuring of data requirement on the database on the cloud, would also lead to a better comprehension of the solution functioning, enabling to know which are the causes leading to breakdowns and performance and quality losses during the use phase. To address this, the paper proposes a method combining the Failure Mode and Effect Analysis with the Overall Equipment Effectiveness frame-work.

Improving maintenance service delivery through data and skill-based task allocation

Roberto Sala[1], Fabiana Pirola[1], Giuditta Pezzotta[1], Mariangela Vernieri[2]

[1]University of Bergamo, Italy; [2]Balance Systems, Italy

Maintenance service delivery constitutes one of the most problematic tasks for companies offering such service. Besides dealing with customers expecting to be served as soon as possible, companies must consider the penalties they are incur-ring if the service is delivered later than the deadline, especially if the service sup-pliers want to establish long and lasting relationships with customers. Despite be-ing advisable to use appropriate tools to schedule such activity, in many compa-nies, planners rely only on simple tools (e.g., Excel sheets) to schedule mainte-nance interventions. Frequently, this results in a suboptimal allocation of the in-terventions, which causes customer satisfaction problems. This paper, contextual-ised in the Balance Systems case study, proposes an optimisation model that can be used by planners to perform the intervention allocation. The optimisation mod-el has been developed in the context of the Dual-perspective, Data-based, Deci-sion-making process for Maintenance service delivery (D3M) framework, which aims to improve the maintenance service delivery by making a proper use of real-time and historical data related to the asset status and the service resources availa-ble. The proposed model tries to cope with the current problems present in the company's service delivery process by proposing the introduction of a mathemat-ical instrument in support of the planner. Being strongly influenced by the con-textual setting, the model discussed in this paper originates from the D3M framework logic and is adapted to the company necessities.

The contracting of advanced services based on digitally-enabled product-service systems

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This paper uses an integrative literature review to explore the contracting of advanced services based on digitally-enabled product-service systems (PSS). The need for this study was derived from studies that have highlight-ed the difficulty of selling and buying advanced services with a digital ele-ment. Other studies confirmed that firms had challenges with obtaining the value expected from such advanced service contracts. The integration of dig-ital into a PSS value proposition increases the complexity and the potential application of advanced services. The emergence of digitally-enabled PSS (based on "Smart Products" in many cases) suggests a need to understand the sales and contracting process better. An integrative literature review was chosen, as the literature was fragmented between different fields. Forty-eight papers were selected as relevant, and 14 were then considered key to creating an initial model for the contracting process. It was identified that there were limited examples of contracts with high degrees of value-cocreation and that the ability of manufacturing firms to translate a value proposition successfully into a binding contract was weak. The contract ne-gotiation process was found to be well defined, yet the governance of such contacts over their duration was again weak. For these reasons, a model based on the lifecycle was proposed. The model should be further integrated into the contracting process for services. This is an initial study, and it is recommended that further research should test the model.

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A methodology to build a framework for collaboration performance assessment in PSS delivery

Mourad Harrat, Farouk Belkadi, Alain Bernard

Ecole Centrale de Nantes, France

Companies are more and more seeking for external partners in order to man-age new solutions at their development and use phases, especially when the type of these solutions is Product-Service Systems (PSS). PSS have some or-ganizational particularities which increase the complexity of collaboration processes. In this context, collaborating efficiently with the different partners is a key aspect to reduce the risk of failure of PSS projects, and is influenced by various organizational factors and practices. This paper proposes a meth-odology in four steps to build a decision-aid framework supporting collabo-ration assessment and management in the presented context. Important fac-tors and performance indicators are identified based on literature review and industrial practices. Then, Fuzzy techniques as well as decision trees are used to build the assessment systems. An exploratory case study is conducted to explain the different steps of the proposed framework, and analyzed in depth for the framework validation.

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Lean and Six Sigma in Services Healthcare

Time: Monday, 06/Sept/2021: 5:15pm - 7:15pm

Capacity Management as a tool for improving infrastructure in the Lean Healthcare: a systematic review

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The objective of this research is to identify work and practices that address capacity management in a health environment specifically in urgency and emergency areas where Lean Healthcare can be applied. We used the research method with systematic and bibliometric narrative review of articles on Lean Healthcare and Capacity Management, the method we sought to filter in publications with up to five years of publication and peer-reviewed articles. The systematic bases of the research were Emerald Insights, Periodical Capes, Scopus/Elsevier, Medline/PubMed, Web of Science. When seeking the same subject in health care environments i.e. in a Lean Healthcare environment, one is confronted with the scarcity of bibliographic material that addresses Capacity Management and, few that are found are with restricted access and most of the readings emphasize Patient Flow Management, Hospitalization Units, Capacity Management, Resource Allocation, Bed Occupancy Leveling, Queue Theory, Hospital Screening, Lean Methodology and Dynamic Health System Performance. This research differs from others because the topic of Capacity Management in a health environment is not used as in manufacturing industries. With this form of management, it is possible to generate activities that add more value to the infrastructure and control the service capacity, eliminating queues and bottlenecks in the health environment, thus contributing to an effective service through a continuous flow in the urgency and emergency of the UPAs-24h.

Kaizen & Healthcare: A Bibliometric Analysis

Sandro Alberto Vianna Lordelo[1], Sara Monaliza Sousa Nogueira[1], José Rodrigues Farias Filho[1], Helder Gomes Costa[1], Christiane Lima Barbosa[2], Robisom Damasceno Calado[3]

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The objective of this article was to map the state of the art, by means of bibliometric research, of how the scientific evolution of Kaizen has been occurring in theory, in practice and, especial-ly, in the health área around the world, in order to guide future research in the same, as, for example, kaizen has been contributing to humanization within health centers. A broad struc-tured search was performed using keywords and Boolean logic, in the PubMed, ISI and Scopus data bases. The identified publications were cataloged in EndNote and NVIVO 10 software for bibliometric analysis. Through these, 1,467 publications were identified, in the three databases, excluding the repeated publicatoins and those without relevant information. The main key terms identified and in common in all publications were: “manage-ment”, “lean”, “quality” and “kai-zen”; and the authors who publish the most were Van Aken, E.M., Farris, J. A., Suárez-Barraza, M.F. and Glover, W. J; and when kaizen applied to healthcare was evaluated, the most cited article among the 1467 selected was the “Lean in healthcare: The unfilled promise?”, by Radnor, ZJ, Holweg, M. and Waring, J., which has 316 citations in Scopus. It was evidenced that kaizen applied to health still has much potential to expand.

The benefits of deploying the Toyota kata

Gislayne Vieira Borges, Alexandre Beraldi Santos, Luiz Fernando Torres, Messias Borges Silvas, Gabriel Nascimento Santos, Robisom Damasceno Calado

Universidade Federal Fluminense, Brazil

The purpose of this article is to identify, through a theoretical, combined, descriptive and bibliographic research, carried out through a literature review, the benefits of the Toyota Kata implantation and routine. As these aspects are very specific, our results suggest that the main benefits found, in various contexts, are: construction of knowledge and organizational culture; impro-ving efficiency and reducing waste.

Toyota Kata when applied in its essence is an effective continuous improve-ment mechanism within organizations. Generating improvement in operatio-nal results, higher quality of services, growth in the volume of production, optimization of tasks and success in solving problems because it involves pe-ople, usually from different sectors of the organization, generating greater in-tra and extra sector engagement.

An Adaptive Large Neighborhood Search Method to Plan Patient's Journey in Healthcare.

Olivier Gérard[1,2], Corinne Lucet[1], Laure Devendeville[1], Sylvain Darras[2]

[1]MIS Laboratory, France; [2]Evolucare Technologies, France

In this paper an adaptation of the Adaptive Large Neighborhood Search (ALNS) to a patient's journey planning problem in healthcare is proposed. We formalize it as an RCPSP problem that consists of assigning a start date and medical resources to a set of medical appointments. Different intensification and diversification movements for the ALNS are presented. We test this approach on real-life problems and compare the results of ALNS to a version without the adaptive layer, called LNS. We also compare our results with the ones obtained with a 0-1 linear programming model. On small instances, ALNS obtains results close to optimality, with an average difference of 1.39 of solution quality. ALNS outperforms LNS with a gain of up to 18.34% for some scenarios.

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An ACO algorithm for scheduling problem in health simulation center

Simon CAILLARD, Laure Brisou-Devendeville, Corinne Lucet

Laboratoire MIS - Université de Picardie Jules Verne

SimUSant e is one of the biggest European simulating and training centers, proposing training sessions for all involed in healthcare: professionals, students, patients. This paper presents the timetabling problem encountered by SimUSant e with regard to the quality objectives and the time and resource constraints. To solve it, SimUACO-LS which is the hybridization of the Min-Max Ants Colony Optimization algorithm SimUACO with the variable neighborhood search SimULS [3], is presented. SimULS, SimUACO and SimUACO-LS are compared in a set of representative instances [2], newly generated and derived from those of the Curriculum-Based Course Timetabling problem [1]. SimUACO-LS always improves both results of SimULS and SimUACO by respectively 3.84% and 2.97%.

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Production Management in Food Supply Chains

Time: Monday, 06/Sept/2021: 5:15pm - 7:15pm

Application of hybrid metaheuristic optimization algorithm (SAGAC) in beef cattle logistics

Irenilza de Alencar Nääs, Marco Marco Antonio Campos Benvenga

Paulista University-Graduate Program in Production Engineering, Brazil

The study objective was to evaluate the performance of SAGAC in optimizing a linear mathematical model in whole variables to determine the most cost-effective solution in transporting cattle for slaughter. The model determines the choice of refrigerator truck, road (route), and an open truck in a scripting process. The tests performed with the SAGAC algorithm for optimizing the proposed model were compared with the results obtained, under similar conditions, by the branch-and-bound method for solving entire problems and solving a problem optimally. After the first twenty-two experimental trials, for comparison between the two methods, nine more experimental trials were carried out, with an increase in the degree of complexity, only with the SAGAC algorithm. The results obtained in the first twenty-two experimental trials demonstrate an equivalent performance between the two methods, showing that the SAGAC algorithm, even though it is not a technique that guarantees optimal results, in this case, was also able to find them. The nine final experiments performed only by SAGAC showed satisfactory results, with an evolutionary curve of exponential behavior.

Investigating the role of institutional frameworks in food waste reduction at the retailer interface in the European Union

Yvonne Rachael OWASI[1], Marco FORMENTINI[2]

[1]Audencia Business School, France; [2]DISI, University of Trento, Italy

The role of institutional frameworks in curbing and preventing food wastage cannot be overstated. Recently, policy makers have increased their interest in helping supply chain actors to reduce food waste by initiating policies at national and local level, but also opened questions on how such initiatives are affecting supply chain actors' practices towards sustainable food supply chains. Based on this concern, this study set out to investigate the role institutional frameworks have to play in tackling the problem of food wastage at the retailer-supplier interface within the European Union (EU). To this end, the study mainly focuses on the issue of food wastage in France by taking a look at the impact of the French food waste law on the retail-supplier activities and relationship.

This qualitative study underlines that the French food waste law has led to initiatives that are promoting circular economy and closed loop food supply chain, though the policies are being limited by behavioural aspects of actors along the food supply chains. Therefore, this research calls for a better understanding of behaviour of actors and collaboration along the supply chain through the use of information technology to have a full positive impact of the policy interventions towards sustainable production and distribution of food.

Predicting Exports using Time Series and Regression Trend Lines: Brazil and Germany Competition in Green and Roasted Coffee Industry

Paula Ferreira da Cruz Correia[1], João Gilberto Mendes dos Reis[1], Emerson Rodolfo Abraham[1], Jaqueline Severino da Costa[2]

[1]RESUP- Research Group in Supply Chain Management - Postgraduate Program in Production Engineering, Universidade Paulista, São Paulo, Brazil; [2]Agroindustrial Management Department, Universidade Federal de Lavras

Trade is essential for countries development. In Brazil, coffee has been one of the most important export items and by large is commercialized as a green or roasted bean. The aim of this article is to establish a prediction mode for coffee exports using time series and trend lines. To do so, we collected the exportation volume from the two main export countries in each segment: Brazil and Germany. A five-year forecasting was produced using regression curves provided by Microsoft Excel. Our results indicated that polynomial fits best and this function is consistent with agricultural production that is conditioned to edaphoclimatic factors.

Selecting the Sustainable Fresh Food Surface Transport Array Using Analytic Hierarchy Process

Irenilza de Alencar Nääs[1], Nilsa Duarte da Silva Lima[1], Manoel Eulálio Neto[2], Gilson Tristão Duarte[1]

[1]Paulista University-Graduate Program in Production Engineering, Brazil; [2]Centro Universitário Santo Agostinho, Teresina

The present study investigates the various arrays of the sectors involved in the logistic of fresh food transportation and distribution, considering the sustainability of the overall process, applying the AHP technique. The focus was on Brazil's fresh food distribution centers and how it is distributed in large cities. The criteria applied in two levels were selected from the literature, and the judgment was made by three experts using an online AHP plat-form. The final computation was considered the best array with a very high (90.4%) degree of agreement between the participants. The choice of Local food represented 72.1% in the concept of high sustainability. Choosing local foods must not be feasible in large countries or in countries that depend on food imports. However, for fresh food production, the local food production benefits go beyond economic costs, as it helps to reduce greenhouse gas emissions, improve the carbon footprint of consumers, encourage sustainable agriculture, and have the shortest traceability.

Digital Twin application for the temperature and steam flow monitoring of a food pasteurization pilot plant

Giovanni Paolo Carlo Tancredi, Eleonora Bottani, Giuseppe Vignali

University of Parma, Italy

In this paper, the development of a Digital Twin of a beverages pasteurization system for temperature monitoring, using NI Lab-VIEW control system toolkit which is composed by a set of probes connected to a cDAQ controller and a user-friendly software interface, developed via G-Code. A cyber-physical production system, composed of a real-time simulation tool and a controller, has been set up and tested on a pilot plant installed in a university laboratory. The paper shows how the software platform, together with the hardware, has been implemented in a traditional system, not (yet) ready for Industry 4.0 technologies, and therefore underlines the main issues occurred during its development. The aim of the Digi-tal Twin is to monitor the machine status, with a particular attention to the tem-perature reached by the service water and the required steam flow. To demon-strate the effectiveness of this system, a set of simulation and experimental tests has also been carried out.

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Regular session: Frameworks and conceptual modelling for systems and services efficiency

Time: Monday, 06/Sept/2021: 5:15pm - 7:15pm

Framework of the architecture of the communication process within Industry 4.0 oriented production system

Marek Fertsch, Michał Fertsch, Agnieszka Stachowiak

Poznan University of Technology, Poland

. Implementation of the Industry 4.0 concept requires changes on many lev-els. Implementation of technical solutions (ICT technologies, automation, robotization, AI) entails changes in the organization of processes, as well as in management and communication patterns. The article presents the con-cept of the IT system architecture supporting communication between the production planner and the production system in the enterprise. The aim was to develop a solution supporting and improving communication between a man and a machine. This area is important for the effectiveness, complete-ness and quality of information flow and the quality of decisions made on the basis of interpreted feedback. The solution presented in the article was developed as part of the study work on the preparation of the concept of re-organization of the company's production system during the preparation for the implementation of the Industry 4.0 concept. The analyzed enterprise manufactures single large-size machines. The technologies used include casting, machining and assembly. The analyzed production unit was the ma-chining department, as it was selected as a pilot department for the imple-mentation of Industry 4.0. The developed solution will be exemplary and will be the best practice to be used at the next stages of the implementation of Industry 4.0 in the enterprise.

A fuzzy risk analysis approach for using in concurrent engineering platform

mahmoud Shahrokhi[1], Alain Bernard[2]

[1]University of Kurdistan, Iran, Islamic Republic of; [2]Centrale Nantes (LS2N UMR CNRS 6004), Nantes, France

This paper uses the fuzzy theory basics to assess accident risk that may damage a target (e.g., humans, assets, or the environment). Converting a target's position to a membership degree in a fuzzy danger zone (FDZ) helps calculate risk indices. Using FDZs normalizes the effects of different kinds of hazards, similarly visualizes them, and lets to distinguish the impact of a threat on various types of targets. This paper presents a related mathematical formulation. The proposed approach evaluates the accident risks by simulating industrial activities in CAD, virtual reality, and augmented reality when using a concurrent engineering platform. This approach can calculate the risk index during a human task simulation and through real-time human interaction with a virtual machine during safety analysis and training. The results also are credible to activate alarm systems according to the operator's limbs place during work. The model provides a normalized and similar scale for various risks (e.g., biological, chemical, and physical hazards) and computes the effect of danger on different target types.

Service Capability Ontology

David Görzig, Thomas Bauernhansl

Fraunhofer IPA, Germany

Digitization is transforming previously physical products into holistic product-service systems which open up opportunities for new business models. But to achieve an excellent customer experience, a use case-specific configura-tion of the extensive product-service systems is necessary. One possible approach for the efficient implementation is to modularize the systems. In digital product-service systems, these modules require a holistic view that includes physical and digital resources as well as processes and people. The construct of capability might be a suitable framework to define such modules purpose-based and to man-age the configuration. However, capabilities are not sufficiently defined in the literature and are, therefore, hardly ever used in practice. The aim of this paper is to create a common understanding of the term capability in the context of prod-uct-service systems with the help of an ontology.

Guideline to development smart service business models for small and medium sized enterprises

Mike Freitag[1], Christian Schiller[1], Oliver Hämmerle[2]

[1]Fraunhofer IAO, Germany; [2]Universität Stuttgart

The shift from product-oriented to service-oriented business requires a rethink, espe-cially in traditional companies in the mechanical and plant engineering industry. This guideline for the development of Smart Services business models is intended to illus-trate the complexity and thus improve their handling, supporting the planning and modelling of a Smart Service. The focus of this paper is to introduce a step-by-step model to develop business models for small and medium sized enterprises in the manufacturing industry and on the selection of suitable service business model pat-terns. Therefor it will show alternative service business model patterns and at the end to select the right one. This is an important process before starting smart service engi-neering.

Conceptual approach to product development process based on supply chain concepts

Joanine Facioli Urnau[1,2], Osiris Junior[1], Alda Yoshi Uemura Reche[1], Anderson Luis Szejka[1], Arthur Beltrame Canciglieri[1]

[1]PUCPR - Pontifical Catholic University of Paraná, Brazil; [2]Boticário Indústria de Cosméticos – Boticário Group

There is currently a trend in the Product Development Process (PDP) and Supply Chain (SC) to make this relationship closer and more fluid, present-ing a difficulty due to the complexity involved. The complexity of innova-tion projects can be even more demanding, especially due to the need to launch them in shorter and more assertive terms in the current context of in-dustry 4.0, in which global networks are emphasized in the exchange of in-formation. Given this context, this article aims to conduct a systematic re-view of the literature exploring the relationship between the PDP and SC. In this way, it was possible to propose a new approach contemplating the con-ception of the product development process combined with the concepts of the supply chain, such as support for the design and conception of product packaging from an industry in the cosmetics sector. As a result, it was possi-ble to contribute to the existing gap between the integration of these two re-search areas.

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Sustainability in Production Planning and Lot-Sizing

Time: Monday, 06/Sept/2021: 5:15pm - 7:15pm

A partial nested decomposition approach forremanufacturing planning under uncertainty

Franco Quezada[1,2], Céline Gicquel[3], Safia Kedad-Sidhoum[4]

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We seek to optimize the production planning of a three-echelon remanufacturing system under uncertain input data. We consider a multi-stage stochastic integer programming approach and use scenario trees to represent the uncertain information structure. We introduce a new dynamic programming formulation that relies on a partial nested decomposition of the scenario tree. We then propose a new extension of the recently published stochastic dual dynamic integer programming algorithm based on this partial decomposition. Our numerical results show that the proposed solution approach is able to provide near-optimal solutions for large-size instances with a reasonable computational effort.

An Integrated Single-Item Lot-Sizing Problem in a Two-Stage Industrial Symbiosis Supply Chain with Stochastic Demands

Cheshmeh Chamani[1,2], El-Houssaine Aghezzaf[1,2], Abdelhakim Khatab[3]

[1]Ghent University, Belgium; [2]Flanders Make, Belgium; [3]Lorraine University, France

We consider a two-stage supply chain in which two production plants are collaborating in an industrial symbiosis to satisfy their respective stochastic demands. We formulate the production planning problems of these two plants as an integrated capacitated lot-sizing problem, in which the second production plant uses as an alternative raw material a by-product obtained as a residue from the production of the first plant. The goal is to minimize the overall total cost in the supply chain, including production and inventory of the final product and by-product transfer costs, while meeting the stochastic demands. First, a natural formulation of the problem is proposed, and is solved using the Sample Average Approximation (SAA) method. The analysis of the gaps exhibits however quite large optimality gaps. To improve these optimality gaps, a plant location like reformulation for this integrated lot-sizing problem is developed. The analysis has been carried out again to evaluate both formulations' performances in terms of the optimality gaps and computational times, both when items demands follow Gamma and Normal distributions.The analysis indicates that despite having a computational time of on average 1.7 times higher than the main formulation, the plant location reformulation provides better optimality gaps on average 22% improved and better ranges for upper and lower bounds under stochastic demands.

A Lot-Sizing Model for Maintenance Planning in a Circular Economy context

Ernest Foussard[1,2], Marie-Laure Espinouse[1], Grégory Mounié[2], Margaux Nattaf[1]

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The transition towards Circular Economy is a crucial issue of European environmental policies. It requires a complete overhaul of production systems, intending to improve product lifecycles and reduce the ecological footprint. In this context, maintenance is key to extend the products durability. This study addresses maintenance planning optimization within the Circular Economy framework.

An original lot-sizing model for tactical maintenance planning on a single-machine with multiple components is presented. Notable features of this model takes into account components health index and global budget on the environmental impact. The computational limits of the model and the impact of the budget constraint are assessed through experimentations.

Three-phase method for the capacitated lot-sizing problem with sequence dependent setups

François Larroche[1,2], Odile Bellenguez[1], Guillaume Massonnet[1]

[1]IMT Atlantique; [2]VIF Software

This paper focuses on an industrial lot-sizing and scheduling problem that arises in the food industry and includes lost sales, overtimes and sequence-dependent setups on parallel machines. We propose a preliminary version of a three-phase iterative approach to optimize separately the affectation, the sequencing and the production of items. Our first numerical results suggest that with some additional improvements, this approach could be use in real-life by planners to reduce their costs.

Optimization for lot-sizing problems under uncertainty: a data-driven perspective

Paula Metzker[1], Simon Thevenin[1], Yossiri Adulyasak[2], Alexandre Dolgui[1]

[1]IMT Atlantique, France; [2]HEC Montréal

In a manufacturing context, the lot-sizing problems (LSP) determine the quantity to produce over a planning horizon. Often, the parameters used in the LSP models are unknown when the decisions are made, and this uncertainty has a critical impact on the quality of the decisions. However, the large amount of data that can nowadays be collected from the shop floor allows inferring information on the LSP parameters and their variability. Therefore, a recent research trend is to properly account for the uncertainty in the LSP optimization models. This work presents a survey on data-driven optimization approaches for the LSPs. We also provide a comparison of some promising optimization methodologies in the context of data-driven modeling of LSPs.

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Finance-Driven Supply Chain

Time: Tuesday, 07/Sept/2021: 12:00pm - 2:00pm

Financing and Cost sharing for a Supply Chain under CSR - sensitive demand

Franck MORAUX, Dinh Anh Phan, Thi le Hoa Vo

Université de Rennes 1, CNRS, CREM UMR6211, France

Downstream firms nowadays adopt either financing or cost sharing (CS) mechanisms to enhance the corporate social responsibility (CSR) performance of their suppliers. In this paper, we are interested in combining these two mechanisms in a supply chain. We consider a supply chain where the demand is CSR-dependent and where a large retailer shares the costs of CSR activities undertaken by a SME supplier. We investigate how the retailer's choice of two financing mechanisms, namely Bank Financing (BF) and Reverse Factoring (RF), can influence the various operational decisions of both parties and the performance of the supply chain. Our findings demonstrate that no matter which financing mechanism is applied (BF or RF), CS leads to higher CSR effort and higher profits for all supply chain members. Moreover, a CS contract affects the financing preferences of both the retailer and the supplier. Managerially, a CS contract combined with an appropriate financing mechanism help to improve the CSR performance and the profita-bility of a supply chain.

An EOQ-based lot sizing model with working capital requirements financing cost

Yuan BIAN[1], David Lemoine[2,4], Thomas G. Yeung[2,4], Nathalie Bostel[3,4], Vincent Hovelaque[5,6], Jean-Laurent Viviani[5,6]

[1]University of Chinese Academy of Sciences, China, People's Republic of; [2]IMT Atlantique; [3]Universit´e de Nantes; [4]LS2N UMR CNRS 6004; [5]IGR-IAE of Rennes, University of Rennes 1; [6]CREM UMR CNRS 6211

In time of financial crisis, bank loans are often extremely difficult to obtain for many companies. However, companies always need free cash flow to efficiently react against to any uncertainty. This work demonstrates the impact of financial consequences on operational decisions in the single-product, single-level, infinite capacity EOQ model. We propose an operation-related working capital requirement (WCR) model in a tactical planning context. The classic EOQ model is extended by integrating the WCR financing cost with a cost minimization objective and deriving its analytical solution. Compared with the optimal policy of the classic EOQ model, our approach leads to a new policy with a smaller production lot size due to the new cost trade-offs. Furthermore, an analytical analysis with a classic EOQ-based formula that considers the cost of capital demonstrates the sensitivity of approximating financial costs compared to our exact approach. Finally, sensitivity analysis is provided.

Put option contracts in Newsvendor Model with bankruptcy risk

Pooya HEDAYATINIA[1], David Lemoine[2], Guillaume Massonnet[2], Jean-Laurent Viviani[1]

[1]Universite de Rennes 1-IGR-IAE; [2]IMT Atlantique

This paper studies a newsvendor problem in which the retailer can mix two contracts, a wholesale price and a put option contract. We consider that the newsvendor is financially constrained and may need to contract a loan to cover her ordering costs, with a probability that she becomes bankrupted. We show that when a put option contract is available, the retailer's order quantity increases, while the bankruptcy risk and therefore the loan's interest rate decrease. We illustrate these results with numerical experiments on a simple example for different demand sizes and variability.

Integrated Business Planning Process: Link between supply chain planning and financial planning

Mohamed Haythem Selmi[1], Zied Jemai[2], Laurent Gregoire[1], Yves Dallery[1]

[1]Industrial Engineering Laboratory, Centralesupelec, University of Paris Saclay, France; [2]LR-OASIS, National Engineering School of Tunis, University of Tunis El Manar, Tunis, Tunisia

In this paper, we explore the interactions between supply chain planning and financial planning. To do so, we investigate the integrated business planning (IBP) process as a suitable interface between them. We focus on the French business culture. First, we provide the results and conclusions of a survey on the structure and details of the sales and operations planning (S&OP) pro-cesses of five top French multinational corporations and the extent to which finance is integrated into these processes. These companies have achieved a revenue of over 16 billion euros in 2020. Then, we conclude on the steps that the participating companies have implemented to transition from the tra-ditional S&OP process to the complete IBP process, and thus on the steps that remain to be taken. We note that all participating companies have taken their first steps towards adopting an integrated business planning approach. They have all embraced scenario analysis. However, they are lagging behind on the other steps that require cross-functional and cross-company collabora-tion, such as financial integration. Finally, we define how the IBP process in-teracts with financial planning on four fronts, namely revenue and costs budgeting, monthly updates to budgets, capital expenditures budgeting, and working capital requirements planning.

Pricing Decisions for an Omnichannel Retailing under Service Level Considerations

Minh Tam Tran[1,2], Yacine Rekik[1], Khaled Hadj-Hamou[2]

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An increasing number of retailers are presently moving to omnichannel configurations and embracing modern innovations to integrate the physical store and the online store to provide customers a comprehensive shopping experience. We develop a classical newsvendor model where a retailer buys items from a supplier and distributes them through two market segments, online vs. offline. We seek optimal prices for the product in the two channels under the newsvendor model with a single period, price-based stochastic demand, and cycle service level-based order quantity to maximize the retailer's profit. Motivated by market share models often used in marketing, we focus on a demand model involving multiplicative uncertainty and interaction between the two sales channels. The pricing problem arising is not to be well behaved because it is difficult to verify the joint concavity in prices of the objective function's deterministic version. However, we find that the objective function is still reasonably well behaved within the sense that there is a unique solution for our optimal problem. We observe such a situation through the visualization graphs in bounded conditions for prices and find the approximate optimal point.

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Gastronomic Service System Design

Time: Tuesday, 07/Sept/2021: 12:00pm - 2:00pm

Geospatial Intelligence for Health and Productivity Management in Japanese Restaurants and Other Industries

Takeshi KURATA

National Institute of Advanced Industrial Science and Technology (AIST), Japan

Health and Productivity Management (HPM) requires simultaneous improvement of labor productivity and Quality of Working (QoW), which consists of health, workability, and rewarding. In order to deal with a wide range of issues for HPM, engineering approaches are much more effective rather than just relying on experience and intuition. First, this paper outlines Geospatial Intelligence (GSI) as a tool for such engineering approaches, which supports problem solving by linking geospatial data with other data. Next, we summarize use cases of GSI in service and manufacturing sites, including Japanese restaurants, which have addressed labor productivity and QoW. Finally, we extract the metrics regarding labor productivity and QoW used in those use cases.

Digital Ordering Improves Labor Productivity in Multiproduct Restaurants

Takeshi Shimmura[1], Syuichi Ohura[2]

[1]Ritsumeikan University, Japan; [2]Ganko Food Service co. ltd.,

This study assessed a digital ordering system (DOS) for use in a multiproduct Japanese cuisine restaurant to enhance labor productivity. La-bor productivity of restaurants is lowest among Japanese service industries. After DOS is introduced, restaurant operation processes were changed: order receiving duties are allocated to the DOS, not staff members; also, the num-ber of dishes for preparation is decided based on the DOS promotion con-tents. Thereafter, restaurant managers can change the work schedule to re-duce the total labor hours necessary for operations. Work hours and sales per labor hour measured before / after DOS introduction are recorded as a KIP showing productivity improvement. Results show that DOS introduction reduces labor hours, but increases sales per labor hour. However, the system should be improved to provide greater utility for customers. Moreover, DOS has no character size expansion function. Therefore, elderly customers have difficulties caused by poor vision. Also, DOS does not show all menus to-gether. Therefore, customer selection of dishes to order can take some time and effort.

A Study on Menu Planning Method Considering the Variation in Menu Orders - Application to daily foods in a company cafeteria -

Ruriko Watanabe[1], Nobutada Fujii[1], Daisuke Kokuryo[1], Toshiya Kaihara[1], Kyohei Irie[1], Kenji Yanagita[2], Kenichi Harada[2]

[1]Kobe Universtiy, Japan; [2]TMES Corporation

It is a problem that dietitians have a shortage of labor and a large amount of work per person. The work of a dietitian includes menu planning, ordering meals, nutritional guidance, etc. Among them, menu planning is an im-portant work. Menu planning is an advanced work that considers dietitians adjustment, safety and economic efficiency based on basic knowledge such as cooking combination, food combination, appropriate amount for one-person, seasoning ratio, cooking method, etc. It is thought that reducing the burden on menu planning will lead to more efficient work for dietitians. The subjects for which a dietitian makes a menu plan are classified into managed meals such as those provided at hospitals and daily meals provid-ed to healthy people in a company cafeteria. This paper proposes a menu planning method that meets the requirements for menu plans for regular meals in the company cafeteria, which has more constraints than managed meals and is a complicated problem. The menu planning is optimized by a DGA (Distributed Genetic Algorithm) using an evaluation function that expresses the variations in menu orders.

Forecasting the Number of Customers Visiting Restaurants Using Machine Learning and Statistical Method

Takashi Tanizaki[1], Shunsuke Kozuma[1], Takeshi Shimmura[2]

[1]Kindai University, Japan; [2]Ritsumeikan University, Japan

In this paper, it is proposed the forecasting of the number of customers visiting restaurants using machine learning and statistical method. There are some researches on forecasting the number of customers visiting restaurants. Since the beginning of last year, the number of customers visiting restaurants has plummeted due to COVID-19. A machine learning-based approach can be applied to forecast something including stable trends. Therefore, in this paper, machine learning that incorporates the moving average method is proposed to reflect the latest fluctuation trend. Furthermore, a forecasting method using deep learning is proposed to improve forecasting accuracy. In the method using deep learning, the analysis results on the normalization of training data and the contribution of meteorological data to the forecasting accuracy are described. It was found that the introduction of the moving average into the explanatory variables is effective when the trend of the number of customers visiting fluctuates rapidly. It was also found that normalization for each year of training data is effective when the annual average number of customers visiting restaurants increases or decreases monotonically.

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Systems engineering analysis for cooking recipes from the perspective of work instructions

Tomomi Nonaka[1], Kaoru Kamatani[1], Nobutada Fujii[2]

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In this paper, we focus on the labor-intensive human cooking process and analyze cooking recipes using systems engineering techniques. The purpose of this is paper to help analyze the impact of specifying cooking recipes from the perspective of work instructions on the reproducibility and devel-opment of food. Specifically, we use as an example the recipe for "Fuhafuha Tofu," which appears in number 21 of the cookbook "Tofu Hyakuchin" published in the Edo period between 1603 and 1868 in Japan. We focus on the ambiguity of the description method in this cooking recipe. First, we ex-tract expressions that are described as explicit textual information in the cooking recipe. Next, we analyze the information containing the ambiguity described in the cooking recipe and the information that is not directly de-scribed. These are assumed to be information containing ambiguities that can be inferred from the context even without being instructed when the operator performs the cooking task. We will take the specifications of mod-ern cooking recipes and compare and analyze how they are written from the perspective of work instructions.

Engineering Large Event Catering Services

Kai-Wen Tien, Vittaldas V. Prabhu

The Pennsylvania State University, United States of America

In the United States, catering services constitute about $8.6 billion annually. The main objective in managing large catered events is centered around ensuring good customer satisfaction while minimizing food wastage. Achieving this management objective is challenging because of some of the key characteristics of such service systems such as long setup time, time-varying demand, and complex customer food preferences. Industry practice heavily relies on the experience of individuals with little use of model-driven decision-making for planning such events. This paper takes a service system engineering approach for event catering by developing an analytical framework for decision-making by event planners to determine kitchen capacity, temporary storage capacity for warmers, and staffing level for buffet service. The proposed model is distribution-free and provides intuitive visualization for decision-making. As a practical case study, the model is applied to a large catered event with an attendance of about 10,000 over three hours.

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Modern scheduling and applications in industry 4.0

Time: Tuesday, 07/Sept/2021: 12:00pm - 2:00pm

An Approximation Algorithm for the k-Connected Location Set Cover Problem with Color-spanning Constraint

Yin Wang[1,2], Yinfeng Xu[1,2]

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Motivated by the need for a more sensitive server assignment strategy in supply-chain network management, our total cost comprises coverage area (i.e., disk) sizes and ``moving'' service modes that facilitate multiple and flexible demand fulfillment. Selection of k color-spanning centers to achieve cost minimization is the aim of our k-Connected Location Set Cover Problem with Color-spanning Constraint (k-CLSCPCC). The cost reflects the sum of the radii of the color-spanning disks plus the cost of connecting to disk regions. The farthest-color Voronoi diagram(FCVD) helps to assign an individual radius to each selected color-spanning center with aims to minimal cost. The main idea behind our greedy algorithm, which integrates the ideas of the classical minimum-power coverage problem and k-maximum coverage problem, is to minimize the measurable gap between the cost of connecting all nodes and the reduced cost of coverage with k disks. Our proposed algorithm can approximate a 3.368-factor solution within O(n^2 m log m) running time, equal to time cost of generating FCVD, where n is the number of input nodes and m is the number of demand types.

Charging Scheduling Optimization of Battery Electric Bus with Controllable Task Completion

Feifeng Zheng[1], Zhixin Wang[1], Yinfeng Xu[1], Ming Liu[2]

[1]Donghua University, China, People's Republic of; [2]School of Economics & Management, Tongji University

In order to reduce carbon emissions, various government organizations have taken measures to promote the development of electric vehicle industry. Motivated by scheduling practices, this work proposes a battery electric bus (BEB) charging scheduling problem. Different from the existing research on scheduling, the completion level of each task in this problem is controllable, because the charging level of BEB can be controlled. Besides, for saving charging cost, bus companies usually charge their battery electric buses (BEBs) at night. Due to the concentration of charging time, the decision-maker must make charging scheduling decision under a given departure schedule to ensure charging without any delay. For solving this problem, we first establish a linear programming model with the objective of minimising the total electricity cost and battery loss cost. Numerical experiments demonstrate the electiveness of the proposed model.

Multitasking Scheduling Problem with Uncertain Credit Risk

Feifeng Zheng[1], Zhaojie Wang[1], Yinfeng Xu[1], Ming Liu[2]

[1]Donghua University, China; [2]Tongji University, China

Parallel machine scheduling problem in multitasking environment plays an important role in modern manufacturing industry. Multitasking is a special scheduling method, in which each waiting job interrupts the primary job, causing an interruption time and a switching time. The existing literatures discuss the problem of multitasking scheduling, however, few studies consider credit risk into such a realm of scheduling models. In this work, we combine customer credit risk (or payment probability) into a multitasking scheduling problem. Besides, due to the existence of credit risk and the constraint of deadline of each accepted job, we also consider the job rejection into this problem. To hedge against the worst-case performance (total profit in the worst-case), we then propose a robust stochastic mathematical model with the objective of minimising the maximum difference between total job rejection cost and total revenue. Since commercial solvers cannot directly solve this robust stochastic programming model, a SAA approximate model is proposed to further solve this problem. Numerical experiments are conducted to demonstrate the effectiveness of the proposed SAA approach.

Parallel machine scheduling with stochastic workforce skill requirements

Xin Liu, Ming Liu

Donghua University, China, People's Republic of

In the context of Industry 4.0, both of the ability to handle unexpected events and personalization customization are emphasized. This work investigates a parallel machine scheduling problem with uncertain skill requirements. The problem involves a two-stage decision-making process: (i) determining the workers' skill training plan and the number of opened machines on the first stage before the realization of uncertain skill requirements, and (ii) scheduling jobs and assigning workers to jobs on the second stage, under known skill requirements. The objective is to minimize the expected total cost, including the workers' skill training cost, machine opening cost and the expected penalty cost of jobs' tardiness. A two-stage stochastic programming formulation is proposed, and an illustrative example shows the applicability of the model.

A MILP model for the scheduling of a multiproduct tree-structure pipeline network in mining industry

Meryem Bamoumen[1], Selwa Elfirdoussi[1], Libo Ren[2], Nikolay Tchernev[2]

[1]EMINES School of Industrial Management, Université Mohammed VI Polytechnique, Maroc; [2]Clermont Ferrand University, France

The scheduling of multiple products through pipelines, to meet a demand over a considered time horizon, is a challenging problem that many research-ers have been interested in. Although pipelines are considered mainly in the petroleum industry, they can also be used in other industries. This paper deals with the multiproduct pipeline network scheduling problem in the con-text of mining industry. The objective is to schedule a sequence of batches, to be transported through the pipeline network, to ensures all product de-mand, while respecting the different technical constraints. The proposed ap-proach is a MILP model with a continuous representation of time and batch volume. It provides maximizes the volume of batches to satisfy all product demands. The model was tested using different instances over a short-term horizon.

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Regular Session: Green production and circularity concepts

Time: Tuesday, 07/Sept/2021: 12:00pm - 2:00pm

Developing a qualitative maturity scale for circularity in manufacturing

Federica Acerbi[1], Vafa Järnefelt[2], Jorge Tiago Martins[2], Leila Saari[3], Katri Valkokari[4], Marco Taisch[1]

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Circular Economy (CE) is gaining momentum and its diffusion in manufac-turing companies remains a key element to be addressed. Indeed, the princi-ples and practice of circularity can enhance sustainability in the manufac-turing sector, but changes are required in organizations in order to fully em-brace this paradigm. Therefore, several assessment models have been pro-posed to quantitatively measure CE performance, yet covering niche as-pects, whereas a holistic perspective is usually neglected. In addition, there is significant scope to improve the elements composing the big picture through delineating where possible improvements might occur and this can be provided through an evaluation of the current status of a manufacturing company in respect to the optimum or reference model. Therefore, the goal of this contribution is to create the building blocks for a maturity model as-sessment proposing a complete and exhaustive maturity scale supporting companies in clarifying strategic objectives towards circularity in manufac-turing. This goal has been achieved through a review of the scientific litera-ture and a validation exercise performed through two workshops in which practitioners and researchers have been involved. This mixed-methodology allowed to strengthen the results obtained.

Business Models in Circular Economy: A Systematic Literature Review

Beatrice Colombo, Paolo Gaiardelli, Stefano Dotti, Albachiara Boffelli

University of Bergamo, Italy

Scientific literature lacks a comprehensive and extensive overview of business models built upon circular economy principles. Based on this premise, this paper performs a systematic literature review, through which it aims at iden-tifying and then categorizing circular business models processed in the literature to date. Fifteen circular business models are identified and analysed. The results show that circular business models can be associated with different circular strat-egies, but that some are more studied than others. The research also indicates that each circular business model can be associated with one particular life cycle stage of a product-service, thus making it more suitable for a specific circular strategy.

Industry 4.0 Driven Quantitative Methods for Circular Supply Chains: A Bibliometric Analysis

Biman Darshana Hettiarachchi[1], Stefan Seuring[1], Marcus Brandenburg[1,2]

[1]Chair of Supply Chain Management, University of Kassel, Germany; [2]School of Business, Flensburg University of Applied Sciences, Germany

The Industry 4.0 (I4.0) concept comprises advanced digital technologies that facilitate the digitally enabled sustainability approach leading to a Circular Economy (CE). I4.0 driven CE initiative leads to a paradigm shift in supply chain management (SCM), where quantitative methods provide practical solutions to issues that arise when adopting circular practices. Therefore, the intersection of I4.0, CE, SCM and quantitative methods has been identified as an upcoming area worthwhile investigation. Hence, we conduct a bibliometric analysis on extant literature to visualise and unravel the current scholarly discussion while providing insights to the scholars and practitioners who pursue the current dynamics, trends, prospects pertaining to the intersection mentioned above.

Rethinking Circular Business Models: The Role of the Learning Factory

Maria Flavia Mogos[1], Sigurd Sagen Vildåsen[1,2], Johanne Sørumsbrenden[1], Daryl Powell[1,2]

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There is a need for both increased knowledge and for effective solutions in the transition from linear to circular business models. Circular hubs are increasingly regarded by academia and policy makers as facilitators of circularity in industry. This paper investigates how a circular hub can better integrate circular economy principles into existing business models, through conducting case study research where we analyse 16 months of data about a circular hub, which appeared to effectively aid the participants both in the transition towards the circular utilisation of resources and the pursuit of Sustainable Development Goals. The case is a circular hub for the reuse, repair, remanufacture and repurpose of furnishing in Norway. The findings of this paper include a framework for the assessment of the impact of circular hubs on existing business models, as well as the following facilitators: (i) organising the circular hub as a learning factory for pupils and other stakeholders in collaboration with local schools, (ii) the municipality coordinating the learning factory, (iii) researchers ensuring that high-level concepts of circularity are explored by the stakeholders, and (iv) public financial support. Proposed avenues of future research include investigating the role of network action learning principles and methods in achieving higher circularity and hub maturity levels.

Crop selection and scheduling for green production with intercropping and rotation

Canan Pehlivan[1], Thomas G. Yeung[2], Aline S. A. Munguia[2]

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In this study, we address a crop selection and scheduling problem employing two cropping systems, crop rotation and intercropping, simultaneously on a given parcel of land. Moreover, we also consider other ecological practices such as the use of fallow and green manure. We propose a 0-1 linear programming model to maximize revenue by determining the optimal combinations of crops in space (crops to be planted as neighbors) and in time (crop rotation schedule) while meeting the yearly demand of each crop. A realistic numerical example is presented to demonstrate the performance of the model.

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Regular session: Optimization of supply chain agility and reconfigurability

Time: Tuesday, 07/Sept/2021: 12:00pm - 2:00pm

An Approach to Assess Risks related to Information System in Supply Chain

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Capgemini Engineering, France

On one hand, no one can deny the importance of the information system in today's industrial and logistic activities. The progress in IT tools and systems allowed to process real-time data giving the opportunity to enhance considerably the manage-ment of production and transportation operations. On the other hand, supply chain digitalization is a sensitive process that can generate increased risks for the compa-nies' activities. Therefore, such risks should be identified and managed. In this study, we follow Failure Mode, Effects, and Criticality Analysis (FMECA) approach to assess the risk linked to the information system of supply chains. We also present the methodology and choices adopted to apply this study in an aeronautical supply chain case.

Supplier selection by using the goal programming approach

mahmoud Shahrokhi[1], Zahra Sobhani[2], Alain Bernard[3]

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Supplier selection problems have been considered widely in literature; however, considering the availability and reliability of the products provided by suppliers has been investigated less. In this regard, the presented work addresses a supplier selection problem in which the reliability of the parts is one of their main factors for supplier selection. This paper develops a multiobjective mathematical goal programming model to allocate the system's components orders to the suppliers. The model minimizes the system construction costs and maximizes the probability of working the system in nominal and half capacity. The similarity of the or-dered components affects their delivery lead times and prices. The model determines the optimal solution for an industrial system composed of 4 parts. The proposed approach includes using the reliability block diagram to develop the Markov chain model. A multiobjective binary nonlinear mathematical program uses the Markov model to select the optimal components suppliers. Solving the model by goal programming approach provides the possibility of reflecting the decision-maker opinion relative to the construction cost's importance compared to system availability.

Using an Auction-based System in Cloud Manufacturing for Selecting Manufacturing-as-a-Service Providers

Kelvin Sparr, Damian Drexel, Ralph Hoch

FH Vorarlberg, Austria

The shift towards mass customization in production and technological advancements lead to new manufacturing paradigms. Such paradigms facilitate the distribution of production to distributed companies, located all around the globe, essentially creating a cloud-based manufacturing platform. In such a system, manufactures may provide their production facilities as services to others -- leading to the paradigm of Manufacturing-as-a-Service (MaaS). One major challenge in MaaS is the discovery of manufacturing resources and the distribution of orders to them. We propose an ontology based template matching method to find fitting manufacturing resources. Based on this selection we introduce a multi agent-based auction system for distributing orders and production planning. To illustrate its practical applicability we integrated the proposed approach in an existing cloud manufacturing platform.

Modularity metric in Reconfigurable Supply Chain

Slim ZIDI[1,2], Nadia HAMANI[2], Lyes KERMAD[1]

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Confronted with an increasingly uncertain and fluctuating economic environment characterized by a technological evolution driven by industry 4.0 concepts, companies have to adapt their supply chains in order to improve its competitiveness. They must also implement strategies that allows them to deal with these new challenges. Supply chain modularity offers the opportunity to change and reorganize the structure of the supply chain to meet changing market needs. In this paper, we propose a new framework to design a modular supply chain using Design Structure Matrix and a modularity measurement in Reconfigurable Supply Chain. We also show the importance of integrating the direction of flows, i.e. inbound and outbound flows in the calculation of modularity and, in particular, its impact on lead time. Finally, an illustrative example is developed to validate the proposed measurement.

Heuristic algorithm for the safety stock placement problem

Abderrahim Bendadou[1], Rim Kalai[1], Zied Jemai[2], Yacine Rekik[3]

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In this paper, we develop an iterative heuristic algorithm for the NP-hard optimization problem encountered when managing the stock under the Guaranteed Service Model in a multi-echelon supply chain to determine a good solution in a short time. Compared to the Baron solver that was restricted with a maximum time equal to 20000 seconds, we achieved on average more than 88% reduction in calculation time and about 0,3% cost reduction.

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System Identification for Manufacturing Control Applications

Time: Tuesday, 07/Sept/2021: 12:00pm - 2:00pm

Expert-Classification Methods for Estimation of the Structure and Parameters of Controlled Queueing Systems

Alexander Mandel[1], Sergey Granin[2], Victor Laptin[3]

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The problem consideration of estimating the structure and parameters of a queu-ing system, in which at the moments of control, which are separated from each other by a fixed time step, the optimal switching of the service channels is carried out. To solve the problem of assessing the structure and parameters of the model, procedures of expert-classification analysis and structural forecasting are pro-posed.

Construction of multi-step price forecasts in commodity markets based on qualitative and quantitative data anal-ysis methods

Zinaida Avdeeva, Elena Grebenyuk, Svetlana Kovriga

Institute of control sciences RAS, Russian Federation

The article proposes a method for constructing and correcting a multistep forecast for the year ahead (with a monthly breakdown) of prices for raw materials and products of industrial enterprises. The proposed approach con-sists in the formation of a price forecast taking into account 1) the price of the predicted indicator, the prices of goods participating in the product value chain, and macro indicators (time series); 2) information about the strength and direction of environmental factors affecting the market. Structured in-formation about the effects of the external environment is the result of pro-cessing expert knowledge and hypotheses from heterogeneous information sources, through analysis and modeling on a cognitive map of the situation (CCS). We form a forecast by constructing an ensemble of time series mod-els, each of which reflects the dependence of the target indicator on its past values and the prices of related products, the composition of which is deter-mined by the results of cognitive modeling and time series analysis. Based on the results of monitoring on the cognitive map of the situation, conducting in order to analyze possible changes in the external environment and digital monitoring of prices, to identify changes in modes, we perform a forecast correction. The results obtained in this study show that the use of cognitive modeling and monitoring of changes in forecasting improve the accuracy of predictions.

Identification of Nonlinear Dynamic Systems Structured by Expanded Wiener Model

Besarion Shanshiashvili

Georgian Technical University, Georgia

A problem of parameter identification of nonlinear manufacturing systems repre-sented by expanded Wiener model, linear elements of which are described by the ordinary differential equation, in the frequency domain is considered. Method of parameter identification in steady state based on the observation of the system's input and output variables at the input harmonic influences is proposed. The solu-tion of the problem of parameter identification is reduced to the solution of the systems of algebraic equations by using the Fourier approximation. The parame-ters estimations are received by the least squares method. Reliability of the re-ceived results, at the identification of the nonlinear systems in industrial condi-tions at the presence of noise, depends on the accuracy of the measurement of system input and output signals and mathematical processing of the experimental data at the approximation. The parameter identification method is investigated by means of both the theoretical analysis and the computer modelling.

Simulation Experiment in a Virtual Laboratory Environment as a Ground for Production Competencies Acquiring

Natalia Bakhtadze[1], Oleg Zaikin[2], Andrzey Żylawski[2]

[1]V.A.Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Russian Federation; [2]Warsaw School of Computer Science

The paper describes the areas of using simulation in industrial systems and, in particular, the benefits of using simulation to train personnel in production sys-tems. The concept of creating a virtual laboratory for solving these problems in a virtual environment presented. Two approaches to modelling briefly presented and analysed, Queuing systems and Simulation. The advantages of distance learning based on these approaches proposed. In addition, the briefly described case study proposes a combined way of learning these two methods with an emphasis on modelling selected core processes of manufacturing systems. The concept provides for the division of this method depending on the student's ed-ucation level.

Formation of work plans and schedules at enterprises with conveyor assembly

Evgeniy Khobotov[1,2], Maria Ermolova[1]

[1]Trapeznikov Institute of Control Sciences, Russian Academy of Sciences, Russian Federation; [2]Bauman Moscow State Technical University, Russian Federation

The methods of constructing plans and schedules for the production of components and assembly of manufactured products from them on the conveyors of machine-building enterprises are considered. Work planning can be carried out both in the production of incoming orders for manufactured products, and in the production of products taking into account the current demand for it.

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The Future of Lean Thinking and Practice

Time: Tuesday, 07/Sept/2021: 12:00pm - 2:00pm

Managing Variability in Production

Ralph Richter[1], Jochen Deuse[1,2], Peter Willats[3], Marius Syberg[1], David Lenze[1]

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The corresponding author worked for many years with Toyota coaches, supporting Bosch in the development of pilot value streams for the Bosch Production system. The coaches spent considerable time and effort to analyze and decouple production from customer fluctuations and to stabilize the flow of production with adequate inventory buffers and capacity. The project team, on the other hand, was impatient, wanting to redesign lines, install Kanban and perform Kaizen activities. They did not understand that their coach was reducing unevenness and overload, so called Mura and Muri, striving for basic stability, as a precondition for lean activities. Later, they denoted a line possessing this basic stability in Bosch as an “improvable system”. In this paper the authors develop methods to analyze and reduce variability in value streams. The value stream is divided into zones, which are then qualified as stable or unstable. Measures are introduced to turn unstable into stable zones, step by step, enabling sustainable improvement activities in those stabilized zones. An IT system is developed to acquire and process the vast amount of data needed for variability measurements, and to provide structured information to support the management of variability in production.

Practical Estimation of the Impact of a Reduction of the Number of Kanban Cards on the Delivery Performance

Christoph Roser, Yannik Regending, Bernd Langer, Claas-Christian Wuttke

Karlsruhe University of Applied Science, Germany

Kanban systems are the best-known variant of pull systems and a cornerstone of lean manufacturing. Kanban systems help to maintain a good material availability in relation to the inventory. One of the main adjustments is the number of kanban cards in a kanban system. The number of kanban is a tradeoff between the cost of inventory, and the cost of a stock-out. Since kanban are used for make-to-stock production, a high availability of completed products is desired, often measured as the delivery performance (on time in full). At the same time excessive inventory is to be avoided to reduce inventory cost and to improve throughput. This paper describes a practical approach to estimate the impact of a reduction of kanban on the delivery performance, based on an analysis of the supermarket inventory.

A Lean approach for multi-criteria decision-making in public services’ strategy deployment

Felix Preshanth Santhiapillai, Chandima Ratnayake

University of Stavanger, Norway

The public services’ related strategy deployment (SD) process involves complex and multi-criteria decision-making. Group decision-making is often characterized by, among other things, some degree of managerial discretion, silo thinking, poor consensus and ad hoc approaches, for simplification purposes. This reduces consistency and results in a high level of variability in the overall performance, due to ambiguous and flawed translation into operational targets. Hence, it is necessary to investigate the potential use of scientific approaches to improve the consistency and minimize the variability of the performance of organizations providing public services. This paper presents the use of a Lean approach, by incorporating Gemba Walks, A3 and the analytic hierarchy process, to improve consistency and minimize the variability of an SD-related decision-making process in a public organization. Action research, supplemented by a practical case exercise, is performed, using qualitative and quantitative data, in one Norwegian police district. The proposed methodology provides a structured approach to consolidating different managerial perspectives, to systematically prioritize strategic alternatives and directions in a more meticulous and credible way, decreasing the possibility of minority domination and subjective views. The suggested approach can help build consensus and improve the consistency associated with group decision-making and minimize the adverse consequences of an ineffective SD process.

Exploring the link between lean practices and sources of uncertainty in Supply Chain

Claudia Del Monte, Matteo Zanchi, Paolo Gaiardelli

Università degli Studi di Bergamo, Italy

In an ever-changing environment, supply chains face countless risks generated by different sources of uncertainty. The adoption of lean management initiatives has been recognized as a viable and effective way for dealing with these uncertainties. However, since constant and rapid change of variables affect-ing supply chains risks nullifying or diminishing the potential benefits of lean initiatives, identification of proper lean practices emerges as essential to address their successful implementation. On these premises, this study proposes a model linking lean management practices with different forms of supply chain uncer-tainty. The model, built upon an analysis of the literature, is designed to help managers and practitioners in identifying and prioritizing lean actions to address issues within their supply chains.

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Implementation of 5S+S for knowledge work in engineering projects

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The purpose of this manuscript is to propose a framework for implementing 5S+S into engineering-to-order (ETO) projects with a focus on knowledge work. The application of this framework helps to improve overall performance in companies providing knowledge work. The methodology guarantees transparency and control over projects in day-to-day management, by the implementation of digital tools such as visual management, 5S+S online audits, key performance indicators (KPI), dashboards, etc. This paper presents the implementation of lean management concepts in customer-specific tailor-made engineering projects, which has not been sufficiently addressed in the existing literature. The methodology used in this paper is based on the application by researchers of lean concepts in a combination of three different disciplines, namely, lean project planning and control (LPPC), lean quality management system (LQMS) and Lean Design. First, attempts at knowledge work improvement through lean are presented, based on the existing literature. Second, all three approaches: LPPS, LQMS and Lean Design are explained. Third, the possibility of combining all three concepts into one framework is discussed. The use of 5S+S in knowledge work is demonstrated, and a framework is developed, based on a DMAIC (Define, Measure, Analyze, Improve, and Control) approach. The use of the framework is presented using an illustrative case in a small and medium size enterprise (SME) providing engineering services. The suggested methodology is applicable for companies providing engineering services seeking overall project performance improvement. The findings are useful for project managers and engineering discipline leaders who aim to implement lean thinking in engineering projects.

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Intelligent Systems for Manufacturing Planning and Control in the Industry 4.0.

Time: Tuesday, 07/Sept/2021: 3:00pm - 5:00pm

Industry 4.0: An Indian perspective

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Industries are now adopting Industry 4.0 practices to complete the mass customized demands of customer and maintain their reputation in global market competition. Industry 4.0 can be considered as the current trend of data exchange in manufacturing processes and automation. In India, the Industry 4.0 is in the ini-tial stages where the terms digitalization and Industry 4.0 are more widely accepted than fourth industrial revolution. The research work on Industry 4.0 is still limited in India. However, the Government of India has launched some policies and initiatives related to Industry 4.0 and its technologies. The main aim of this paper (1) to provide the more depth insight about the Industry 4.0 and similar terms. (2) to suggest the policies related to India for the transition to Industry 4.0. As Industry 4.0 in India is in its initial stages so industries should consider the Industry 4.0 practices seriously as they are shifting their business models from traditional to Industry 4.0 business models. Some issues like cyber security, machine-to-machine interaction, reliability and stability of CPS should be considered in a better way. In this paper we have discussed about the different initiative by Government of India related to Industry 4.0 technologies. For the successful implementation of Industry 4.0 in India some of policies are suggested.

Dynamic scheduling in a flow shop using Deep Reinforcement Learning

Maria Grazia Marchesano, Guido Guizzi, Liberatina Carmela Santillo, Silvestro Vespoli

Università degli Studi di Napoli Federico II, Italy

Machine Learning (ML) techniques and algorithms, which are emerging technologies in Industry 4.0, present new possibilities for complex scheduling methods. Since different rules can be applied to different circumstances, it can be difficult for the decision-maker to choose the right rule at any given time. The purpose of the paper is to build an "intelligent" tool that adapts its choices in response to changes in the state of the production line. A Deep Q-Network (DQN), a typical Deep Reinforcement Learning (DRL) method, is proposed for creating a self-optimizing scheduling policy. The system has a set of known dispatching rules for each machine's queue, from which the best one is dynamically chosen, according to the system state. The novelty of the paper is how the reward function, state, and action space are modelled. A series of experiments were conducted to determine the best DQN network size and the most influential hyperparameters for training.

Risk Assessment and Mitigation for Industry 4.0: Implementation of a Digital Risk Quick Check

Julia C. Arlinghaus, Falko Bendik

Otto-von-Guericke-Universität Magdeburg, Germany

While academics and professionals overwhelmingly agree that current advances in manufacturing present tremendous capabilities to advance manufacturing processes, their view and awareness of the related risk management varies widely. We have developed a method of classifying digital technologies, assessing risk factors and assigning situation-specific mitigation strategies to a variety of digital manufacturing applications. It is based on the analyses of over 350 digital manufacturing projects and over 40 in-depth interviews with academic and industry experts.

A classification of digital technologies and risk factors including fields of application serves as the basis for the web-based assessment and mitigation tool designed to evaluate digitalization projects in all areas of manufacturing and logistics as well as in all phases of development.

A deep learning algorithm for the throughput estimation of a CONWIP line

Silvestro Vespoli, Andrea Grassi, Guido Guizzi, Valentina Popolo

Università degli Studi di Napoli Federico II, Italy

The ability to meet increasingly personalized market demand in a short period of time and at a low cost can be regarded as a fundamental principle for industrialized countries' competitive revival. The aim of Industry 4.0 is to resolve the long-standing conflict between the individuality of on-demand output and the savings realized through economies of scale. Significant progress has been established in the field of Industry 4.0 technologies, but there is still an open gap in the literature regarding methodologies for efficiently manage the available productive resources of a manufacturing system. The CONtrolled Work-In-Progress (CONWIP) production logic, proposed by Spearman et al., allows controlling the Work-In-Progress (WIP) in a production system while monitoring the throughput. However, an affordable estimation tool is still required to deal with the increased variability that enters the current production system. Taking advantage of recent advances in the field of machine learning, this paper contributes to the development of a performance estimation tool for a production line using a deep learning neural network. The results demonstrated that the proposed estimation tool can outperform the current best-known mathematical model by estimating the throughput of a CONWIP Flow-Shop production line with a given variability and WIP value set into the system.

Exploring Interdependency Effects of Production Orders as Central Impact Factors of Logistics Performance in Manufacturing Systems

Victor Vican[1], Julia C. Arlinghaus[2]

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Production planning relies on accurate predictions of logistics performance indicators for production orders. Unforeseen interdependencies operational among production orders, such as unplanned prioritisation, may lead to compounding delay effects, which may negatively affect logistics performance. In this contribution, we present a general framework as well as new interdisciplinary methods for understanding production order interdependencies. We deliver first evidence of such effects in real manufacturing systems, which may lead to performance improvements when predicting logistics performance. Based on the results of this contribution, first insights into the drivers of such effects are derived.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Learning and Robust Decision Support Systems for Agile Manufacturing environments

Time: Tuesday, 07/Sept/2021: 3:00pm - 5:00pm

Due date-related Order Prioritization for Scheduling with Decision Support in Dynamic Environments

Michael Bojko, Susanne Franke, Luigi Pelliccia, Ralph Riedel

Department of Factory Planning and Factory Management, Chemnitz University of Technology, Germany

With the recent and ongoing pursuits to introduce digitalization to corporate shop floors, decision support systems (DSS) for improved task distribution also gain importance. These systems aim to achieve higher effectiveness, efficiency as well as satisfaction of factory staff. However, the necessary implementations and standards for the successful introduction of DSS are not yet available for every given production environment. In this paper, an approach developed by the Department of Factory Planning and Factory Management to introduce decision support in dynamic production environments is presented. The concept allows workers to easily identify orders and tasks of high priority in a complex and highly dynamic environment, to meet the assigned due dates, and to increase customer satisfaction. The proposed concept considers priority-relevant parameters, derives priorities for incoming and pending orders dynamically in real-time, and allows to feed the priority values into a DSS for scheduling orders and their related tasks. The concept can be implemented as a standalone module to production environments as well as being integrated into existing scheduling systems.

A digital twin-driven methodology for material resource planning under uncertainties

Dan Luo, Simon Thevenin, Alexandre Dolgui

IMT Atlantique, LS2N-CNRS, La Chantrerie, 4 Rue Alfred Kastler, 44307 Nantes, France

With the Industry 4.0 revolution currently underway, the manufacturing companies are massively adopting new technologies to achieve the virtualization of their shop floor and the collaboration of their information systems. This process often leads to the construction of a real-time, collaborative, and intelligent virtual factory of their physical factory (so-called digital twin). The data collected for the virtualization is valuable for decision support tools. This paper introduces a vision and a methodology to enhance Material Resource Planning (MRP) with digital twin technologies. Indeed, the data collected from the shop floor can improve the accuracy of the optimization models used in the MRP software. First, several MRP parameters are unknown when planning, and some of these parameters may be accurately forecasted from the data with machine learning. Nevertheless, the forecast will never be perfect, and the variability of some parameters may have a critical impact on the resulting plan. Therefore, the optimization approach must properly account for these uncertainties, and some methods must allow building probability distribution from the data. Second, as the optimization models in MRP are based on aggregated data, the resulting plans are often not implementable in practice. The capacity constraints may be acquired by communication with an accurate simulation of the execution of the plan on the shop floor.

Smart short term capacity planning: A reinforcement learning approach

Manuel Schneckenreither, Sebastian Windmueller, Stefan Haeussler

University of Innsbruck, Austria

Capacity planning is an important production control function that significantly influences firm performance. Especially, in the short term, we face a dynamically changing system which calls for an adaptive capacity planning system that reacts based on the current state of the shop floor. Thus, this paper analyzes the performance of a reinforcement learning (RL) algorithm for overtime planning for a make-to-order job shop. We compare the performance of the RL algorithm to mechanisms that set overtime-hours statically or randomly over time. Performance is measured in total costs which consist of overtime, holding and backorder costs. The results show that our tested benchmarks can be outperformed by the RL algorithm, where the major savings were achieved due to less needed overtime.

Reactive Scheduling by Intelligent DSS

Yumin He[1], Yaohu Lin[1], Hongbo Liu[2], Mengpeng Guo[3]

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Agile manufacturing is in practice by many companies. In agile manufacturing environments, it is important for companies to make quick response to the changes in the environments. This paper proposes an intelligent decision support system (DSS) for reactive scheduling to handle disturbances in agile manufacturing environments. The intelligent decision support system integrates a knowledge-based system for intelligent and multiple criteria decision-making. The intelligent DSS includes three basic modules, the database module, the model base module, and the interface module. The framework of the intelligent DSS is presented. The objective-oriented data model, the knowledge-based rules, and rule induction are designed. The reactive scheduling algorithm is developed. Radio frequency identification and knowledge acquisition tools are applied by the intelligent DSS. The intelligent DSS can be implemented by applying contemporary information technology and can provide an approach to make reactive production scheduling decisions quickly to handle disturbances for manufacturing firms to obtain competitive advantage and agility.

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Real-time machine learning automation applied to failure prediction in automakers supplier manufacturing system

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The Industry 4.0 smart factories allow both optimization and integration of internal processes, utilizing the predictability of failure elements/components in a manufacturing process to prevent reprovals at the end of the process for quality control. The Supervised Machine Learning (ML) methods could be useful to detect anomalies and gain even more value throughout the entire supply chain. The ML approaches face barriers since it demands a changing in the production plant mindset to a more digital production and in the organization's structure for a more advanced data security. The paper aims to propose a smart inconsistency and fail prediction system for manufacturing systems of an automakers supplier assembly process based on the applications of ML techniques. The data provided for the training showed significant deviations and non-linearity allied to only 5 attributes as input variables, which is considered a small number of features for similar problems in the literature. The trained model was then applied to the assembly line with unobserved data of new products, with its result compared with similar previous productions. The results of the tests showed that the proposed stacking model lessens the possibility of rework in the next stages of assembly and creates a more precise process control for the supervisor. The implementation's results pointed out the potential of the stacking model proposed to be a useful tool in the context of Industry 4.0 since the reductions mean greater availability of production time and lower costs with quality control.

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Lean and Six Sigma in Services Healthcare

Time: Tuesday, 07/Sept/2021: 3:00pm - 5:00pm

Proposed Method for Identifying Emergency Unit Profiles from the Monthly Service Number

Ana Paula Barbosa Sobral, Robisom Damasceno Calado, Aline Rangel de Oliveira, Hevelyn dos Santos da Rocha, Harvey José Santos Ribeiro Consenza

Federal Fluminense University, Brazil

The indicators are used to quantify how the results of the Emergency Care Units (UPAs) can be classified, with regard to the efficiency and quality of the services provided to its users. In this sense, the objective of this work is to identify typical patterns of the curves of the indicator number of monthly attendance of the proce-dure "Reception with Risk Classification" in a sample of 50 PSUs. For this, a quantitative and exploratory research was carried out that adopted the Machine Learning technique known as Cluster Analysis not supervised by the AGNES “AGlomerative NESting” method. 10 profiles (groups) of curves for the Recep-tion with Risk Classification were identified in the selected UPAs. Group 1 char-acterizes the standard profile of these UPAs (76% of the total) and the other groups characterize the atypical patterns. The results were obtained using the free software R.

Lean Healthcare In Reducing HAI An Integrative Literature Review

Laryssa Carvalho de Amaral, Robisom Damasceno Calado, Luiza Werner Heringer Vieira, Sandra Maria Do Amaral Chaves

Federal Fluminense University - UFF, Brazil

Abstract. The aim of this study was to analyze the contributions of the Lean Healthcare approach through the use of methods and tools to reduce Healthcare-Associated Infections (HAI). The guiding question of the study was to investi-gate how can the Lean Healthcare approach contribute to the implementation of actions to mitigate the risk of HealthCare-Associated Infections? Articles were collected from 2010 to February 2021, in the Web of Science, Scopus, Emerald databases. An analysis form was created. Of the 21 articles collected, 09 were se-lected, according to the PRISMA®. As for Lean Healthcare methods and tools, the use of standardized work, CTQ and SIPOC was identified as the most used to mitigate the risk of HAI. The high LOS of patients in the hospital increases the risk of HAI, with Lean Six Sigma results in the reduction of hospital costs and lower rates of LOS, with the reduction of the number of complications and infec-tions. Standardized work has reduced the rates of HAI, which reinforces the idea of the need to implement the Lean Healthcare approach, with a focus on respect for people and consequently on the valorization of teamwork, which leads to change in the organizational culture.

Karakuri: A proposal to waste reduction in Health Service

Stephanie D'Amato Nascimento[1], Maria Helena Teixeira da Silva[1], Sergio Crespo Coelho da Silva Pinto[1], Robisom Damasceno Calado[1], Ricardo Rodrigo Alves[2]

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The objective of this study is to analyze the adherence of the Karakuri (low-cost automation) technology for eliminating Lean wastes in healthcare units. To carry out this study reports of continuous improvement practices were analyzed from three Units located in the State of São Paulo (Brazil). These practices of Lean Healthcare approach implementation were applied during the period from June to October 2020. The present literature on the term Karakuri was also analyzed in four data research bases and it was made a study around correlate cases. In conclusion, it is noted that Karakuri seems capable of eliminating the main wastes re-ported in the analyzed health units in question, which are: defects, motion, waiting, and not using human talent

Home Healthcare Routing and Scheduling Problem during the COVID-19 Pandemic

Fatemeh Taghipour, Reza Tavakkoli-Moghaddam, Maryam Eghbali-Zarch

University of Tehran, Iran, Islamic Republic of

Home healthcare routing and scheduling problems provide a better condition for elderly and disabled people. In the presence of the worldwide pandemic of coronavirus disease 2019 (COVID-19 pandemic), these problems have shown their efficiency and necessity to notice this new group of patients suffering from COVID-19. For this purpose, a new mathematical model is developed for a home healthcare routing and scheduling problem (HHCRSP) regarding the impact of the COVID-19 outbreak. The satisfaction and cost of assigning staff to patients with suspected or confirmed COVID-19 are considered. This problem considers travel time between patients and aims to minimize it. The proposed model is solved using GAMS optimization software. Computational experiments are considered for several test problems and a sensitivity analysis is con-ducted to validate the model performance.

MDE-S: A CASE STUDY OF THE HEALTH COMPANY DIAGNOSTIC METHOD APPLIED IN THREE HEALTH UNITS

Alexandre Beraldi Santos, Robisom Damasceno Calado, Sandra Maria do Amaral Chaves, Stephanie D' Amato Nascimento, Messias Borges Silva, Saulo Cabral Bourguignon

UFF - Universidade Federal Fluminense, Brazil

The objective of this study was to evaluate the degree of organiza-tional maturity in three Emergency Care Units (a.k.a. UPA in Bra-zilian acronym) in a city in the interior of the state of São Paulo - Brazil, with the following fundamental criteria observed: the util-ity, feasibility, and specialized technical knowledge of the health unit contextualized in this study. The method used was the Health Company Diagnostic Method (MDE-S), which is an ap-proach to study and qualify the level and organizational maturity, that has the fundamental characteristic of providing a cycle of continuous improvement in the company. Among the most rele-vant results, the study demonstrated, in comparison with a study conducted in Basic Health Units in the interior of the state of Rio de Janeiro, an existent lack of knowledge in health management tools and basic administration fundamentals of the evaluated units. Finally, the study recommends that a strategic system be created for the management and deployment of goals and guide-lines, based on Hoshin Kanri. It is considered that, despite the challenges that will certainly occur, this small-scale and well-developed diagnostic system will certainly be useful, and may be-come an important step towards a continuous practice of efficient management in the investigated health unit.

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Modern Analytics and New AI-based Smart Techniques for Replenishment and Production Planning under Uncertainty

Time: Tuesday, 07/Sept/2021: 3:00pm - 5:00pm

Optimization of a Periodic Review Joint Replenishment Policy for a Stochastic Inventory System

Lei Wang, Haoxun Chen

Logistics and Optimization of Industrial Systems, University of Technology of Troyes, Troyes, France

A stochastic inventory system with multiple products controlled by a periodic review joint replenishment policy P(s,Si) is considered. This system places a joint replenishment order to bring the inventory position of each item i to its order-up-to level Si when the aggregate reorder point of all items drops below s at each review moment. By imposing service levels on the system, we propose an algorithm for optimizing the policy to minimize the total cost of the system. The performance of this algorithm is evaluated by numerical experiments on randomly generated instances.

CGA-Based Optimal (r, Q) Policy Tuning in Goods Distribution Systems with Complex Topologies

Lukasz Wieczorek, Przemyslaw Ignaciuk

Lodz University of Technology, Poland

The paper addresses the inventory control problem in logistic networks with complex, mesh-type topologies. The goods are shipped with non-negligible lead-time delay and an uncertain, arbitrary demand may be imposed on any node in the system. Excess demand is lost. Single-item periodic-review distribution process is governed by the (r, Q) policy. In order to adjust the policy parameters, a continuous genetic algorithm is used. In the optimization procedures, three objectives – holding and transportation costs reduction and customer satisfaction maximization – are considered. The paper shows how one can effectively find the reorder point and order quantity for each node when the policy is implemented in a distributed mode, as desired in complex systems. Two approaches to the crossover operation have been compared. The separate operator allows one to obtain more suitable solutions at the expense of more significant computational effort.

Effect of Informed Demand Lead Time under Imperfect Advance Demand Information

Koichi Nakade, Tsubasa Seino

Nagoya Institute of Technology, Japan

This paper considers two types of imperfect advance demand information. The advance demand information is given each day, and the actual arrival time is sto-chastic. In a known demand lead time model, the arrival date of actual demand, which is called demand lead time, is informed, and it is fixed. In unknown de-mand lead time model, the demand information does not include the demand lead time. In both cases, the actual demand may not occur with a given probability, and urgent demand may appear each day, which requires a product in the same day. The ordering, lost sale, holding and return costs are incurred. In this paper, these two cases are compared under the same situation except demand lead time information. To derive the optimal policy on order and return, each of the models is formulated as a Markov decision process. The optimal ordering policy in each day is derived, which minimizes the total expected cost over a finite horizon. The experimental results show that the total expected cost under the optimal policy in the case of the known lead time is smaller than that in the unknown lead time case, but the difference becomes small when the holding cost is small or the frac-tion of urgent demand is large.

A Probabilistic Estimation of Perfect Order Parameters

Valery Lukinskiy[1], Vladislav Lukinskiy[1], Boris Sokolov[2], Darya Bazhina[1]

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In the digital economy, information systems have a significant impact on supply chain management. However, there is a need for further development of theoretical knowledge and mathematical models, including methods for managing risk in complex supply networks to best serve customer orders. In the supply chain operations reference (SCOR) model, reliability is assessed by calculating perfect order parameters. The component/process reliability is calculated as the product of the weighted averages of the perfect order parameters, and possible combinations of failure features are not taken into account. This paper presents an approach to probabilistic estimation of perfect order parameters based on the general theorem on the repetition of experiments, and proposes to use a binomial distribution to approximate the values obtained. The obtained results make it possible to assess the efficiency of possible measures (increasing the insurance stock, replacing the carrier, etc.) to improve the reliability of perfect order fulfilment.

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Modern scheduling and applications in industry 4.0

Time: Tuesday, 07/Sept/2021: 3:00pm - 5:00pm

A mathematical model for bus scheduling with conditional signal priority

Ming Liu[1], Yecheng Zhao[1], Feng Chu[2], Feifeng Zheng[3], Chengbin Chu[4]

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Inaccuracy of buses is a common situation. A common practice is that a certain amount of slack is usually added to the schedule of bus operation, so that the bus can execute the schedule in most cases. On the other hand, slack means that buses sometimes have to wait for a while at the station or slow down while driving. Since the bus cannot accelerate the driving process by itself, this method cannot make the bus fully implement the schedule. Researchers invented the Transit signal priority (TSP) and conditional signal priority (CSP), the purpose of which is to give the bus signal priority to speed up when it is delayed to a certain extent. Some previous work has studied the driving process of buses with CSP. However, there is still room for further improvement in the mathematical description of the bus driving process based on CSP. In this article, we analyze the driving state of the bus under different CSP states, that is, positive and negative. Then a series of representative and operational assumptions are given. These assumptions can be used as the basis for future research on such topics. With the assumptions, we give a mathematical model of the bus driving process using CSP. According to some performance indicators of the bus driving process obtained in the modeling process, an optimization goal is established to comprehensively improve the driving effect of the bus. Mathematical analysis and numerical solution verify the applicability of the model.

Electric Bus Charging Scheduling Strategy with Stochastic Arrival Time and State of Charge

Ming Liu[1], Yueyu Ding[2], Feng Chu[3], Feifeng Zheng[4], Chengbin Chu[5]

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To alleviate the range anxiety of drivers and time-consuming charging for electric buses (eBuses), opportunity fast-charging has gradually been utilized. Considering that eBuses have operational tasks, identifying an optimal charging scheduling will be needed. However, in the real world, arrival time and state of charge (SOC) of eBuses are uncertain. Therefore, it is challenging for the charging station to efficiently schedule charging tasks. To solve the problem, this paper develops a two-stage stochastic eBus charging scheduling model. In the first stage, eBuses are assigned to designated chargers. After the arrival time and SOC are realized, the second stage determines the charging sequence of eBuses on each charger. The objective is to minimize the penalty cost of tardiness by determining the charging start time and the corresponding charging duration time. Then, a sample average approximation (SAA) algorithm is applied. Additional numerical experiments are performed to verify the efficiency of the stochastic programming model and algorithm.

Group scheduling and due date assignment without restriction on a single machine

Ying Chen, Yongxi Cheng

Xi'an Jiaotong University, China, People's Republic of

We consider a single machine scheduling problem in which the scheduler decides optimal due dates for different jobs under a group technology environment, in which the jobs are classified into groups in advance due to their production similarities, and jobs in the same group are required to be processed consecutively to achieve efficiency of high-volume production. The goal is to determine an optimal job schedule together with a due date assignment strategy to minimize an objective function that includes earliness, tardiness, due date assignment and flow time costs. The due date assignment is without restriction, that is, it is allowed to assign different due dates to jobs within one group. We present structural results that fully characterize the optimal schedule, and give an optimal $O(n\log n)$ time algorithm for this problem.

Research on the O2O Takeout Orders Merger and Routing Optimization

Wenjie Wang, Lei Xie, Li Jiang, Yangyun Song

Glorious Sun School of Business and Management, Donghua University, China, People's Republic of

Delivery service of O2O takeout platforms requests the high timeliness, which frequently results in explosive orders during peak period. Because the order must be completed delivery during committed service time, the orders merger and delivery routing optimization are essential to O2O takeout delivery service. Taking into consideration the amount of the different order locations, this paper studies the order delivery with the closest pickup distance principle in O2O takeout platform. Firstly, we use the K-means algorithm to cluster and merge the orders. Secondly, due to the strictly time constraints of real-time order, we propose the delivery routing optimization model of order cluster with soft time window, and which can be solved with simulated annealing algorithm. Finally, using the actual delivery data of O2O takeout platform, we further demonstrate the orders merger and delivery routing optimization mode we proposed with Python.

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Exploiting the full potential of I4.0 technologies for products EOL recovery process

valentina popolo, mosè gallo, andrea grassi, mariagrazia marchesano

Università degli studi di Napoli Federico II, Italy

The recent advancements of technology have been radically transforming the industrial world and our societies as well. The application of the new technologies is ubiquitous involving various domains from industrial production to everyday life. This paper investigates whether and how it is possible to better support product life-cycle management by exploiting product's enhanced capabilities stemming from an I4.0 ecosystem. To this aim, this paper proposes the new concept of Product 4.0 that is a product archetype combining the functionalities of an intelligent product with those permitted by I4.0 technologies. As Product 4.0 has the potential to benefit the various phases of the product life cycle, this paper also provides further details on the end-of-life recovery options for this new product archetype, by means of an explanatory case dealing with a laser-jet printer.

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New trends and challenges in Reconfigurable, Flexible or Agile Production System

Time: Tuesday, 07/Sept/2021: 3:00pm - 5:00pm

A Systematic Approach to Development of Changeable and Reconfigurable Manufacturing Systems

Ann-Louise Andersen, Alessia Napoleone, Thomas Ditlev Brunoe, Bjørn Christensen, Kjeld Nielsen

Aalborg University, Denmark

The implementation of changeable and reconfigurable manufacturing systems and realization of benefits connected to rapid, efficient, and dynamic change of functionality and capacity is key to achieve manufacturing competi-tiveness. Therefore, this paper proposes a systematic methodology for the design and development of changeable and reconfigurable manufacturing systems, de-rived from design theory, reconfigurability theory, as well as practical experi-ence. The methodology consists of a concrete course of actions that connects de-sign phases and working steps based on the content of the design task. Further-more, the paper addresses project-related and contextual aspects of reconfigura-bility development, which indicates how the proposed methodology should be adapted to the specific company and task at hand. Thus, the proposed methodol-ogy is intended for further validation in different types of manufacturing compa-nies that are transitioning towards reconfigurability.

A bi-objective based measure for the scalability of reconfigurable manufacturing systems

Audrey Cerqueus, Xavier Delorme

Mines Saint-Etienne, Univ Clermont Auvergne, CNRS, UMR 6158 LIMOS

The reconfigurable manufacturing systems aims to efficiently respond to demand changes. One of the key characteristics of these systems is the scalability, i.e. the ability to modify the volume of the throughput in order to fit to the demand variability. The design of the RMS has a high impact on its scalability. In the literature, there are only few indicators to evaluate the scalability of a system and most of them are a posteriori measures. In this article, we propose a new measure to assess the scalability since the design phase of the RMS. We present experimental results on state-of-the-art instances to validate our approach.

Digital twin framework for reconfigurable manufacturing systems: Challenges and Requirements

Emna Hajjem[1], HICHEM HADDOU BENDERBAL[2], Nadia Hamani[1], Alexandre Dolgui[2]

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Due to the rapid advance in new generation information technologies, such as IoT, Big Data analytics, Cyber-Physical Systems, cloud computing and artificial intelligence, Digital twins areseen as major enablers of smart manufacturing. Therefore, their use in industry has attracted the attention of many practitioners and researchers. Despite this, there is still a need for an integrated and detailed Digital Twin framework for Reconfigurable Manufacturing Systems. In an effort to investigate related works, this paper reviews the existing Reconfigurable Manufacturing Systems Digital Twin frameworks. It also presents a classifications of several work based on the Digital Twin framework features and properties, the used decision-making tools and techniques as well as the manufacturing system characteristics. The paper is concluded with a discussion and future challenges to put forward a structured and an integrated Reconfigurable Manufacturing Systems - Digital Twin framework

Aggregate planning for multi-product assembly lines with reconfigurable cells

Mehmet Uzunosmanoglu, Veronique Limere, Birger Raa

Ghent University, Belgium

This paper deals with aggregate planning of Reconfigurable Assembly Lines (RAL). The assembly line considered in this paper consists of hexagonal cells. These have multiple slots where processing modules can be inserted to perform certain operations. In addition, each cell has a single central slot where a central module can be inserted for inter-cellular and intra-cellular transportation of parts. Multiple products with different assembly sequences must be handled over multiple planning periods. An Integer Quadratic Programming (IQP) model is proposed to solve the following problems simultaneously: (i) assigning processing modules and a central module to the cells; (ii) installation of the cells and conveyors between the cells; and (iii) routing products, ensuring that availability of the resources is not exceeded. The assembly line should be reconfigured over time to adapt to possible product functionality and demand changes at minimum reconfiguration, operational and material handling costs while ensuring the demand is met within each period. The IQP model is implemented and solved for an illustrative problem and its extensions using Gurobi.

Scalability and Convertibility Models and Approaches for Reconfigurable Manufacturing Environments

Abdelhak DAHMANI, Lyes BENYOUCEF

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The reconfigurable manufacturing system (RMS) is one of the newest manufacturing paradigms. In this paradigm, machine components, machine soft-ware, or handling units can be inserted, removed, modified, or interchanged as needed and, where appropriate, imposed by the need to adapt and adjust quickly and cost-effectively to changing requirements. RMS is considered to be a convenient processing paradigm for the manufacture of varieties as well as a scalable enabler for this variety. Considered as two of the six main RMS characteristics, in this paper, we review the most used models and solving approaches dedicated to scalability and convertibility.

APMS 2021 Conference | Artificial Intelligence for Sustainable and Resilient Production Systems

Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Regular Session : Advanced modelling approaches

Time: Tuesday, 07/Sept/2021: 3:00pm - 5:00pm

An Empirical Examination of the Consistency Ratio in the Analytic Hierarchy Process (AHP)

Valery Lukinskiy[1], Vladislav Lukinskiy[1], Boris Sokolov[2], Darya Bazhina[1]

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Papers related to solving practical problems in all areas of economic activity use the AHP methodology from the 1980s, proposed on the basis of studying a limited number of tangible objects. One possible option to overcome this situation could be a new approach based on probability theory and mathematical statistics. We used information obtained from processing 292 matrices collected between 2014 and 2020 and reflecting expert judgements. We were able to compare a particular expert's judgement with an array of expert judgements from previous studies to refine the computational operations of the AHP. It was found that the probability estimates of the consistency indices for expert judgements differ significantly from the probability estimates for the generated values; e.g., for 6 6 matrices, they differ by a factor of 20. The results of our study do not confirm the need to revise expert judgements if the consistency ratio (C.R.) is greater than 0.10, and confirm the need for more example calculations for tangible objects and for new dependencies to estimate intangible objects based on artificial intelligence models and methods.

Performance Indicators in Emergency Operating Theaters: A State of the Art

Gustavo Santamaria Acevedo[1], Benjamin Legros[2], Zied Jemai[3], Oualid Jouini[1]

[1]CentraleSupelec, France; [2]EM Normandie, France; [3]ENIT, Tunisia

This article aims to provide a review and classification of the current state of the art on the performance metrics used for the operations management in emergency operating theaters. We have classified the metrics into two categories. The first category consists of hospital-centered metrics. They are performance measures that are of interest to the hospital due to their possible impact on the institution's productivity or revenue. The second category consists of patient centered metrics. These metrics take explicitly into consideration the patients' experiences and which have a direct impact on the patients' safety and satisfaction. Having a comprehensive set of performance indicators used in Emergency Operating Theaters will allow surgery chiefs and hospital managers to implement missing indicators and to identify previously unknown quality issues, bottlenecks, and areas for improvement.

Energy Transparency in Compound Feed Production

M.T. Alvela Nieto, E.G. Nabati, K.-D. Thoben

University of Bremen, Faculty of Production Engineering, BIK-Institute for Integrated Product Development, 28359 Bremen, Germany

The finite nature of energy resources forces animal feed producers to minimize their energy consumption. As a first step towards energy conservation, more transparency over the energy usage in compound feed plants is required. However, current feed processing strategies do not consider the high dynamics in products and process conditions, nor do they augment the operator´s energy awareness. Digital support tools, such as virtual and augmented reality, can close the gap between required information (e.g., actual operating conditions) and knowledge of operators. In this paper, first, a methodology for making energy values transparent is presented. Then the state of the art of digital tools and related requirements are discussed, followed by a description of the integration of a digital tool in a case study of a compound feed plant located in northern Germany.

A Framework To Assess Risk of Illicit Trades Using Bayesian Belief Networks

Rashid Anzoom, Rakesh Nagi, Chrysafis Vogiatzis

University of Illinois, Urbana-Champaign, United States of America

Recent years have seen the initiatives against illicit trades gain significant traction at both national and global levels. A crucial component in this fight is correct assessment of the risks posed by different trades across different regions. To aid in this cause, we provide a risk prediction framework based on Bayesian Belief Networks. It involves the development of a causal model incorporating variables related to the rise/decline of the illicit trade volume. The influence of these variables are determined by training on available data that are allowed to update over time. Implementation on a sample case study shows relatively low prediction accuracy of our model. Factors constraining its performance are analyzed and possible ways to avert them are discussed. We expect this framework to act as a decision support tool to the policymakers and strengthen them in the fight against illicit trades.

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Autonomous Robots in Delivery Logistics

Time: Tuesday, 07/Sept/2021: 6:15pm - 8:15pm

Drone Delivery Vehicle Routing Problem with Multi-flight Level

Yonggab Kim, Hoyoung Jeong, Seokcheon Lee

Purdue University, United States of America

The advantage of drone delivery is that it can efficiently use the vertical space in the air, allowing multiple operations at different flight levels. However, flight level and delivery efficiency come at a tradeoff, especially in a metropolitan area with many skyscrapers; placing drones higher requires more time, but the higher they are, the less detour they make due to the smaller number of buildings at higher altitudes, resulting reduced time in routing. This study integrates the prob-lem by dividing the heights and identifying buildings that could possibly be an obstacle. We propose a novel vehicle routing problem for multi-flight level drone delivery to minimize delivery completed time.

Sustainable Facility Location-Routing Problem for Blood Package Delivery by Drones with a Charging Station

Shirin Ghasemi, Reza Tavakkoli-Moghaddam, Mahdi Hamid, Meysam Hosseinzadeh

University of Tehran, Iran, Islamic Republic of

This paper proposes a multi-objective integrated facility location and drone routing problem in blood package delivery by considering sustainability factors. We seek to locate the predetermined number of capacitated launching facilities and charging stations for the drones' battery. Candidate construction points are ranked by the TOPSIS method in terms of sustainability indicators. The objectives are to maximize the weight of selected points and the amount of demand coverage while minimizing the transferring and constructing facilities cost. Then, we assign drones to open launch facility and demand points to drones and launch facility. It should be noted that we consider the drone's battery consumption, and if the drone battery is not enough to continue its mission, we as-sign them to an opened charging station. GAMS software is employed to solve small-sized problems. The solution result indicates the performance of our model.

A MILP formulation for an Automated Guided Vehicle Scheduling Problem with battery constraints

Adriano Masone, Teresa Murino, Claudio Sterle, Monica Strazzullo

University of Naples "Federico II", Italy

The introduction of automated guided vehicles (AGVs), due to their dexterity, efficiency, and flexibility, had a great impact on logistics leading to the creation of new business models. Nowadays, AGVs are frequently used in industries for the internal transportation of goods or pallets between various departments or locations within the same factory or for receiving, storage and sorting goods in shipment areas. The aim of an AGV-based internal transportation system is to transfer the right amount of the right material to the right place at the right time. Therefore, the determination of a good scheduling of the AGV tasks is essential to overcome delays in production and material handling processes. In this work, we study a scheduling problem arising from an internal transportation system of a company operating in the manufacturing field where AGVs subject to battery constraints are used for horizontal movement of materials. The aim of this work is to highlight the impact of the AGV battery recharge times on the completion time of the material handling process. To this aim, we propose an original mixed integer linear programming (MILP) formulation to optimally solve theaddressed problem. The proposed model is validated on test instances built from real data comparing its results with those obtained disregarding the battery constraints. The results show the effectiveness of the proposed solution method and the impact of the AGV charging time on the handling process completion time.

Planning autonomous material transportation in hospitals

Giuseppe Fragapane[1], Debjit Roy[2], Fabio Sgarbossa[1], Jan Ola Strandhagen[1]

[1]Department of Mechanical and Industrial Engineering, Norwegian University of Science and Technology, Trondheim, Norway; [2]Department of Production and Quantitative Methods, Indian Institute of Management Ahmedabad, Gujarat, India

Until recently, architects planned the layout for a new hospital based only on design aspects, experience, and legal regulations. Today, hospital logistics planners are included at an earlier stage in the project and support hospital layout planning with important logistics aspects. While methods supporting patient flow are prioritized in the layout planning, methods focusing on material flow are lacking. Therefore, this study is part of a project that aims to develop a decision support model for hospital layout planning that includes material flow. We develop a semi-open queuing network model of a hospital with multiple floors and compare it with agent-based simulation modeling. Simulation results show that a semi-open queuing network is a promising approach to support hospital planners in the decision-making process of hospital layout planning that includes planning material flow performed by autonomous mobile robots.

Collaborative hybrid delivery system: Drone routing problem assisted by truck.

Ho Young Jeong[1], Seokcheon Lee[2]

[1]Purdue University, United States of America; [2]Purdue University, United States of America

Unmanned Aerial vehicles (UAV) or drones have significant market potential due to their high mobility and cost savings. Simultaneously, the hybrid delivery system in which collaborative use of trucks and drones is also receiving much attention and intensively studied as traveling salesmen problem with drone (TSP-D). This delivery system has significant advantages since it can selectively exploit the strength of each vehicle. However, in many cases, drones are only used as an assistant method of supporting truck delivery. In this paper, as a reverse idea, we present a new model, named drone routing problem with truck (DRP-T), in the form of a truck assisting drones' delivery. We present a mathematical model formulated as mixed-integer linear programming (MILP) and conduct a comparative analysis with one of the existing TSP-D models with an actual map-based case study. Our experiments show that it is possible to have substantial savings with the proposed model compared to the truck-only and TSP-D model.

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Digital Transformation Approaches in Production Management

Time: Tuesday, 07/Sept/2021: 6:15pm - 8:15pm

The Survival Analysis for A Predictive Maintenance in Manufacturing

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The Predictive Maintenance (PdM) as a tool for detection future failures in manufacturing has recognized as innovative and effective method. Different approaches for PdM have been developed in order to compromise availability of data and demanding needs for predictions. In this paper the Survival Analysis (SA) method was used for the probability estimation for the machine failure. The paper presents the use of the two most popular SA models Kaplan-Meier non-parametric and Cox proportional hazard models. The first model was used to estimate the probability of machine to survive certain amount of cycles time. The Cox proportional model was used to find out the most significant covariates in the observed data set. The analysis shown that use of SA in the PdM is a challenging task and can be used as additional tool for failure analysis. However, due to its foundation there are several limitations in the application of SA which in most cases are the availability of the right information in the data set.

Barriers hindering an efficient implementation process of digital technologies; a case study at Norwegian manufacturing companies

Eirin Lodgaard[1], Hans Torvatn[2], Johanne Sørumsbrenden[1], Gaute Andreas Knutstad[1]

[1]SINTEF Manufacturing, Norway; [2]SINTEF Digital, Norway

The existing wave of improvement in manufacturing industry is strongly driven by the application of digital technologies. Unfortunately, the implementation process is not straightforward. To understand the barriers which hinder a smooth implementation process is essential for successful implementation of digital technologies. Our study aims to identify the major barriers based on a case study per-formed at six Norwegian manufacturing companies, to know what to solve enabling a smoother implementation process. The findings shows that both technical and organizational aspects are of importance to consider, where the organizational aspects are seen as the most underestimated. The lack of digital competence alongside underestimated need for organizational development of involved people emerges as prominent barriers. Some technical problems were also pertinent, like system integration. Sharing of data was seen as a potential asset, but both legal, strategic and technical issues hampered this. The results of this study may help managers and practitioners to address the major barriers highlighted, paving the way for successful implementation and integration of digital technologies in the manufacturing industry.

Exploring Accidental Digital Servitization In An Industrial Context

Matthew Anderson[1], Shaun West[2], David Harrison[1]

[1]Glasgow Caledonian University, United Kingdom; [2]Lucerne University of Applied Sciences and Arts, Switzerland

Recent advances in the Industrial Internet of Things (IIoT) and 'Smart Products' within manufacturing industries have promoted a shift to service-related offerings [1], often inadvertently and without the prerequisite foundations in place, in terms of operating models, impact upon revenue streams, and business strategy in general. This paper endeavors to investigate and analyze this occurrence by reviewing three distinct examples of 'smart innovations' for medium-sized industrial businesses and considers the impact upon the business when a service becomes 'smart.' We further review the impact and suggest mitigation approaches relevant to Servitization

A hybrid architecture for the deployment of a Digitally-enhanced Quality Management (DQM) System for Zero-Defect Manufacturing in Industry 4.0

Chiara Caccamo[1], Ragnhild Eleftheriadis[1], Maria Chiara Magnanini[2], Daryl John Powell[1], Odd Myklebust[1]

[1]Sintef Manufacturing, Norway; [2]Politecnico di Milano, Italy

The adoption of Industry 4.0 technologies is slow and lacks homogeneity across the manufacturing landscape. Challenges arise from legacy IT systems, or a low level of digitization leading to difficult integration processes, or simply the fear of investing too much in building the necessary infrastructure versus the uncertainty of the potential benefits. The market has also become more demanding, both in terms of competition and customer requirements, so that more and more manufacturers are faced with the demand for high production flexibility, high quality, and low operating costs. This paper aims to address the implementation complexity of a cyber-physical production system for zero-defect manufacturing in dynamic, high-value, high-mix, and low-volume contexts where the level of digitalization is still low, or the IT infrastructure is rigid.

Detection of fluid level in bores for batch size one assembly automation using convolutional neuronal network

Alexej Simeth[1], Jessica Plaßmann[2], Peter Plapper[1]

[1]University of Luxembourg, Luxembourg; [2]Hochschule Trier, Germany

Increased customization and shortening product life cycles pose a challenge for automation, especially in assembly. In combination with the nature of assembly tasks, which may require high level of perception, skill, and logical thinking, these tasks are often conducted manually, especially in certain industries (e.g. furniture, power tools) or small and medium-sized enterprises. One of such tasks is the liquid level monitoring in gluing processes. Existing non-manual solutions are based on conventional and less flexible algorithms to detect the current liquid level. In production environments with highly individualized products, a need for more performant models arises. With artificial intelligence (AI) it is possible to deduct decisions from unknown multidimensional correlations in sensor data, which is a key enabler for assembly automation for products with high degree of customization.

In this paper, an AI-based model is proposed to automate a gluing process in a final assembly. Images are taken of a gluing process with a camera and used to train a convolutional neuronal network in order to extract images features. The features are applied to a support vector machine classifier to identify the liquid level. The developed model is tested and validated with a Monte-Carlo-simulation and used on a demonstrator to automate a gluing process. The developed model classifies images of liquid levels with over 98% accuracy. Similar results are achieved on the demonstrator.

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Digital Transformations Towards Supply Chain Resiliency

Time: Tuesday, 07/Sept/2021: 6:15pm - 8:15pm

ANALYTICS WITH STOCHASTIC OPTIMIZATION: EXPERIMENTAL RESULTS OF DEMAND UNCERTAINTY IN A PROCESS INDUSTRY

NARAIN GUPTA[1], GOUTAM DUTTA[2], KRISHNENDRANATH MITRA[3], MANOJ KUMAR TIWARI[4]

[1]Management Development Institute; [2]Indian Institute of Management , Ahmedabad, India; [3]University of Calcutta; [4]National Institute of Industrial Engineering

The key objective of the research is to report the results of testing of a two stage stochastic linear programming (SLP) model with recourse using a multi scenario, multi period, menu driven user friendly DSS in a North American steel company. The SLP model and the DSS is generic which can be applied to any process industry. It is capable of configuring multiple materials, multiple facilities, multiple activities and multiple storage areas. The DSS is developed using 4th Dimension programming language, and the SLP model was solved using the IBM CPLEX solver. The value of the SLP solution derived from the experimentation of the DSS with a real-world instance of one steel mill is 1.61%, which is equivalent to a potential benefit of US$ 24.61 million.

A set of experiments were designed based on the scenarios with demand distributions. The research reports a few interesting patterns emerged from optimization results when the volatility in demand of finished steel rises and the distribution of the demand skewness changes from left to right tail. The academic contribution of this research is two folds. Firstly, the depicting potential contribution to profit in a steel company using a SLP based DSS under probabilistic demand scenarios. Secondly, the optimization experiments confirm that the value of SLP solution increases with the increase in demand uncertainty. The research has applied implications that the practicing managers would be encouraged to look for more optimization based solutions, and the prescriptive analytics discipline will fetch more scholarly and industry attention.

Information Distortion in a Fast Fashion Supply Network: the impact of digitalization

Maria Antonietta Turino, Marta Rinaldi, Marcello Fera, Roberto Macchiaroli

University of Campania Luigi Vanvitelli, Italy

During the last decades, Information Sharing has gained a global attention among academic researchers. It has been widely demonstrated that such strategy improves the supply chain management and mitigates the bullwhip effect. In this research, the information distortion and its impact on a Fast Fashion Supply Chain has been modeled. The aim of this paper is to analyze how false data can affect the system performance. A simulation model has been developed in order to reproduce the behavior of the players. Then, different scenarios with different levels of digitalization and distortion have been tested. Results show that both upstream and downstream distortions have a disruptive impact on the system and a strong ripple effect. Moreover, negative effects result to be not linear, and small distortions already show great disruptive effects.

Modelling critical success factors for the implementation of Industry 4.0 in Indian manufacturing MSMEs.

Pulok Ranjan Mohanta, Biswajit Mahanty

Indian Institute of Technology Kharagpur, India

This research is based on the recent endeavors of the manufacturers to achieve improvements in supply chain resiliency by implementing Industry 4.0 standards. The large enterprises, in today's scenario, are pursuing their supplier organizations to incorporate information and communication technology (ICT) based advancements to their production systems. But successful implementation of such technologies in the resource deficient supplier organizations depends on several factors that need due consideration of the decision makers. In this paper, we have identified 14 such critical success factors from extant literature for implementation of technologies conforming to Industry 4.0. Further, through an empirical investigation comprising of 222 micro, small and medium enterprises (MSMEs) from the automotive manufacturing sector in India, we have made use of exploratory factor anal-ysis and structural equation modelling to identify the hidden constructs and examine the influencing relationships between them.

Requirements on Supply Chain Visibility: a case on inbound logistics

Ravi Kalaiarasan[1], Tarun Kumar Agrawal[1], Magnus Wiktorsson[1], Jannicke Baalsrud Hauge[1], Jan Olhager[2]

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Events such as Covid-19 have revealed the vulnerabilities that companies face due to low visibility. Consequently, companies experience impact on their supply chains in terms of disruptions of material supply, deliveries, productivity and revenue. Thus, the importance of Supply Chain Visibility (SCV) in global and competitive markets with increasing sustainability demands has received widespread recognition. Yet, the literature provides limited understanding of requirements to consider when developing a SCV system. Addressing this gap, this study presents the findings from a case study during the first months of 2021 at a global manufacturing company developing a SCV system to improve their inbound flow. Using a system engineering perspective, this study presents requirements highlighted during early stage for a SCV system. The results indicate the importance of ensuring SCV system requirements to enable data collection, handling and usage for decision making leading to both supply chain sustainability and resilience. This study contributes to the understanding of SCV by presenting and categorizing requirements considered in a live case at a manufacturing company when developing a SCV system.

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Smartwatch Integration in Digital Supply Chains

Ioan-Matei Sarivan, Casper Schou, Ole Madsen, Brian Vejrum Wæhrens

Aalborg University, Denmark

As the maturity of digital integrated supply chains grows, the amount of operations which are tracked or which are directly controlled by a computerised system has seen a rapid increase with the emergence of the Industry 4.0 paradigm. This is notably desired in high-cost countries where having an overview on the supply chain is crucial in ensuring the delivery dependability for the customer. However, the manual tasks are overlooked to a certain extent. Most digitalisation initiatives have the worker interact manually with the manufacturing execution systems (MES) using terminals placed around the shop floor. Two scenarios in which the worker has to interact with a MES are given in this paper and a digital solution is proposed to solve the implied shortcomings concerning the interface between production planning and shop-floor production. A solution comes under the form of an open-source, freely available smartwatch app designed to be used by the workers for fast and easy interaction with the MES and enterprise resource planning system while at the same time serving as a task deployment method. The solution proposal is aligned with extant initiatives of obtaining end-to-end supply chain digitalisation while enabling the worker's fast responsiveness upon task deployment.

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Engineering of Smart-Product-Service-Systems of the Future

Time: Tuesday, 07/Sept/2021: 6:15pm - 8:15pm

Smart Landscaping Services

Kai-Wen Tien, William E. Sitzabee, Phillip Melnick, Vittaldas V. Prabhu

The Pennsylvania State University, United States of America

Landscaping services industry is estimated to be about $100 billion in the US. These services tend to be labor-intensive and are varied in scales ranging from single-family homes to large hospitality and leisure enterprises such as resorts and golf courses. From a management perspective the three main objectives of landscaping services are maintaining aesthetics, pest control, and lowering cost. Some of the major activities in landscaping include mowing lawns, pruning shrubs, clearing leaves, trimming hedges, and mulching. Operating cost depends on staffing level, frequency of activities, and associated fuel consumption, which have been investigated in several studies. The focus of this paper is to make land-scaping services smarter by using decision-support models for managing them. Specifically, this paper proposes a two-stage optimization model for lawn mowing. The first-stage model assigns appropriate pieces of equipment and staff to various areas to minimize both operating costs and labor costs. The second-stage model optimizes the schedule of activities based on the desired due times for various areas. A numerical study is used for demonstrating the application of the decision-support model. Future direction for smart landscaping through better decision-making based on data from IoT sensors for monitoring growth, soil conditions, and weather data is also proposed.

Digital servitisation and smart services for the new normal

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The COVID-19 Pandemic has caused an economic breakdown, especially in the manufacturing industry. Manufacturing companies have used Digital service to stay in contact with their customers and as a source of revenue even during the general lockdown An exploratory focus group has been carried out to understand the problems and opportunities manufacturing companies went and are going through and to suggest open research questions that both research and industry should explore further. To deeply analyses the content of the discussion, Latent Dirichlet Allocation (LDA) was used to identify the main research topics. 4 topics were identified as the most relevant to be investigated: digitalization and collaboration emerged as the most interesting trends that will characterize the new normal. For each of the topics, insights, critical points and research questions are presented and discussed, reporting the main evidence of the focus group discussion.

Transformation of Manufacturing Firms: Towards Digital Servitization

Slavko Rakic[1], Ivanka Visnjic[2], Paolo Gaiardelli[3], David Romero[4], Ugljesa Marjanovic[1]

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Digital technologies are disrupting servitization in manufacturing firms. In the last decade, manufacturing firms transform their business models from traditional offers of physical goods to digital solutions for their customers. In this paper, we investigate the transformation of digital servitization in manufacturing firms. We challenge relations between traditional and digital service portfolios offered by applying linear regression on the data obtained from 690 manufacturing firms from the Republic of Serbia from 2015 to 2020. The results show that firms significantly increase the offer of traditional services from 2015 to 2018. Moreover, results demonstrate a rapid growth of digital services in the period from 2018 to 2020. The application of traditional and digital services in manufacturing firms increased by 30 percent in five years.

Service Shop Performance Insights from ERP Data

Shaun West[1], Daryl Powell[2], Fabian Ille[1]

[1]Lucerne University of Applied Sciences and Arts, Switzerland; [2]SINTEF Manufacturing AS

Enterprise Resource Planning (ERP) systems offer firms a wealth of readily available transactional data. However, deriving insights from such data often demands the examination of multiple issues simultaneously. In this paper we use simple data mining to analyze ERP data from 27 service shops over a period of 35 months. The data has been used to provide valuable business performance insights to the service shop managers. Though the granular ERP data needed to be supplemented by further data in some instances, we found it has the potential to provide real insights into a firm's performance. Such simple data min- ing approaches can be standardized and automated across service centers for in- sights that can be used to drive continuous improvement activities within and across sites. We also suggest that this initial, exploratory study opens exciting avenues for further research into business analytics and, business intelligence pipelines.

Setting the Stage for Research on Aftermarket Production Systems in Operations Management

Clemens Gróf, Torbjørn H. Netland

ETH Zurich, Switzerland

Reduction of resource consumption is essential to the Sustainable Develop-ment Goals. One key strategy for achieving this is product life-extension. Products can be maintained or remanufactured to a condition that is better than new. A fragmented literature uses terms such as remanufacturing, maintenance, repair, and overhaul (MRO), or simply service, to refer to vari-ous forms of product life-extension. Even though different terms are used, these operations share common characteristics and challenges that are dis-tinctive compared to traditional manufacturing. Addressing the ambiguous use of terms for product life-extending operations and the fragmented body of knowledge, we introduce Aftermarket Production Systems (AmPS) as an umbrella term for industrialized product life-extending operations. The pur-pose of this paper is to provide an overview of AmPS-related literature and to discuss future directions for research on industrialized product life-extending operations.

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Lean and Six Sigma in Services Healthcare

Time: Tuesday, 07/Sept/2021: 6:15pm - 8:15pm

Lean Transformation in Healthcare: A French Case Study

Anne Zouggar[1], benjamin Garel[2], Bruno Vallespir[1]

[1]Ims Lab, University of Bordeaux, France; [2]CHU de Martinique

Evidence from current publications mainly US, UK, Canada and recently Europe has highlighted the relevancy of Lean healthcare in improving patient pathway efficiency. The aim of this case study is to demonstrate how the French public hospital succeeded at using Lean thinking, and how, using the Lean tools with the team's involvement, it improved the quality of health services delivered to the patient. Emergency complaints dropped by 50%, length of stay reduced by 30%. This paper highlights how Lean was implemented to revolve around the patient, creating valuable results which improved the global performance, whilst maintaining employees' involvement and satisfaction. Two Lean experiences in hospital units are described showing the reduction of wastes and the possible monitoring of KPI to sustain Lean pillars Jidoka and JIT. These two first Lean experiences are not alone, more hospital services have been experiencing Lean approaches and more results will be communicated soon in wider publication.

A Robust Home Health Care Scheduling and Routing Approach with Time Windows and Synchronization Constraints under Travel Time and Service Time Uncertainty

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Home health care (HHC) services represent a set of medical services given to patients at their homes. The patients require a set of care that must be coordinated and treated by skilled caregivers corresponding to their needs. This study proposes an HHC routing and assignment approach based on a mixed-integer linear programming model that aims to minimize total route cost. The HHC approach takes into account a set of HHC specific constraints and criteria. Secondly, we propose a new robust counterpart HHC model under uncertainty based on the well-known budgeted uncertainty set. The robust counterpart HHC model deals with travel and service times uncertainty. The computational results compare the deterministic model with its robust counterpart model. The small and medium instances have been solved using TSP benchmarks with specific data concerning HHC problems. The models have been implemented using ILOG CPLEX Optimization Studio. The computational results of small and medium instances indicated the efficiency of the proposed approach. Robustness analysis of the obtained results was conducted using a Monte Carlo simulation and indicated the price of robustness. The increase of route cost in comparison with the risk of infeasibility shows the importance of the designed robust routes for HHC routing and scheduling problems.

Lean Healthcare Applied Systematically In The Basic Image Examination Process In A Medium-sized Medical Clinic

Samuel Martins Drei[1], Paulo Sérgio de Arruda Ignácio[2], Antônio Carlos Pacagnella Junior[2], Li Li Min[3], Thiago Augusto de Oliveira Silva[4]

[1]Fluminense Federal University; [2]School of Applied Sciences, Campinas State University; [3]School of Medical Sciences, Campinas State University; [4]Institute of Exact and Applied Sciences, Federal University of Ouro Preto

The objective of this paper is to propose a systematic application of Lean Healthcare in the activity of fetching the next patient in the X-ray examination process. The methodology used is based on two pillars: the first, called a survey, aims to map the process in which the focus activity is inserted and, thus, obtain the associated waste, identifying the root cause of what will be treated. Then, the proposed Lean pillar will propose a tool to remedy the waste in question, applying the necessary actions within a schedule and, finally, collecting the results and comparing them with the initial measurement. As a result, there is an improvement in the hospital processes from the Lean perspective, specifically in the activity of fetching the next patient, in the X-Ray examination, reducing the non-added value identified in this activity, that is, in the waiting time of the patient. As conclusions, it was possible to obtain concrete information about the implementation of this proposed systematic application, so that it can be replicated in other wastes, generating a systematic proposal, filling a gap in the literature, which covers the lack of fully structured studies with practical results of Lean Healthcare systematics in the medical clinic wing of hospitals.

Application of VSM for improving the medical processes - case study

Katarzyna Antosz[1], Aleksandra Augustyn[2], Małgorzata Jasiulewicz – Kaczmarek[3]

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Lean Manufacturing has been used in many types of organizations, including healthcare. In the healthcare area, lean healthcare is a management philosophy to develop a hospital culture characterized by increased patient, and other stakeholder, satisfaction through continuous improvements. The starting point for improving activities in the healthcare is identification of the problems and wastes in the processes. In this context VSM is a helpful tool. That why the purpose of this paper is to present the possibility of application the VSM for improving the selected process in the healthcare. Thanks to the application of this method, the necessary information on the sources of losses in the analyzed process was obtained.

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DMAIC: a proposed method to improve the cleaning and disinfection process in hospitals

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Introduction: The hospital environment influences the chain of transmission of pathogenic microorganisms linked to the incidence of infections, making cleaning and disinfection (L&D) management measures necessary in order to contribute to patient safety. This study aimed to propose the viability of using the Lean Six Sigma approach in the management and improvement of the hospital terminal hy-giene process. Method: Exploratory descriptive research, through a theoretical survey of tools used in the Lean Six Sigma approach. The DMAIC method, was used as a guide for this project hypothesis of management of the process of ter-minal hygienization of beds of a University Hospital in the city of Rio de Janeiro. Results: In the definition and organization phase of the project, the terminal sani-tization process can be mapped through the VSM diagram and by an employee interview instrument during GEMBA. L&D quality assessment tools like fluo-rescent markers, ATP test and microbiological cultures can serve as pre and post indicators for possible improvement interventions. Tools such as: Current Reality Tree; GUT matrix; Prioritization matrix and 5W2W plan have proven to be good choices for the analysis and improvement phases. Finally, audits, visual and par-ticipative management, indicator reports for maintenance of actions can be done. Conclusion: The application of the DMAIC method of the Lean Six Sigma ap-proach in hospital cleaning processes proved to be objective and feasible accord-ing to the proposed method, presenting itself as an alternative basis for future projects in the area.

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Production Management in Food Supply Chains

Time: Tuesday, 07/Sept/2021: 6:15pm - 8:15pm

Use of Paraconsistent Logic Evidential Annotated Eᴛ in Logistic Systems

Liliam Sayuri Sakamoto, Jair Minoro Abe, Luiz Antonio Lima, Nilson Amado de Souza, Jonatas Santos de Souza, Angel Antonio Martinez

Universidade Paulista - UNIP, Brazil

In this article, the traditional Logistics Systems were analyzed in the use of vehicle tracking modules that use traditional processes and classic logic, with a proposal for digital transformation and implementation of the use of Eᴛ Annotated Paraconsistent Logic for optimization and reduction of risk exposure of the cargo transport process. The methodology used was the use of the para-analyzer algorithm, with selection of specialists on the issues of improvement, use of applied logic questionnaires. The main results were compared to the Case Study of the Volkswagen Modular Consorti-um and Agrobusiness Company systems critical incident, from a logistical point of view, in which the three main factors arising from this study that can prove the implementation of this innovation.

Integrated Workforce Scheduling and Flexible Flow Shop Problem in the Meat Industry

Beatrice Bolsi[1], Vin´ıcius Loti de Lima[2], Thiago Alves de Queiroz[3], Manuel Iori[1]

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We address a problem from a meat company, in which orders are produced in two stages, consisting of preparing meats on benches and allocating them to conveyors to be packed in disposable trays. In an environment where machines are unrelated, the company has to take daily decisions on the number and start time of working periods, the number of workers and their allocation to machines, and the scheduling of activities to satisfy the required orders. The objective of the problem is to minimize, in a lexicographic way, the number of unscheduled activities, the weighted tardiness, and the total production cost. To solve the problem, we propose a multi-start random constructive heuristic, which tests different combinations of number of workers in the machines and for each combination produces many different schedules of the orders. The results of our computational experiments over realistic instances show that the heuristic is effective and can support the company on its daily decisions.

Scheduling of parallel print machines with sequence-dependent setup costs: A real-world case study

Manuel Iori[1], Alberto Locatelli[1], Marco Locatelli[2]

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In the present work, we consider a real-world scheduling problem arising in the color printing industry. The problem consists in assigning print jobs to a heterogeneous set of flexographic printer machines, as well as in finding a processing sequence for the sets of jobs assigned to each printer. The aim is to minimize a weighted sum of total weighted tardiness and total setup times. The machines are characterized by a limited sequence of color groups and can equip additional components (e.g., embossing rollers and perforating rolls) to process jobs that require specific treatments. A job is characterized by a sequence of colors and, during its print, each color takes exactly a color group, respecting a specific chromatic order. The process to equip a machine with an additional component or to clean a color group takes a long time, with the effect of significantly raising the setup costs. Furthermore, the time required to clean a color group between two different jobs depends directly on the involved colors.

To tackle the problem, we propose a constructive heuristic followed by some local search procedures that are used one after the other in an iterative way. Extensive tests on real-world instances prove that the proposed algorithm can obtain very good-quality solutions within a limited computing time.

Food Exports from Brazil to the United Kingdom: An Exploratory Analysis of COVID-19 Impact on Trade

JOAO GILBERTO MENDES DOS REIS[1], SIVANILZA TEIXEIRA MACHADO[2], EMEL AKTAS[3]

[1]Universidade Paulista, Brazil; [2]Instituto Federal de São Paulo, Brazil; [3]Cranfield University, United Kingdom

Brazil and the UK have been strategic partners throughout the years. While the former has traded minerals and food products – mainly agricultural commodities – the latter has been critical to infrastructure development in the South American country. However, the Crisis of COVID-19 Pandemic altered the scenario of international food production and distribution. This article aims to analyse Brazilian food exports to the UK in 2019 and 2020 to identify the impact of COVID-19 on the trade flows. To do so, we collected data from the Brazilian Ministry of Economy regarding the exports between the two nations and performed an exploratory investigation using graphical and quantitative analysis. The results suggest that the Pandemic crisis rose Brazilian exports of cereal and grains to the UK by around 50%, and the shortage of these items in the internal market has increased consumer prices by more than 60% during 2020.

Optimization Strategies for In-Store Order Picking in Omnichannel Retailing

Xiaochen Chou[1,2], Nicola Ognibene Pietri[2], Dominic Loske[3,5], Matthias Klumpp[4,5,6], Roberto Montemanni[2]

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The COVID-19 pandemic is changing consumer behavior and accelerating the acceptance of online grocery purchases. Hence, traditional brick-and-mortar retailers are developing omnichannel solutions enabling also online purchases, for example, according to Buy-Online-Pick-up-in-Store concepts. Efficient omnichannel supply chains increasingly rely on optimized policies. This requires efficient order picking, not only within dedicated warehouses but also in grocery stores when processing online orders. Optimization concepts like sequential ordering problems, arise to model realistically products picking throughout the store shelfs. We discuss such an approach based on real-life data from a German retailer, and we propose a pathway for arriving at solutions to the problem.

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Recent Advances in Sustainable Manufacturing

Time: Tuesday, 07/Sept/2021: 6:15pm - 8:15pm

Sustainable Process Plan Generation in RMS: A Comparative Study of Two Multi-objective Evolutionary Approaches

Imen Khettabi[1], Lyes Benyoucef[2], Mohamed Boutiche[1]

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In today's manufacturing industry, staying competitive requires being both cost and time effective, as well as being environmentally benign. In this paper, two versions of the well-known non-dominated sorting genetic algorithm (NSGA) namely Dynamic-NSGA-II and NSGA-III are proposed and compared to solve an environmental oriented multiobjective single unit process plan generation problem in a reconfigurable manufacturing environment. In addition to the traditional total production cost and total production time, two other criteria namely, total amount of hazardous liquid waste and total amount of greenhouse gases (GHG) emitted are minimized. Firstly, a non-linear multi-objective integer program (NL-MOIP) is proposed. Secondly, to illustrate the efficiency of the two approaches, several instances of the problem are experimented and the obtained results are analyzed using three metrics respectively spacing metric, inverted generational distance and cardinality of the mixed Pareto fronts.

The most critical decisions in manufacturing: Implications for a Circular Economy

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Through product development and design, manufacturers wield great influence on the entire product's life cycle resulting in creating value to customers and thus, have great potential to decouple this value provision from linear resource consumption to a Circular Economy (CE). However, since CE is a systemic concept rooted in the principle of conservation of resources, its implementation cannot only be done in one of the firm's functions or facilities, as it requires collaboration and commitment enterprise wide and conscious management of stakeholders. In view of this, the current research focuses on the identification and evaluation of the most critical decisions in manufacturing and how they may impact the implementation of CE. In so doing, this study contributes with building a solid base of empirical research on CE in the manufacturing sector, hence contributing to literature on CE and manufacturing.

How is value created in the circular economy? Evidence from remanufacturing and repair businesses

Melissa C Marques, Umit S Bititci, Amos P Haniff

Edinburgh Business School, Heriot-Watt University

The circular economy refers to a cluster of strategies which are necessary in the pursuit of more sustainable production-consumption systems. In despite of the importance of repair and remanufacturing in the context of circular economy and sustainability, research in value creation within this sector is limited. There is little empirical evidence pertaining to the different ways that repair and remanufactur-ing activities can contribute to value creation across firms. This study therefore aimed to investigate value creation in the circular economy, particularly in context of fifteen repair and remanufacturing firms. Through a multi-method approach, data pertaining to value creation strategies were collected in both original equip-ment manufacturers (OEMs) and non-OEMs, and inductively analyzed with the aid of mapping tools. As a result, four generic patterns of value creation were identified, expanding upon previous literature by highlighting that 'OEM status' and 'servitization' are important variables of value generation.

Modeling the Parallel Machine Scheduling Problem with Worker- and Position-Dependent Processing Times

Jairo R. Montoya-Torres[1], Valerie Botta-Genoulaz[2], Nick Materzok[2], Þorgeir Páll Gíslason[2], Sélène Mendiela[2]

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Traditional deterministic scheduling problems consider that processing times of jobs are fixed and constant over time. However, this assumption is not realistic in practice in hand-intensive manufacturing contexts. To deal with this, the current paper studies the deterioration effect of processing times on a parallel machine scheduling problem. In such a case, job processing times depend on the position of jobs in the execution sequence. The objective function is the minimization of the maximum delay of the set of jobs, that is the makespan. A mixed-integer linear programming model is provided for the basic case in which the processing time of jobs deteriorate only as a function of their position in the schedule. Then, two original ex-tensions are proposed. The first one considers that both the position and the worker do impact the processing time, while in the second situation workers can have a break after a given period of time. Preliminary experiments are carried out to illustrate the impact of such situations on the objective function. Results are promising.

Challenges in Setting up a Production Line during Pandemic

Kiwook Jung[1], Scott Nieman[2], Boonserm Kulvatunyou[3]

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The pandemic caused by COVID-19 brought on many challenges. Sustaining manufacturing production is one of them. Some market segments may experience reductions in demands, while other market segments may experience explosions in demand. Companies have to manage these changing needs and supply uncertainties while keeping employees safe and remaining profitable. This paper characterizes the problems encountered in setting up new production lines in two different industries and describes solutions adopted and envisioned.

Regular Session: Improvement models and methods for green and innovative systems

Time: Wednesday, 08/Sept/2021: 12:00pm - 2:00pm

Generation Y – Modularity Enabling Radical Innovation

Bjørnar Henriksen[1], Carl Christian Røstad[2]
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SMEs, in particular, have challenges working purposefully with innovation and development, as this is in a continuous conflict with day-to-day operations. The innovation work is therefore often random and characterized by further develop-ment of existing product / production, or with technology suppliers setting the agenda. Traditionally, a distinction is made between stepwise / incremental and radical innovations. The latter involves creating new products, services, processes or mindsets (Generation Y) that can outdate existing ones (Generation X). Radi-cal innovations require conceptual and long-term thinking, and often require large amounts of resources that make it challenging to succeed. Incremental innova-tions, often via further development / improvement of existing products and pro-duction systems, occur far more frequently, and the overall effect of gradual in-novations can be significant. But the step-by-step innovations can be unstructured and do not necessarily contribute in a direction that ensures long-term competi-tiveness in relation to Generation Y. Through three different (but connected) pro-jects, we have approached different aspects of aiming to enable a more modular, but radical innovation process. This involves the development of solutions to concretize the future concepts for product / production through reference models, define the various innovation steps (modules), and solutions to follow up the path towards radical innovation (Generation Y).

Disassembly Line Balancing using Recursive Optimization in presence of Task-Failure

Rakshit Kumar Singh, Amit Raj Singh, Ravindra Kumar Yadav
National Institute of Technology, Raipur, India

Disassembly lines have to face task-failure situations due to the variability in quality of incoming product. Such failure violates the precedence relationship for the remaining task at downstream stations. Therefore, task failure requires corrective measure to improve the profitability of disassembly line. In this paper, a recursive optimization approach has been proposed to improve the profitability of disassembly lines, which takes corrective measure to determine optimal sequence of tasks. For this purpose, Teaching Learning Based Optimization (TLBO) algorithm has been used to find optimal sequences before and after task failure. To reduce the computational time required during recursion, the proposed solution approach is equipped with memoized list for finding corrective measure. A numerical illustration has been used to demonstrate the applicability of proposed solution approach which is capable to handle high variability in quality of incoming products.

Quantity-flexibility contract models for the supply chain with green-sensitive demand in the automotive manufacturing industry

ZHE YUAN[1], Yeming GONG[2], Mingyang CHEN[3]
[1]Leonard de Vinci Pôle Universitaire, Research Center, France; [2]EMLYON Businees school, France; [3]Business School, Henan University, China

This paper considers a quantity-flexibility contract with green-sensitive demand in the automotive industry. The automobile manufacturer determines the green level, and the retailer determines the retail price. The authors apply game theory to build the models, optimize the green level for maximizing the automobile manufacturer's profit, and optimize the retail price for maximizing the retailer's profit. We consider the equilibrium decision between the green level and the retail price to maximize the supply chain's profit. Furthermore, we conduct experiments to verify our analysis results. Interestingly, this study finds that it is optimal for the retailer in the decentralized case to charge a higher price when the green sensitivity increases. However, the optimal price in the centralized case is not necessarily monotonic when the demand is lower. The manufacturer should set a higher green level as the greening investment parameter increases. The setting of the retail price and the green level can affect the value of the quantity-flexibility contract.

How much green investments are efficient for a smart production system?

Rekha Guchhait[1], Mitali Sarkar[2], Biswajit Sarkar[1]
[1]Yonsei University; [2]Chung-Ang University

The increasing global warming effect on the environment is massive nowadays and the production industry is trying to reduce carbon emission to the minimum level. This study investigates the effect of green investment in a smart production system under the effect of energy. The effect of the green movement is depicted on the customer satisfaction level. The machine produces imperfect products at a random time and gets reworked within the same cycle. The system failure rate relates the imperfect production with reliability. The mathematical model is solved by the classical optimization procedure and found the global optimum solution. Managerial insights are provided to show the applicability of the model. Results find that the carbon reduction due to the green investment and customer satisfaction holds a wide margin of the profit.

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DDMRP buffer positioning considering carbon emissions

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Firms are more and more interested in reducing the carbon footprint related to their activity. Their supply chain remains one of the main sources of carbon emissions. Better operational routines and planning adjustments have proven to be an effective way to reduce the carbon emissions but not enough. In this paper, the carbon footprint is taken into consideration in the Demand Driven Material Requirement Planning (DDMRP) strategic buffer positioning problem. The focus is put on the storing activities and transportation, for which a function was proposed to quantify the associated emissions. Two environmental regulations are simulated: carbon emissions tax and carbon emissions cap. These approaches have been implemented in a buffer positioning model with a cost minimization objective function. The resulting models were solved using CPLEX solver for multiple instances. The numerical results provide a better measurement of the buffer positioning impact on the carbon emissions. The observed sensibility of the problem to the environment parameters would give insights for further research work.

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Regular Session: AI-based approaches for quality and performance improvement of production systems

Time: Wednesday, 08/Sept/2021: 12:00pm - 2:00pm

A Neural Network Model for Quality Prediction in the Automotive Industry

Anders Risan, Mohamed Kais Msakni, Peter Schütz

The Norwegian University of Science and Technology, Norway

In this paper, we present a machine learning application for the automotive industry. We study the use of neural networks to predict the location of milled holes in a bumper beam using historical measurement data. The overall goal of the study is to reduce the time needed for quality control procedures as the predictions can supplement manual control measurements. Our preliminary results indicate that the neural network can generally capture the production process variations, but underestimates larger deviations from the specified location.

AI and BD in Process Industry: a literature review with an operational perspective

Rosanna Fornasiero[1], David Nettleton[2], Lorenz Kiebler[3], Alicia Martinez de Yuso[4], Chiara Eleonora De Marco[5]

[1]CNR, Italy; [2]IRIS; [3]IML Fraunhofer; [4]ZLC; [5]ciaotech

Among digital technologies, Artificial Intelligence (AI) and Big Data (BD) have proven capability to support different processes, mainly in discrete manufacturing. Despite the fact that a number of AI and BD literature re-views exist, no comprehensive review is available for the Process Industry (i.e. cements, chemical, steel, and mining). This paper aims to provide a comprehensive review of AI and BD literature to gain insights into their evo-lution supporting operational phases of the Process Industry. Results allow to define the areas where AI/BD are proven to have greater impact and areas with gaps in the like for example the process control (predictive models) ar-ea, machine learning and cyber-physical systems technologies. The sectors lagging behind are Ceramics, Cement and non-ferrous metals. Areas to be studied in the future are the interaction between intelligent systems and humans and the external environment, and the implementation of AI for the monitoring and optimization of parameters of different operations.

Implementing an Online Scheduling Approach for Production with Multi Agent Proximal Policy Optimization (MAPPO)

Oliver Lohse, Noah Pütz, Korbinian Hörmann

Siemens AG, Germany

The manufacturing process relies on a well-coordinated schedule that optimally incorporates all available resources to achieve maximum profit. In the case of machine breakdowns, the created schedule does not contain information on how to proceed further. Manual adjustments to the process order do not guarantee optimal utilization of the available resources, as many interconnections of the manufacturing process are not evident to a human. A reliable method is needed that can react to changing conditions on the shop floor and form well-founded decisions to mitigate negative effects. This paper presents an approach to implement Multi Agent Reinforcement Learning for online scheduling a cell-based manufacturing environment with unpredictable machine breakdowns. The developed "Multi Agent Proximal Policy Optimization"-Algorithm (MAPPO) combines already existing approaches in a novel way, by using the centralized learning and dezentralized execution together with an objective function developed for OpenAIs Proximal Policy Optimization algorithm.

Operation Twins: Synchronized Production-Intralogistics for Industry 4.0 Manufacturing

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The widespread adoption of Industry 4.0 technologies in factories are transforming manufacturing operations management. Multiple resources are interconnected, massive data are real-timely collected by smart devices to provide visibility and traceability. It is generally acknowledged that real-time data are beneficial for manufacturing operations management. How to utilize these data for facilitating production and intralogistics (PiL) operations management is an emerging challenge. This study proposes a new concept, operation twins, for achieving synchronized PiL operations based on three dimensions of synchronization (cyber-physical synchronization, spatial-temporal synchronization, and data-driven decisions synchronization).

Regular Session: Classification and data management methods

Time: Wednesday, 08/Sept/2021: 12:00pm - 2:00pm

Dissimilarity to class medoids as features for 3D point cloud classification

Sylvain Chabanet, Valentin Chazelle, Philippe Thomas, Hind Bril El-Haouzi

CRAN, France

The sawmilling industry disposes of several simulators able, taking into account a 3D scan of the shape of a log, to numerically simulate the set of lumbers that would be obtained by transforming it at a given sawmill. Considering that those simulators can be computationally intensive, several authors have proposed to use quicker Artificial Intelligence metamodel. Such models can approximate a simulator result using a vector of descriptive features representing a log, or, alternatively, the full 3D log scans. This paper proposes to use dissimilarity to representative log scans as features to train a Machine Learning classifier.

A Comparative Study of Classification Methods on the States of the USA based on COVID-19 Indicators

İbrahim Miraç ELİGÜZEL[1], Eren ÖZCEYLAN[2]

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COVID-19 spreads across the world and specific pre-caution strategies are required for different regions depending on the current satiation. Therefore, proper region-specific pre-caution processes occupy a significant place to tackle with COVID-19 pandemic. During the COVID-19 pandemic, significant data are cumulated and these data can be utilized in order to cope with pandemic efficiently via providing a better understanding for decision-makers. In the aforementioned aspect, data related to the COVID-19 pandemic is used to decide on group states where the application of the same pre-caution processes has become efficient and effective. Therefore, COVID-19 indicators (e.g. number of deaths and infected) can be utilized to cluster the states, regions, countries, etc. In order to accomplish the underlined objective, data with seven features (rate of one dose, rate of two doses, number of cases, death, tests, recovered people, and percentage of positive tests) are retrieved for each of 50 states in the USA. After that, a dissimilarity matrix for cities is generated with respect to the corresponding seven features. Lastly, clustering methods (K-means, Agglomerative Hierarchical and BIRCH clustering, and P-median model) in literature are applied to gather clusters of states. In the proposed study, 50 states are taken into consideration and four different methods are applied to divide states into 6 subsets. The best result is gathered via the K-means application.

Maintenance data management for condition-based maintenance implementation

Humberto Teixeira, Catarina Teixeira, Isabel Lopes

ALGORITMI Research Centre, University of Minho, Guimarães, Portugal

The ability to rapidly obtain significant and accurate information from extensive data records is a key factor for companies' success in today's competitive environment. Different machine learning algorithms can be used to extract information from data. However, to enable their application appropriate data structures must be defined. In addition, the quality of data must be ensured to allow appropriate decisions to be made based on the resulting information. Condition-Based Maintenance (CBM) decisions usually result from the analysis of the combination of data monitored on equipment with events data, such as failures and preventive maintenance interventions. Thus, to enable CBM implementation, data from equipment maintenance history should be properly organized and systematized. This paper presents a study performed in a manufacturing plant with several production lines. A structure to properly organize the failure records data and an overall data structure, including data events and monitored data, were defined to enable the application of CBM. The information obtained based on the data structure for the failure records allowed prioritizing the failure modes of a machine for CBM implementation.

A machine learning based health indicator construction in implementing predictive maintenance: A real world industrial application from manufacturing

Harshad Kurrewar, Ebru Turanoglu Bekar, Anders Skoogh, Per Nyqvist

Chalmers University of Technology, Sweden

Predictive maintenance (PdM) using Machine learning (ML) is a top-rated business case with respect to the availability of data and potential business value for future sustainability and competitiveness in the manufacturing industry. However, applying ML within actual industrial practice of PdM is a complex and challenging task due to high dimensionality and lack of labeled data. To cope with this challenge, this paper presents a systematic framework based on an unsupervised ML approach by aiming to construct health indicators, which has a crucial impact on making the data meaningful and usable for monitoring machine performance (health) in PdM applications. The results are presented by using real-world industrial data coming from a manufacturing company. In conclusion, the designed health indicators can be used to monitor machine performance over time and further be used in a supervised setting for the purpose of prognostic like remaining useful life estimation in implementing PdM in the industry.

Development of Convolutional Neural Network Architecture for Detecting Dangerous Goods for X-ray Aviation Security in Artificial Intelligence

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Aviation-security X-ray equipment is used to screen objects, while human screeners re-examine baggage and travelers to detect prohibited objects. Arti-ficial Intelligence technology is applied to increase the accuracy in searching guns and knives, considered the most dangerous in X-ray images at baggage and aviation security screening. Artificial intelligence aviation security X-ray detects objects, finds them rapidly, reducing screeners' labor, thereby providing better service to passengers. In this regard, neural networks based on machine learning have been continuously updated to develop such ad-vanced equipment. In this study, the neural network O-Net is developed to improve object detection. O-Net is developed based on U-Net. The devel-oped O-Net is tested for various neural networks, providing a wide range of experimental results.

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Supply Chain Risk Management under Coronavirus

Time: Wednesday, 08/Sept/2021: 12:00pm - 2:00pm

Stochastic integrated supplier selection and disruption risk assessment under ripple effect

Ming Liu[1], Zhongzheng Liu[1], Feng Chu[2], Feifeng Zheng[3], Chengbin Chu[4]

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The impact of the COVID-19 pandemic in the supply chain (SC) evokes the need for valid measures to cope with the SC disruption risk. Supplier selection and disruption risk assessment, as valid measures, have received increasing attentions from academia. However, most of existing works focus on supplier selection and disruption risk assessment separately. This work investigates an integrated supplier selection and disruption risk assessment problem under ripple effect. The objective is to minimize the weighted sum of the disrupted probability and the total cost for the manufacturer. For the problem, a new stochastic programming model combined with Bayesian network (BN) is formulated. Then, an illustrative example is conducted to demonstrate the proposed method.

A new robust dynamic Bayesian network model with bounded deviation budget for disruption risk evaluation

Ming Liu[1], Tao Lin[1], Feng Chu[2], Feifeng Zheng[3], Chengbin Chu[4]

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Dynamic Bayesian network (DBN), combining with probability intervals, is a valid tool to estimate the risk of disruptions propagating along the supply chain (SC) under data scarcity. However, since the approach evaluate the risk from the worst-case perspective, the obtained result may be too conservative for some decision makers. To overcome this difficulty, a new robust DBN model, considering bounded deviation budget, is first time to be developed to analyse the disruption risk properly. We first formulate a new robust DBN optimisation model with bounded deviation budget. Then a linearization technique is applied to linearize the nonlinear bounded deviation budget constraint. Finally, a case study is conducted to demonstrate the applicability of the proposed model and some managerial insights are drawn.

A tabu search heuristic for the robust dynamic bayesian network optimisation problem under the supply chain ripple effect

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Due to the impact of the global COVID-19, supply chain (SC) risk management under the ripple effect is becoming an increasingly hot topic in both practice and research. In our former research, a robust dynamic bayesian network (DBN) approach has been developed for disruption risk assessment, whereas there exists a gap between the proposed simulated annealing (SA) algorithm and commercial solver in terms of solution quality. To improve the computational efficiency for solving the robust DBN optimisation model, a tabu search heuristic is proposed for the first time in this paper. We design a novel problem-dependent neighborhood move to keep the search in feasible solution space. The computational experiments, conducted on randomly generated instances, indicate that the average gap between our approach and commercial solver is within 0.07%, which validates the performance of the proposed method.

Pharmaceutical Supply Chain risk assessment in the time of COVID 19/ Case Study

Jihene Jlassi[1], Jihene Jlassi[2], Jihene Jlassi[3]

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As of March11, 2020 the world Health Organization (WHO) declared Corona virus disease 2019 (COVID-19) as a pandemic. The disastrous outbreak of Covid-19 is described as humanity's worst crisis since World War II. Effectively, not only has it caused severe disruptions around the world at different levels –social, economic, political-but it has also acutely disrupted supply chains worldwide. Pharmaceutical supply chain is a significant component of the health system as to supplying medicines. Today, pharmaceutical companies face a tremendous array of risks. The goal of this study is to determine therisk assessment in pharmaceutical industry in Tunisia during this challenging period due to COVID-19pandemic. We suggest the fuzzy AHP method to identify the most important risk.

APMS 2021 Conference | Artificial Intelligence for Sustainable and Resilient Production Systems

Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

System Identification for Manufacturing Control Applications

Time: Wednesday, 08/Sept/2021: 12:00pm - 2:00pm

Application of Linear Random Processes to Construc-tion of Diagnostic System for Power Engineering Equipment

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Some mathematical models of informational signals and methods of the diagnos-tic system construction is considered. Different type of linear random processes is recommended for application. Some properties of the random processes are discussed. Application of the models depends on many factors. Such processes are used for classification of stochastic informational signals in the case of non-Gaussian distribution realizations of the signals, which energy spectra (within the framework of the first two moments) possess is often not enough for reliable recognition and classification of such signals. It is expedient to use information on higher moments or statistical characteristics of distributing such signals. It is possible to use the higher-order moments of such signals realization as the diag-nostic features and provided the increase in accuracy and reliability of Power En-gineering Equipment diagnostics. Attributes at the power engineering equipment diagnostic system construction are above mentioned justified diagnostic features, as well as informational diagnostic signals having been justified by the investiga-tion of the appropriate mathematical models. Obtaining numerical estimation of chosen diagnostic features is first of all necessary for forming teaching complex-es, and, further, for conducting the diagnostics itself according to the formed teaching complexes. Some peculiarities of constructing the multilevel diagnostic systems for resilience operation of electric power facilities are considered. An ex-ample of 3-level diagnostic system development for a Power station is represent-ed.

Data Analysis and Production Process Control

Bo Yang[1], Yumin He[2], Honghao Yin[1]

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Production process control is an important issue. Production processes are affected by many factors and some processes are very complex. Statistical process control (SPC) can apply statistical methods to monitor and control production processes for quality improvement. SPC methods include control charts and process capability analysis. This paper presents a method for continuous production process improvement. The control flow of the proposed method is developed. The method identifies the production process to be improved, collects and verifies data, applies Xbar-R control chart analysis and process capability analysis, analyzes the causes, forms measures for improvement, and takes actions for the improvement. An application example is provided. The results of the study indicate the quality improvement of their production process. This research can provide a reference for companies to apply SPC methods and statistical tools and take process capability analysis and control chart analysis for production process control to improve the quality of production processes.

Product Quality Improvement based on Process Capability Analysis

Na Zhao[1], Yumin He[2], Mingxin Zhang[1], Gaosheng Cui[1], Fuman Pan[1]

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Product quality is important to companies. Many factors affect the quality of products. Statistical process control (SPC) applies statistical methods to process control and can be utilized to improve the quality of products. This paper proposes an approach for product quality improvement based on problem analysis and statistical process control application. A framework is presented with the steps from problem identifying to problem solving to improve product quality. These steps include problem identification, problem analysis, SPC method determination, production analysis, cause analysis, and problem solving. A case study is made to a real manufacturing company. The proposed approach is applied to the company. The case company identified its production problem and made the actions on the production process improvement with the good result of product quality improvement. This research can provide a reference for manufacturing companies to apply SPC methods and statistical tools to production process control for product quality improvement.

Software Architecture for an Active Device Driver in Reconfigurable Manufacturing Systems

Jeongha Shin, Duck Young Kim

Pohang University of Science and Technology, Korea, Republic of (South Korea)

Flexible and reconfigurable manufacturing systems aim to enable more versa-tile, connected, and intelligent operations not only from a system-level per-spective, but also from a field-level perspective. This paper focuses on field-level applica-tions for peripheral intelligence and proposes a concept and ar-chitecture for an Active Device Driver (ADD) that can be actively adjusted to unforeseen situations versus repeating fixed task procedures. This new device driver is designed to permit easy and rapid transformability to systems by ena-bling device moduliza-tion and abstraction, control and configuration under service-oriented architecture, actively supporting control reliability, and pro-ducing well-organized manufacturing data. These features can be achieved by implementing the control I/O encapsulating module, device information mod-el, OPC-UA server interface, and peripheral control module. Two case studies with robot grippers are con-ducted to validate the working principle of ADDs.

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Smart and sustainable production and supply chains

Time: Wednesday, 08/Sept/2021: 12:00pm - 2:00pm

A literature review on smart technologies and logistics

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The emergence of smart technologies has brought substantial changes in logistics. Hence, understanding smart technologies applied in logistics has become critical for practitioners and scholars to make smart technologies bet-ter empower logistics activities. Because research on this issue is new and largely fragmented, it will be theoretically essential to evaluate what has been studied and derive meaningful insights through a literature review. In this study, we conduct a mixed-method literature review of smart technologies in logistics. We classify these studies by topic modeling and identify important research domains and methods. More importantly, we draw upon the task-technology fit theory and logistics activities process to propose a multi-level theoretical framework in smart technologies in logistics for understanding the current status in research. We believe that this framework can provide a valua-ble basis for future logistics research.

A Review of Explainable Artificial Intelligence in Production

Kuo-Yi Lin[1,2], Yuguang Liu[1], Li Li[1,2], Runliang Dou[3]

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Artificial intelligence developed rapidly, while people are increasingly concerned about internal structure in machine learning models. Starting from the definition of interpretability and historical process of interpretability model, this paper summarizes and analyzes the existing interpretability methods according to the two dimensions of model type and model time based on the objectives of interpretability model and different categories. With the help of the existing interpretable methods, this paper summarizes and analyzes its application value to the society analyzes the reasons why its application is hindered. This paper concretely analyzes and summarizes the applications in industrial fields, including model debugging, feature engineering and data collection. This paper aims to summarizes the shortcomings of the existing interpretability model, and proposes some suggestions based on them. Starting from the nature of interpretability model, this paper analyzes and summarizes the disadvantages of the existing model evaluation index, and puts forward the quantitative evaluation index of the model from the definition of interpretability. Finally, this paper summarizes the above and looks forward to the development direction of interpretability models.

A robust optimization model for a 2-service community healthcare service network problem

Congke Wang, Guoqing Yang

Hebei University, China, People's Republic of

In this paper, we present a robust model for the 2-service community healthcare service network design problem. The community healthcare service network can determine the locations of central hospital and the allocation of the community medical service stations to minimize costs of the whole network. Beside, we employ the Box+ellipsoidal set to characterize the uncertain parameters. In addition, we reformulate the proposed model into a computationally tractable robust counterpart form. Finally, we verify the validity of the model by a case study.

Research on a preannounced pricing policy in a two-period dual-channel supply chain

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The development of the e-commerce and the fast update of the product have an incentive to widespread attempts at multi-channel with multi-period sales. Prior studies have been mainly focused on revenue management issue in a multi-period traditional channel or a single-period multi-channel. This paper extends these studies by exploring the issue in a multi-period multi-channel context. We propose a two-period dual-channel supply channel model, where the manufacturer sells its product in each period through its direct channel and an independent retail channel. Both channels implement preannounced pricing. The results show that the selling prices of both channels in the first period is higher than those in the second period, and the price rate of change in the retail channel is higher than that in the direct channel. It implies that the manufacturer adopts a deeper discount in the di-rect channel than the retailer does in the retail channel. The numerical anal-ysis reveals that the impact of channel substitutability on the price rate of change in the retail channel is more significant than the direct channel. In addition, the channel substitutability is harmful for the retailer and the manufacturer.

Achieving Circular and Efficient Production Systems: Emerging Challenges from Industrial Cases

Mélanie Despeisse[1], Arpita Chari[1], Clarissa Alejandra González Chávez[1], Xiaoxia Chen[1], Björn Johansson[1], Víctor Igelmo Garcia[2], Anna Syberfeldt[2], Tarek Abdulfatah[3], Alexey Polukeev[4]

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As the need for more responsible production and consumption grows quickly, so does the interest in the concepts of eco-efficiency and circularity. To make swift progress towards sustainability, solutions must be developed and deployed at scale. It is therefore critical to understand the challenges faced by industry to accelerate the uptake of best practices for circular and efficient production systems. This paper presents the emerging issues from three industrial pilots in an on-going collaborative project. We discuss and suggest further work around crucial questions such as: How to deploy circular solutions from lab to industrial scale? How can digitalization support efficient circular processes?

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The Future of Lean Thinking and Practice

Time: Wednesday, 08/Sept/2021: 12:00pm - 2:00pm

Transition towards Circular Economy: An intraorganizational perspective identifying knowledge wastes

Bella B. Nujen[1], Nina Pereira Kvadsheim[2], Deodat Mwesiumo[3], Eivind Reke[4], Daryl Powell[4,5]

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Circular Economy (CE) has been embraced among multiple academics and practitioners alike for some time now. However, in Operations Management it is still in its infancy. Consequently, the dimension of organizational aspects has remained unclear. This study picks up this depict and provides manufacturers with valuable insights regarding in-house product development when transitioning toward CE, which is important as this is where the production starts. To sharpen the under-standing of CE from a theoretical point of view, the study applies Lean thinking as an Organizational learning system where a special focus towards Organizational knowledge is put forward

Heijunka 4.0 – Key Enabling Technologies for Production Levelling in the Process Industry

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Norwegian University of Science and Technology (NTNU), Norway

Abstract. This paper investigates how lean production levelling methods can be better applied in the process industry with support from key ena-bling technologies from Industry 4.0. To investigate such a topic, a litera-ture study is conducted in three main areas, namely production planning in the process industry, Lean Production, and Industry 4.0. Based on the findings from the literature review, a conceptual framework is developed to illustrate the ability of Internet of Things, Big Data Analytics, and the fur-ther integration of IT systems to provide increased reliability for materials, processes, equipment, and forecasts that improves the utilization of Heijunka (production levelling) practices in the process industry.

Lean Production and industry 4.0 Technologies: Link and interactions

Anne Zouggar, bruno vallespir

Ims Lab, University of Bordeaux, France

In current economic environment, two paradigms are sustaining the industrial performance: Lean production and industry 4.0 Technologies. Whatever busi-ness the companies run they have to consider the benefits of Lean and the bene-fits of the arrival of new technologies 4.0. The remaining question is how to consider these two paradigms in successful association to achieve high perfor-mance, reliable products and relevant supply chains. This paper suggests a first attempt to combine those two concepts. Previous works have highlighted the necessity of using both misleading modeling adequate approach of implementa-tion. After browsing the existing studies related to this subject, this contribution shows the interactions that may co-exist between Lean and industry 4.0 tech-nologies. The methodology is based on different analysis with accurate associa-tion of each technology 4.0 and its ability to sustain Lean production approach-es. Bilateral model can rise providing interesting insights to help managers in their transformation strategy often covering Lean and 4.0 technologies imple-mentation.

Lean Six Sigma in knowledge work: A case study from policing and prosecution services

Felix Preshanth Santhiapillai, Chandima Ratnayake

University of Stavanger, Norway

Lean Six Sigma (LSS) continues to greatly interest public sector organizations as a means to continuously improve service performance. However, given the plethora of research and literature on LSS in the public sector, research specifically about LSS in policing and prosecution services, which are dominated by knowledge work, is significantly limited. It is necessary to measure the knowledge work performance, to achieve continuous improvement. This manuscript presents a case study about the use of LSS in the Norwegian police service. It reports on the existing framework of LSS and explicates how to systematically analyse data regarding knowledge work-related waste to identify improvement areas in the criminal justice process. The LSS methodology and framework applied in this study provides a systemic approach that uncovers waste, which gives grounds to holistically analyse and indicate how the current overall process is performing, based on the scope of defects. This study demonstrates the implementation potential of LSS in policing and prosecution services to support managers who are engaged in any form of continuous improvement initiatives. The findings also add evidence to the existing argument on the applicability of LSS in policing services. However, there is a need to further develop and apply the LSS methodology in such a context.

Industry and Services: different Organizational Cultures, same Openness to Lean Implementation?

Paulo Amaro, Anabela Alves, Rui M. Sousa

Centro ALGORITMI, University of Minho, Portugal

Since 1990, attempts to implement lean, especially by production companies, have grown in number and depth. With the publication of the book Lean Thinking, lean projects quickly spread to other activity sectors, but achieving success in such implementations is not something that can be easily accomplished. Research is in progress to identify why some organizations succeed while others do not; one of the findings points to organizational culture as a crucial factor. This means that before implementing lean in a company, its organizational culture should be analyzed, understood, and, eventually, modified, to create the necessary openness for the implementation to be successful. This paper aims to explore the relationship between the organizational culture of companies from industry and services and their openness regarding lean implementation. For this, it was developed and applied a two parts questionnaire: one part involves the four traits of the Denison organizational culture survey and the other part the six dimensions of the Cameron and Quinn model (Competing Values Framework). The questionnaire was applied to the top managers of four companies (one from industry, two from services, and one with both areas). In terms of organizational culture, the findings revealed that in order to move towards successful lean implementation, some companies need to improve specific traits inherent to Denison's approach as well as ensure congruence between the dimensions of the Cameron and Quinn model.

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Intelligent Systems for Manufacturing Planning and Control in the Industry 4.0.

Time: Wednesday, 08/Sept/2021: 3:00pm - 5:00pm

Digital Twin Framework for Machine-Learning Enabled Integrated Production and Logistics Processes

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This paper offers an integrated framework bridging production and logistics processes that employs a machine learning-enabled digital twin to ensure adaptive production scheduling and resilient supply chain operations. The digital-twin based architecture will enable manufacturers to proactively manage supply chain risk in an increasingly complex and dynamic environment. This integrated framework enables “sense-and-respond” capabilities, i.e. the ability to sense potential supplier and production risks that affect ultimate delivery to the customer, to update anticipated customer delivery dates, and recommend mitigating steps that minimize any anticipated disruption. This machine-learning enabled framework senses disruptions at a supplier facility that cascade down the upstream supply chain allowing adaptive changes in the manufacturer’s MES system. Any changes to the production schedule that cannot be accommodated in a revised schedule are propagated across the downstream supply chain alerting end customers to any changes.

Metamodeling of Deteriorating Reusable Articles in a Closed Loop Supply Chain

Eoin Glennane, John Geraghty

Dublin City University, Ireland

In this paper I present a closed loop supply chain for a reusable, deteriorating tool. The tool is used in a manufacturing process on an item in a linear supply chain. A model is created for the linear item supply chain and the tools closed loop supply chain to analyse the interactions between them and various input parameters so that output responses of the system can be modelled. Three approaches are taken to model the system, a brute force factorial design, a modified version of a Latin hypercube space filling design, and a fast flexible space filling design. It is found that all three methods can describe responses that require only a few inputs well but cannot accurately predict more complex responses without all of the relevant factors. Space filling designs should be used if more factors are needed as they minimize the total amount of simulations needed to produce an accurate model.

Demand forecasting for an automotive company with neural network and ensemble classifiers approaches

Eleonora Bottani, Monica Mordonini, Beatrice Franchi, Mattia Pellegrino

Department of Engineering and Architecture, University of Parma, Parma, Italy

This work proposes the development and testing of three machine learning technique for demand forecasting in the automotive industry: Artificial Neural Network (ANN) and two types of Ensemble Learning models, i.e. AdaBoost and Gradient Boost. These models demonstrate the great potential that machine learning has over traditional demand forecasting methods. These three models will be compared to each other on the basis of the coefficient of determination R2 and it will be shown which model has the greatest accuracy.

A Text Understandability Approach for Improving Reliability-Centered Maintenance in Manufacturing Enterprises

Theresa Madreiter, Fazel Ansari

Vienna University of Technology (TU Wien), Austria

Textual data majorly reflects objective and subjective human specific knowledge. Focusing on big data in industrial and operation management, the value of textual data is oftentimes undermined. Optimal use of data reinforces the integrative modeling and analysis of RAM (Reliability, Availability, Maintainability). Data-driven reliability engineering and maintenance management, gains benefit from textual data, especially for identifying unknown failure modes and causes, and solving problems. The scientific challenge is how to effectively discover knowledge from text data and convert it into automated processes for inferential reasoning, predicting and prescribing. This paper outlines how the reliability-centered maintenance in production systems can be improved by explicating and discovering human-specific knowledge from maintenance reports and related tex-tual documents. Hence, a theoretical model for text understanding is proposed, which is demonstrated as a proof-of-concept demonstrator using real world man-ufacturing datasets. The text understanding model is represented by a three-dimensional matrix comprising three indexes, i.e. text readability, word associa-tions within texts as well as sentiment. The implementation of the model as a software prototype involves using text mining techniques and machine learning algorithms. This paper emphasizes on the importance of knowledge extraction from text in the context of industrial maintenance, by demonstrating how an in-creased value of text understandability of maintenance reports correlates to an ear-ly stage detection of failure, the reduction of human failures and leads to an im-mense improvement of explication of human knowledge.

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New trends and challenges in Reconfigurable, Flexible or Agile Production System

Time: Wednesday, 08/Sept/2021: 3:00pm - 5:00pm

Mathematical model for processing multiple parts on multi-positional reconfigurable machines with turrets

Olga Battaïa[1], Alexandre Dolgui[2], Nikolai Guschinsky[3], Fatme Makssoud[4]

[1]Kedge Business School, France; [2]IMT Atlantique, France; [3]National Academy of Science, Belarus; [4]Lebanese University, Lebanon

In this paper, we propose a new mathematical model for the combinatorial opti-mization problem of batch machining at multi-positional machines with turrets. The objective of the optimization is to minimize the total cost. The paper provides the problem definition, all aspects of the mathematical modelling and the results of the model validation through an experimental study.

Assembly line balancing with inexperienced and trainer workers

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In this paper, we present a simple assembly line balancing problem for two different sets of workers: trainer workers who are more experienced and like-ly older, and inexperienced workers who are usually younger and require more time to perform some tasks. Therefore, the main characteristic of this problem is that trainer workers are involved in helping and supporting inex-perienced ones in executing some tasks which are more complicated to be carried out. Moreover, task times vary according to the stations where they can be performed due to different sets of equipment we can find in each of them. The problem is modelled as a linear program and solved optimally by applying it to a real-case application. The developed model can be successful-ly applied in order to help companies to manage a high level of turnover.

FMS Scheduling Integration for Mass Customization

Yumin He[1], Milton Smith[2]

[1]Beihang University, P. R. China; [2]Texas Tech University, United States

In today's manufacturing and supply chain environments, many companies face challenge in responding to customers' requirements quickly and providing customized products quickly at low cost. Mass customization can help companies in providing customized products and services quickly and at a low price. Integrated decision-making has been found effective in many situations. This paper studies the scheduling problem of flexible manufacturing systems (FMSs). The FMS scheduling problem is part of the FMS production and operation management problem. Because the production management of FMSs is very difficult, the FMS scheduling problem is very complicated. Many researchers have investigated the FMS scheduling problem and have developed various approaches for the problem. This paper reviews and summarizes the FMS scheduling research with recent development. In addition, a framework of FMS scheduling integration for mass customization is proposed from the study of FMS scheduling. The control flow of FMS part processing is designed as part of the framework. Future research is also suggested.

A hybrid architecture for a Reconfigurable Cellular Remanufacturing System

Camilo Mejía-Moncayo, Jean-Pierre Kenné, Lucas A. Hof

École de Technologie Supérieure, Canada

Remanufacturing is a practice that postpones the product 'end-of-life,' returning the properties or features of a new product to a used product. This type of process represents an efficient circular economy strategy to extend product life, reducing its footprint. However, remanufacturing systems must reach different challenges related to the uncertainty and its impact on the processes' efficiency. In this sense, this study exposes a hybrid remanufacturing-manufacturing architecture. Here, embedded features from cellular and reconfigurable manufacturing systems facing jointly the system uncertainty by a self-adaptative configuration. The architecture was synthesized in a Mixed Integer Non Linear optimization model, which defines the remanufaturing system configuring the cells and product families, balancing the workloads, establishing the scheduling sequence and quantifying the reconfigurability cost. The result is a system that maintains a continuous production rate by managing its capacity.

Proposal of a methodology to improve the level of automation of an assembly line

Hasnaa AIT MALEK[1,2], Alain ETIENNE[1], Ali SIADAT[1], Thierry ALLAVENA[2]

[1]LCFC, France; [2]Stellantis, France

This paper's aim is to propose a new methodology for organizing and identi-fying the assembly operations that ought to be automated in an automotive assembly line. A state of the art in the matters of automation methods is pre-sented to situate the research work and to analyze the different methods pre-sented in the literature. As a result, there are some lacks in terms of methods that sought to help improve the level of automation. In the last part, the dif-ferent requirements of the methodology are defined, which led to a proposal for a method that respects all the requirements and that allows not only the grouping of operations, but also the analysis of the automation and the line balancing. Finally, and to validate the proposal, three activities of the auto-mation methodology have been applied on a Stellantis assembly line. The re-sult of the study showed that it is possible to group several screwing opera-tions.

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Regular Session: Supply chain and routing management

Time: Wednesday, 08/Sept/2021: 3:00pm - 5:00pm

Reinforcement Learning for Layout Planning – Modelling the Layout Problem as MDP

Hendrik Unger, Frank Börner

Technische Universität Chemnitz, Germany

The layout problem has been a focus point of research in factory planning for over six decades. Several newly emerging techniques for example genetic algorithms have been applied to the problem to generate better solutions closer to practical application. Nevertheless, solving the layout problem without considerable simplification of the base problem still presents a chal-lenge. This publication shows how to model the layout problem in the framework of Markov decision processes (MDP) to apply reinforcement learning as a novel approach for generating layouts. Reinforcement learning (RF) has previously not been applied to the layout problem to the best knowledge of the author. Research in other fields of study shows the enor-mous potential of RF and the capability to reach superhuman performance in a variety of tasks. Although RF may not provide a better solution for finding the global optimum in the layout problem than genetic algorithms or dy-namic programming, we hope to be able to include more constrains that matter for real world planning applications while keeping the calculation time feasibility short for practical application.

Supply chain management by blockchain

Gianfranco Genta[1], Agostino Villa[2], Gianni Piero Perrone[3]

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This paper first presents a formal model of the transactions activated in a blockchain used to manage a supply chain composed by Small-Mid Enter-prises (SME). Such a formal model is based on a correspondence between the decision to be taken by a SME each time a new order is arrived from a down-stream stage of the supply chain, and the formulation of a transaction in a blockchain. Based on this correspondence, a model of the blockchain man-agement of all SMEs included in a supply chain is formulated according to the basic concepts of an event-driven production scheduling problem. The re-sulting blockchain model can be represented by a table showing the interac-tions between a provider and a consumer in terms of smart contract, thus con-necting two stages of the supply chain. The transaction security is assured by secret codes of both the contract and the two actors, namely the provider and the consumer. Applications of blockchain to two SMEs operating in the agro-food sector is briefly described, thus showing the real impact of block-chain-based management in practice situations.

Optimization of Hierarchical Production Planning with Setup Time Feasibility for Effective Supply Chain Management

Guisen Xue, O. Felix Offodile

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In this paper, we propose a two-tier mixed integer linear programming (MILP) model, composed of aggregate production planning (APP) and family disaggregation planning (FDP), to solve the hierarchical production planning (HPP) problem with nontrivial setup times. In addition to disaggregating the aggregate plan in the first period into detailed lot sizing plans as traditional models do, the proposed FDP model optimally adjusts the aggregate plan and eliminates infeasibility arising from the positive setup times. The performance of the proposed model is validated with a case study. Results of the validation show that the proposed model leads to significant cost savings and efficiencies in the supply chain compared to traditional HPP models.

Integrated Planning of IoT-based Smart Bin Allocation and Vehicle Routing in Solid Waste Management

ARINDAM ROY[1,3], APURBA MANNA[2], JUNGMIN KIM[3], ILKYEONG MOON[3,4]

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The internet of things (IoT) is a prominent modern technology that offers robust solutions to modernizing consecutive systems. It accords controlled and calibrated outcomes to streamline smart cities, smart homes, smart industries, and smart environments. In this study, an ultrasonic sensor-based waste filling level is considered on IoT-based waste bins to optimize dynamic routes instead of fixed routes, such that the efficiency of waste collection and transportation can be improved. This article illustrates the time-dependent penalty concept to waste management authorities if these smart bins are not emptied in time after becoming full. This article presents a smart waste management model for smart cities that takes into account both bin allocation costs and routing costs. An innovative meta-heuristic neighborhood search technique is developed to solve the above model. The proposed model is illustrated with some numerical data, and a sensitivity analysis is performed with some parameters. After the waste from smart waste bins is collected, some waste products are recycled and reused through application of the game-theoretic concept involving the South Korean aspect of waste management.

Smart contracts implementation in the allocation of vaccines

MohammadAmin Yazdani, Daniel Roy, Sophie Hennequin

LGIPM, University of Lorraine, Metz, France

The need for the excellent distribution of a supply chain for the different vaccines in disasters to overcome the challenges is critical in today's world. This paper targeted the vaccines' allocation in several periods for the separated demand zones. To discover and make the allocation network more efficient and help the decision-maker decide more wisely, we implemented a smart contract to suggest product allocation in different cases. The cases include the sudden increase and decrease or not so many changes in the demands to see the reactions that happen in the allocation network. Our smart contract tried to decrease the uncovered demands and improve the decision-makers or governments' prediction or about the changes of the demands and evolution of the disease in demand zones. In the end, we discussed the validity and behavior of the proposed smart contract and its benefits.

Regular Session: Robotics and Human aspects

Time: Wednesday, 08/Sept/2021: 3:00pm - 5:00pm

Human-robot collaboration in assembly operations/ Assembly system 4.0

Gursel Suer[1], Najat Almasarwah[2], Jesus Pagan[1], Yuqiu You[1]
[1]Ohio University, USA; [2]Mutah University, Jordan

Manufacturing systems are going through rapid transformation in recent years as a result of various developments in the manufacturing processes, materials, and information technology and also as a result of increased globalization. Several new concepts have been used to capture these developments as advanced manu-facturing, industry 4.0, smart manufacturing, cyber manufacturing among others. Most of these systems involve the Internet of Things (IoT), 3D printing, Weara-ble Robots, Human-Robot Collaboration, etc. This study focuses on allocation of assembly tasks to robot(s) and assembly worker(s) in human-robot collaborative assembly systems 4.0. The main objective is to minimize the cycle time and hence maximize the output with identical processing times and demand. A new method is proposed to allocate tasks of two products to a single robot and a single worker (two resources), the single workstation, where the safety issues are taken into consideration. Two products are run simultaneously in a workstation is to reduce the idle times of both resources. Thus, it is not allowed for the worker and robot to work on the same product simultaneously to avoid any direct contact between them. The proposed method starts with dividing the cycle time for the station into different intervals with unknown and unequal lengths. Afterward, a COMSOAL heuristic is utilized to task allocation to resources (worker and robot). However, the obtained results illustrate the ability of the proposed method to minimize the workstation cycle time and improve productivity.

Methods of Forecasting Environmental Stress and Strain on Working Humans in the Digital Factory

Gert Zülch
Karlsruhe Institute of Technology, Germany

According to the stress-strain concept of ergonomics, a distinction must be made between the stress on the working human and the resulting individual strain. Furthermore, it must be taken into account whether several influences act simultaneously or one of them acts successively. Therefore, point in time-related and period-related influences are to be considered, whereby in the latter case a connection to discrete event-driven simulation is necessary. It has been known for many years that simulation methods can be used to analyze stress on the human caused by the work task itself, at least in macro-ergonomic terms with regard to time utilization. In addition, anthropometric and work-physiological aspects of the work task can be analyzed using digital human models. The evaluation and assessment of influences from the indoor working environment are more difficult. In this case, both micro- and macro-ergonomic analyzes can be performed. In the following, it is explained in more detail to what extent such forecasts can already be carried out in Digital Factory tools. The result shows that there are still a lot of research and development tasks to be solved before a comprehensive forecast of ergonomic influences can be carried out.

Paraconsistent Annotated Evidential Logic Eᴛ Applied to Autonomous Robots in Logistic Center

Flávio Amadeu Bernardini[1], Marcia Terra da Silva[2], Jair Minoro Abe[3], Luiz Antonio de Lima[4]
[1]Paulista University, Brazil; [2]Paulista University, Brazil; [3]Paulista University, Brazil; [4]Paulista University, Brazil

Due to the momentum of Industry 4.0 in various product and service sectors, academic and business investments in the development of new technologies in the logistics sector also stand out. Based on these trends, bibliographical research was carried out of articles dedicated to robotics with application in the logistics sector. Based on the bibliographic survey results, this work proposes a prototype of an autonomous terrestrial mobile robot that must go through corridors in specific layouts in logistics centers with a focus on the aid of control tasks and management information for decision making. The main contribution is testing a para-analyzer algorithm based on non-classical logic such as Paraconsistent Annotated Logic Eᴛ, as the decision-making tool to avoid obstacles.

Human Aspects in Collaborative Order Picking– What if Robots learned how to Give Humansa Break?

Yaxu Niu[1,2], Frederik Schulte[2]
[1]Beijing University of Chemical Technology; [2]Delft University of Technology

Human aspects in collaboration of humans and robots, as common in warehousing, are considered increasingly important objectives in operations management. In this work, we let robots learn about human stress levels based on sensor data in collaborative order picking of robotic mobile fulfillment systems. To this end, we develop a multi-agent reinforcement (MARL) approach that considers human stress levels and recovery behavior next to traditional performance objectives in the reward function of robotic agents. We assume a human-oriented assignment problem in which the robotic agents assign orders and short breaks to human workers based on their stress/ recovery states. We find that the proposed MARL policy reduces the human stress time by up 50% in comparison to the applied benchmark policies and maintains system efficiency at a comparable level. While the results may need to be confirmed in different settings considering different types of humans aspects and efficiency objectives, they also show a practicable pathway to control stress levels and recovery for related problems of human-robot collaboration, inside and outside of warehousing.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

An Integrated QFD Approach for Industrial Robot Selection

Gülçin Büyüközkan, Öykü Ilıcak, Orhan Feyzioğlu

Galatasaray University, Turkey

Nowadays, where Industry 4.0 is discussed extensively, the selection of industrial robots has become an important issue. These robots enable production companies to produce higher quality products with high efficiency and in a cost-effective manner. However, an incorrect selection of these robots can cause significant losses for companies. Various factors need to be considered for the effective selection of industrial robots. In this study, a decision model is presented for industrial robot selection. Quality function deployment (QFD), a well-known and powerful tool that converts customer requirements into final design characteristics, is used in this study, with Group Decision Making (GDM) perspective. In GDM, decision-makers who have different backgrounds or ideas can state their preferences in various formats. The Multiple Preference Relations (MPR) technique is used to combine different assessments. Therefore, this study combines QFD with MPR to handle the different forms of information while calculating the customer requirements importance. Furthermore, the Complex Proportional Assessment (COPRAS) method is used to choose the most suitable industrial robot for the proposed study. The presented method was analyzed in a case study on the robot selection problem for the assembly line of a company operating in the manufacturing industry. The alternatives evaluated with the COPRAS method were also applied with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. The results of both methods were compared and found to be consistent.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Regular Session: Simulation and optimization of systems performances

Time: Wednesday, 08/Sept/2021: 3:00pm - 5:00pm

Multi-Fidelity Simulation-Based Optimisation for Large-Scale Production Release Planning in Wafer Fabs

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This paper focuses on large-scale production release planning problems in wafer fabs. Due to the complexity and dynamic characteristic of production lines, it is useful to develop simulation models to evaluate different production plans and select the optimal one. However, detailed simulation requires large computational costs, especially for large-scale problems. Therefore, we provide a multi-fidelity optimisation with ordinal transformation and optimal sampling (MO2TOS) based on the multiple population evolutionary algorithm to accelerate computational efficiency and address large-scale release planning problems for wafer fabs. In the low-fidelity approximation process of the proposed approach, we employ open queuing theory to estimate cycle times. The experimental results confirm that the low-fidelity model shows a high consistency with the high-fidelity model and the proposed multi-fidelity optimisation method is effective at solving large-scale release planning problems.

Toward a Simulation Model for Capacity Analysis of a New Port Terminal

Erik Bergeron, Léo Gagnon, Jean-François Audy, Pascal Forget, Amina Lamghari

Université du Québec à Trois-Rivières, Canada

With the current growth of the maritime industry, which is a key element for many supply chains worldwide, ports seek to increase their capacity and perfor-mance in order to tackle challenges and opportunities created by the increased demand in the industry. Port expansion is an efficient way to meet this objective, but requires important resources and careful planning. Before undertaking such a major project, it is important for a port to have a firm grasp and understanding of its current capacity as well as the expansion's requirements and limitations in light of its traffic forecasts. This article presents the data analysis realized as part of an expansion project of a Canadian port case. The data analysis is executed in order to feed the first simulation model of its kind in this sector that will simulta-neously simulate the current port and its new terminal with both separate and shared logistics and resources. This article addresses the first steps of the model's conception through data analysis as well as solutions to problems encountered. As the study is underway, the preliminary results of the work are presented.

Design of a physics-based and data-driven hybrid model for Predictive Maintenance

Emiliano Traini, Giulia Bruno, Franco Lombardi

Politecnico di Torino, Italy

The maintenance process is crucial in any system that is prone to failure or degradation, particularly in manufacturing operations. In fact, maintenance costs can reach up to 40% of the cost of production in certain industries. In the era of Industry 4.0, maintenance methods can maximize the use of com-ponents predicting the remaining useful life. These methods are identified as Predictive Maintenance and include several innovative technologies, such as IoT for deploying sensors that monitor machines and AI that provides the algorithms to interpret the data collected. The information generated from sensor data allows for more accurate predictions using statistical models that are sensitive to the peculiarities of an individual tool set on a particular ma-chine and used by a certain operator. These models, unlike traditional meth-ods based on physical laws, increase in efficiency as the data increases, and therefore are not efficient or usable when a sufficient bank of data is not available. This work proposes a hybrid model that, being based on both clas-sical physics and data-drive models, demonstrates how it is possible to obtain a prediction method that estimates the state of the tool even in the absence of historical data and that increases its accuracy as such data increases. The proposed model is evaluated by using a public experimental milling dataset.

Dynamic Bottleneck Starvation Control

Gerd Wagenhaus[1], Niels Gürke[2], Werner Kurt[2], Ulf Bergmann[1]

[1]Otto-von-Guericke-University, Germany; [2]thyssenkrupp Presta Schönebeck GmbH

Choosing the most fitting manufacturing principle largely depends on the tech-nical divisibility of jobs and the quantity to be produced. In most cases, a high quantity causes a higher degree of automation. What to do, however, if the pro-duction programme is evolving into various product modifications in the long run, thus developing from monolithic flow lines to a quasi-continuous batch pro-duction by means of bottleneck machines?

Classic push-controlled routines are failing here, since the batchwise manufactur-ing in combination with performance-reducing parameters within production sys-tems will cause discontinuous outputs that are difficult to control and, moreover, feature an increased creation of work in process (WIP).

This problem is intensified by a combined influence of necessary setup activities, which often lead to sporadic machine failures. As a matter of fact, this invariably causes a dramatic delay in delivery times, not least because of the extension of the throughput times.

In this paper, we will introduce a manufacturing control that is based on dynamic WIP-oriented bottleneck planning, which will allow to maintain the automatically regulated output optimum by means of a self-controlling system.

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Pricing models for data products in the industrial food production

Calvin Rix[1], Jana Frank[1], Volker Stich[1], Dennis Urban[2]

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In the food industry, a very large potential of data ecosystems is seen, in which data is understood, exchanged and monetized as an economic asset. However, despite the enormous economic potential, companies in the food industry continue to rely on traditional, product-oriented business models. Existing data in the value chain of industrial food production, e. g., in harvesting, logistics, and production processes, is primarily used for internal optimization and is not monetized in the form of data products. Especially the pricing of data products is a key challenge for data-based business models due to their special characteristics compared to conventional, analog offerings and multiple design options. The goal of this work is therefore to solve this issue by developing a framework that allows the identification of pricing models for data products in the industrial food production. For this purpose, following the procedure of typology formation, essential design parameters and the respective characteristics are derived. Furthermore, three types for pricing models of data products are shown. The results will serve not only stakeholders in the food industry but also manufacturing companies in general as input for an orientation of their data-based business models.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Regular Session: Risk and performance management of supply chains

Time: Wednesday, 08/Sept/2021: 3:00pm - 5:00pm

Sustainability improvement of coffee farms in Valle del Cauca (Colombia) through system dynamics

Alvaro José Torres Penagos[1], Juan Carlos Osorio Gomez[2], Carlos Julio Vidal Hoguín[3]

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Given the problems generated in the coffee supply chain and identifying the central problem as its low sustainability, especially in Valle del Cauca (Colombia), it is imperative to propose solutions to the current development of this chain, especially about producers, which are the least benefited. These solutions should allow for balanced growth and be aimed at making it pos-sible to overcome the current socioeconomic system based on predatory and competitive growth at the service of private interests. Thus, sustainabil-ity should trigger a profound rethinking about human groups relationships, among themselves and with the environment, betting on cooperation and defense of the general interest. The purpose should not only be the econom-ic growth of companies, many times increasing the poverty of the inhabit-ants of the region or the environmental risks, but it should also be the wealth of all the involved parties.

In our ongoing research, we plan to use dynamic simulation to evaluate al-ternatives that consider the sustainability of coffee farms, including ele-ments of profitability, environmental impact, and social development. Preliminary simulation results are shown. This approach should ultimately allow us to find applicable and quantifiable so-lutions for a sustainable balance in the fundamental links of the coffee sup-ply chain in the northern region of Valle del Cauca, Colombia.

A Study of the Relationships between Quality of Management, Sustainable Supply Chain Management Practices and Performance Outcomes

Tanimu Dandutse, Yahaya Yusuf, Godwin Geyi Dan'Asabe

University of Central Lancashire, United Kingdom

Extant literature on SSCM practices have paid little attention to quality of management attributes that could influence sustainability implementation in supply chains. The aim of this study is to address this gap by examining the relationship between quality of management, SSCM practices, and business performance. A survey of 192 oil and gas companies was carried out. The data collected was analysed using correlation and multiple regression analysis. The correlation results provide evidence that, quality of management is positively related to the implementation of SSCM practices. The regression results indicate that 18.1% of variance in business performance is explained by quality of management, and 26.4% of the variance is explained by SSCM practices.

4.0 Transition Methodology for Sustainable Supply Chain Management

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Customers express more and more willingness to consume sustainable products. This is often considered as a requirement by companies and therefore in their whole supply chains. To ensure an overall improvement of the supply chain environmental performance, the transition to 4.0 must encompass all the stakeholders involved. With a view that facilitates the determination of the required transformations of companies on the sustainability criteria, this article sets out to identify a strategy for optimizing the sustainability of the supply chain considering each stakeholder's resources. Based on deductive research, we propose: 1) a methodology for defining a relevant strategy for 4.0 transition of a supply chain, 2) a qualitative model for assessing the maturity of companies and their entire supply chain, with a focus on the fields of the sustainability, characterizing the 4.0 transformation, 3) a decision-making tool, taking into consideration each stakeholder's deviation from clients' requirements, with a view to identifying and prioritizing the development strategy to be followed for a transition to a 4.0 supply chain.

Intuitionistic Fuzzy Cognitive Map Based Analysis of Supply Chain Risks

Gülçin Büyüközkan[1], Celal Alpay Havle[1,2], Orhan Feyzioğlu[1]

[1]Galatasaray University, Turkey; [2]Özyeğin University, Turkey

One of the most vital actions for a company is to constantly achieve cus-tomer satisfaction, recruitment and achieve it. To reach this, companies must regulate supply chains, value, rank and manage them. Supply chains which are network-like structures are enormous systems. Within these sys-tems, risk factors and components are multifaceted through direct and indi-rect relationships. From this point of view, this study proposes an evalua-tion model for supply chain risk management (SCRM) and a methodological roadmap that allows analyzing supply chain risks with a cognitive map (CM) approach. Due to the complexity of the supply chain systems in real life, human perception and intuition included decision making processes and hesitation, classical CM approach is extended to intuitionistic fuzzy (IF) environment. IFCM technique, which is much more sophisticated of the CMs and fuzzy cognitive maps (FCM) allows different possible future sce-narios through its dynamical behavior. The importance degree of the risks concerning the proposed model is revealed. IFCM models of SCRM are vis-ualized. The study showed that the IFCM approach is useful for solving problems involving many decision variables and uncontrollable decision variables linked to cause-effect relationships.

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A Classification Tool for Circular Supply Chain Indicators

Asiye KURT[1,2], Mario CORTES-CORNAX[2], Van-Dat CUNG[1], Agnès FRONT[2], Fabien MANGIONE[1]

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The Circular Economy approach has gained attention recently. Supply Chains have an important role in the transition to a more circular economy. Thus, being able to assess structurally the circularity of multi-activity Supply Chains is essential to help Supply Chain managers to decide in this transition. An important number of Supply Chains' indicators are proposed in the literature in the context of sustainability. However, to the best of our knowledge, there is no tool, which specifically classifies those indicators according to Circular Supply Chain structures, involving circular activities such as reuse, remanufacturing, refurbishing and repurposing. The aim of this work is to develop such a classification tool for indicators in order to assess the circularity of Supply Chains at the strategic level. This classification tool relies on the three main principles of circular value creation of Ellen MacArthur Foundation. These principles are converted into different dimensions that could be applied to the structures of Circular Supply Chains. These dimensions constitute classification criteria for our tool. In this work, new potential Circular Supply Chain indicators are also proposed and classified by the tool. This tool allows and facilitates academics and Supply Chain managers categorizing and choosing appropriate indicators to assess circularity within Circular Supply Chains.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Smart and sustainable production and supply chains

Time: Wednesday, 08/Sept/2021: 3:00pm - 5:00pm

Sustainable and Resilience improvement through the Design for Circular Digital Supply Chain

Abla CHAOUNI BENABDELLAH[1], Kamar ZEKHNINI[2], Anass CHERRAFI[3]

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Resilient and sustainable supply chain management (SCM) practices have been established in recent decades to reduce the likelihood and consequences of disruptions and the negative environmental effects along the supply chain. To deal with such issues, it's important to be able to quantify the effectiveness of all supply chain processes in a circular economy model while taking technological revolution into account. Furthermore, Design for X (DFX) approaches show significant potential for improving product and service functionality from a variety of perspectives X. In this respect, the aim of this paper is first to propose a circular digital SCOR model that depicts the impact of digital technology on various circular SCOR processes. Second, using DFX techniques, a conceptual model, called Design for circular digital Supply chain (DFCDSC), has been proposed that includes the key design factors for the development and implementation of the circular digital supply chains. Since it highlights the main lines of research in the area, the proposed framework will provide crucial managerial perspectives for practitioners and managers

The Impact of the Number of Regulated Suppliers in Sustainable Supply Chains on Corporate Financial Performance

Xuanchang Qi, Hanhui Hu

Southeast University, China, People's Republic of

In recent years, with the gradual attention to environmental pollution and the deep understanding of sustainability theory, the supply chain of the real estate industry has begun to change to a green and sustainable development approach. In 2016, Society of Entrepreneurs and Ecology and other real estate industry alliance organizations, together with Vanke and other industry leaders, launched the “Green Supply Chain Action” to establish a green procurement whitelist by testing the environmental performance of building materials suppliers in various categories. This paper focuses on the impact of the number of suppliers regulated by the company on the financial performance of the company in the sustainable supply chain. The empirical results show that the number of suppliers under corporate supervision is negatively related to financial performance. In response to the findings, this paper puts forward development suggestions for real estate green supply chain management.

Digitalization for resilience and sustainability during the Covid-19 pandemic: an explorative event study

Seyoum Eshetu Birkie

KTH Royal Institute of Technology, Sweden

This paper reports on an initial explorative investigation on the relationship that exists among resilience, digitalisation, sustainability practices, and operations performance. It builds on literature survey and event study based on Covid-19 news reports from international news outlets. The findings indicate the need for holistic perspectives to leverage from different efforts in manufacturing firms to drive competitiveness with as little impact on other measures especially considering manufacturing SMEs.

Value stream mapping (VSM) to evaluate and visualize interrelated process-chains regarding Circular Economy

Jeff Mangers, Meysam Minoufekr, Peter Plapper

University of Luxembourg, Luxembourg

The concept of circular economy (CE) aims to close and slow resource loops without neglecting the goals of sustainable development. Recently, the concept received encouraging attention among researchers and business experts to be a convenient solution to move away from the finite linear economy concept to a more sustainable solution. However, this change of paradigm is only possible if we consider systems in a holistic manner and can see and localize the preventing hurdles.

Value stream mapping (VSM) is a commonly known lean method, which is used to de-velop current state visualization of product and information flows within organization, helping to seek weaknesses and improve process flows. The motivation of this paper is a new C-VSM model, which enables its users to evaluate and visualize connected process-chains regarding CE on different levels in a holistic manner. For this purpose, the tradi-tional VSM model was adapted towards the needs and requirements of CE through the application of a new representation method, additional indicators, and an appropriated evaluation system. C-VSM is in line with the current political and industrial objectives to apply CE principles by enabling a holistic reflection and consideration of supply-chains (SCs) on different levels. The model itself is validated through an extensive cross-company case study.

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AI for Resilience in Global Supply Chain Networks in the Context of Pandemic Disruptions

Time: Wednesday, 08/Sept/2021: 6:15pm - 8:15pm

Covid-19 Ripple Effect and global supply chain productivity impacts through pandemic propagation modelling

Xavier Brusset[1], Morteza Davari[1], Aseem Kinra[2], Davide La Torre[1]

[1]SKEMA Business School, France; [2]Universität Bremen, Germany

We analyse spatio-temporal dynamics of the propagation of Covid-19 infection in a map enriched with data on population, transport networks, facilities and population flows. The evolution is then represented in mathematical models which will enable prospective analyses to be performed reliably. Such models will be used in what-if scenarios to simulate the impact on both populations and supply chain activities in case of future pandemics. The outcome should be useful tools for policymakers and managers. Results from this research will help understand the impact and the spread of a pandemic in a particular region and on supply chains. The data will be from European regions and the expected models will have validity in Europe.

Towards explainable artificial intelligence (XAI) in supply chain management: a typology and research agenda

Godfrey Mugurusi[1], Pross Nagitta Oluka[2]

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The potential for artificial intelligence (AI) to drive digital supply chain transformation today is beyond question. However, its full potential to ad-dress more complex supply chain management (SCM) problems is still un-clear partly due to AI's black-box problem both in practice and in literature. This paper attempts to highlight the significance of explainable AI (XAI) in SCM and shades light on SCM areas where AI's black-box problem remains problematic. The goal of this integrative literature review paper is to provide new insight into the status of XAI as a solution to AI's black-box problem in SCM where AI techniques have made rapid in-roads. The AI techniques in SCM literature and the significance of XAI in SCM are contrasted. We pre-sent an integrative research typology for XAI in SCM to better align how SCM literature has conceived AI deployment in SCM this far. The typology should help us understand the gap between what we know about AI deploy-ment in practice, AI maturity in SCM, and the extent of XAI in SCM.

Stochastic Logistic Shocks on Supply Chain Networks

Iside Rita Laganà[1], Davide La Torre[2], Cinzia Colapinto[3], Danilo Liuzzi[4]

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The COVID-19 pandemic represents an unprecedented and global impact on economy and society. Nowadays, Supply Chains have become increasingly connected at multiple levels, making them more sensitive to shocks. The exposure to the COVID-19 pandemic has been pointing out the vulnerability of supply chains, forcing companies and governments to adapt their strategies and operations to address these impacts. In this paper, we present an original stochastic framework to model the spread of new epidemic across the different distribution net- works and define the optimal social distancing policy in the case of local and global networks.

A vector logistic dynamical approach to epidemic evolution on interacting social-contact and production-capacity graphs, and its proxy economic cost assessment.

Jan Bart Broekaert, Davide La Torre

SKEMA Business School, France

Population inhomogeneity, in the variations of the social contact `ego' networks and the individual infectious-recovery rates, renders the dynamics of infectious disease spreading uncertain. As a consequence the overlaying economical production network with its proper collaboration components is to extent impacted unpredictably. Our model proposes a vector logistic dynamical approach to SIS dynamics in a social contact network interacting with its economic capacity network. The probabilistic interpretation of the graph state in the vector logistic description provides a method to assess the effect of mean and variance of the infected on the production capacity and allows the strategic planning of social connectivity regulation. The impact of the epidemic mean effects and fluctuations on the production capacity is assessed according cumulative, majority and fragility proxy measures.

Distribution of Vaccines During a Pandemic (Covid-19)

Vignesh Dhanapal, Subhash.C Sarin

Virginia Tech, Blacksburg, Virginia, United States of America

Covid-19 has affected the lives of people in different ways. A number of models are available in the literature to study the dynamics of a pandemic. However, there are very few models that study the impact of vaccine distribution among different population groups. In this paper, we use a modified epidemiological model which incorporates relationships between different populations to incorporate the impact of vaccine distribution and present results for different vaccine distribution strategies. We have presented how a sharing-based vaccine distribution strategy could be implemented in the face of the spread of the virus. The main finding of our work is that an effective vaccine distribution may differ depending upon the level of interactions among different population groups and a sharing-based vaccine distribution strategy is the most effective strategy.

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Data-based services as key enablers for Smart Products, Manufacturing and Assembly

Time: Wednesday, 08/Sept/2021: 6:15pm - 8:15pm

Data Acquisition for Energy Efficient Manufacturing: A Systematic Literature Review

Henry Ekwaro-Osire[1], Stefan Wiesner[1], Klaus-Dieter Thoben[1,2]

[1]BIBA - Bremer Institut für Produktion und Logistik; [2]University of Bremen

Due to the impending threat of climate change, as well as omnipresent pressures to remain competitive in the global market, manufacturers are motivated to reduce the energy and resource consumption of their operations. Analysis of manufacturing data can enable large efficiency gains, but before the data can be analyzed, it must be acquired and processed. This descriptive literature review assesses existing research on data acquisition and pre-processing in the context of improving manufacturing energy and resource efficiency. A number of insights were derived from the selected literature, based on a specific set of questions. Discrete manufacturing has received more attention than process manufacturing, when it comes to data acquisition and pre-processing methodology. Typically only one or two variables are measured, namely electricity consumption and material flow. Data is most often used for real-time monitoring or for historical analysis, to find opportunities for improving energy efficiency. However, acquisition of meaningful real-time data at a high granularity remains a challenge. There seems to be a lack of robust data acquisition and pre-processing methodologies that are designed and proven applicable across machine, process and plant levels within a factory.

Generating Synthetic Training Data for Assembly Processes

Johannes Dümmel, Valentin Kostik, Jan Oellerich

Karlsruhe Institute of Technology (KIT), Germany

Current assembly assistance systems use different methods for object detection. Deep learning methods occur, but are not elaborated in depth. For those methods, great amounts of individual training data are essential. The use of 3D data to generate synthetic training data is obvious, since this data is usually available for assembly processes. However, to guide through the entire assembly process not only the individual parts are to be detected, but also all intermediate steps. We present a system that uses the assembly sequence and the STEP file of the assembly as input to automatically generate synthetic training data as input for a convolutional neural network to identify the entire assembly process. By means of experimental validation it can be demonstrated, that domain randomization improves the results and that the developed system outperforms state of the art synthetic training data.

Review of Factors influencing Product-Service System Requirements along the Life Cycle

Stefan Alexander Wiesner[1], Jannicke Baalsrud Hauge[1,2]

[1]BIBA - Bremer Institut für Produktion und Logistik GmbH at the University of Bremen, Germany; [2]KTH – Royal Institute of Technology, Sweden

Rapid technological changes within a highly competitive global market have induced a transformation in the manufacturing industry. A wide range of services is added to the physical product in order to deliver new customized functions and other benefits in the form of Product-Service Systems (PSS). These developments induce a change from quasi-stable and simple socio-technical systems to a more complex and instable dynamic configuration. Various environmental factors also influence the requirements towards the PSS in all life cycle phases. However, such factors have yet to be systematically identified and categorised. Thus, this paper presents the results of a structured literature review on factors influencing the system requirements along the PSS life cycle. The review has classified such factors in three life cycle phases and four categories. Gaps in research have been identified for factors during operation and end of life, especially beyond functional requirements. Thus, future research opportunities have been derived.

Customer Order Scheduling in an Additive Manufacturing Environment

Benedikt Zipfel, Janis Sebastian Neufeld, Udo Buscher

Technische Universität Dresden, Germany

This paper investigates the customer order scheduling problem on unrelated parallel additive manufacturing machines. The discussed problem comprises the splitting of orders into jobs, the allocation of those jobs to builds and finally the sequencing of builds on 3D printers. A mixed-integer programming model is presented that integrates practical requirements, such as printing profiles and different materials, and minimises total weighted tardiness. Using the Gurobi solver computational results are then given for a comprehensive test bed. It is shown, that medium sized problems can be solved using the proposed model, and that the consideration of printing proles has a relevant impact on the scheduling task in additive manufacturing.

A Conceptual Reference Model for Smart Factory Production Data

Giulia Boniotti[2], Paola Cocca[1], Filippo Marciano[1], Alessandro Marini[2], Elena Stefana[1], Federico Vernuccio[2]

[1]University of Brescia, Italy; [2]Quantra S.r.l., Italy

As a consequence of the fourth industrial revolution, the data produced by compa-nies' day-by-day activities and the rate at which the transactions occur are growing exponentially. In order to extract business value from those data, they need to be organised under a reference conceptual model facilitating data analysis and decision making. Since no sound reference model for organising digital factory production data has been proposed in the literature, this paper aims at developing and testing a conceptual multidimensional model to support a broad range of data analytics activ-ities for the management and optimisation of production in a smart factory. The testing of the model in a case study company of the printing sector provides insights into the applicability of the model and the connected benefits.

Digital Transformation Approaches in Production Management

Time: Wednesday, 08/Sept/2021: 6:15pm - 8:15pm

Supporting Manufacturing Processes Design Using Stakeholder Opinions and Sentiment Analysis

Egon Lüftenegger, Selver Softic

CAMPUS02, Austria

In this paper we propose a novel approach of empowering the design of business processes in manufacturing and broader by using sentiment analysis on comments collected during the design phase of business processes. For this purpose we trained and tested our Sentiment Analysis Module (SAM) to prioritize and classify the stakeholder comments as a part of software tool for BPMN based modeling and annotation. The preliminary result with evaluation test case seem to be promising regarding effective ranking and classifying the improvement proposals on BPMN design of manufacturing processes. However, there is still pleanty of space for improvements in trainings data segment and in extending the tool with social BPMN functionality.

Digitalization in Manufacturing: Trends, Drivers, Challenges, and Research Areas in Norway

Emrah Arica, Daryl Powell

SINTEF, Norway

The manufacturing industry has encountered a need for digital transformation during the past decade. To stay competitive, more and more manufacturing companies are adopting digital technologies, either by internal efforts or through external help from consultants or collaborative research projects. This paper presents an overview of trends and challenges in the Norwegian industry and provides a framework of critical research areas for further efforts in the digitalization of manufacturing. The framework is developed based on an analysis of six exemplary industrial research projects that focus on the subject of digitalization in manufacturing. The paper contributes to the literature by bringing practical insights that guide the digital transformation of manufacturing companies.

Multi-perspective view on sustainable production: A literature review

Marko Samardzic, Ugljesa Marjanovic

University of Novi Sad, Faculty of Technical Sciences, Serbia

Manufactured products should be produced in a sustainable way because of their immense impact on the economy, environment and society. However, due to the many diverse parties involved and their often conflicting motivations, this is usually not the case. This paper is a literature review explaining the drivers for the transition to sustainable production from different points of view by ana-lyzing current literature. The stakeholders are classified in the following catego-ries: Government, Corporate, Consumer, Society. Each of the stakeholder groups has a significant impact sustainable production. Governments set the field for the corporations to operate in through rules and regulations. The effec-tiveness of these rules and regulations depends on government awareness and proactivity. Moreover, consumers play an important role since their demand for sustainably produced goods is an important driving factor for companies. Cor-porations are required to adapt to governmental regulations and consumer de-mand, but they can also lead the way by putting into effect sustainable methods of production. Finally, it is up to society as a whole to promote sustainable pro-duction since it profoundly benefits from it.

Determining Minimal Cost of Action for Task Allocation Within Mobile Robot Swarm in Production Environments

Elmir Babovic[1], Denis Mušić[1], Bahrudin Hrnjica[2], Adil Joldić[1]

[1]"Dzemal Bijedic" University, Faculty of Information Technologies, Bosnia and Herzegovina; [2]University of Bihać, Faculty of Technical Sciences, Bosnia and Herzegovina

This paper describes the continuation of a series of research in which human behavior, in the form of models and algorithms, endeavor to be mapped into the field of mobile robotics, all with the aim of more efficient path prediction with collision detection in a dynamic obstacle environment. In our latest research [1] we proposed a new approach called Sliding Holt (SH) algorithm which is used for calculation of future spatiotemporal state of dynamic obstacle. Besides SH algorithm we also proposed method for (non)collaborative collision detection with dynamic obstacles in 2D and 3D space which ensures full decentralization of the collision detection process. Research described in this paper focuses on the application of Computer Vision for detecting the position and movement direction of mobile robots in order to create assumptions for collision detection and path planning with within the production environment. We propose a new approach for detecting mobile robot direction based on triangular shape and use of Cost of Action in order to allocate tasks within robotic swarm.

Consistent Maintenance Order Processing with Digital Assistance Systems

Robert Rost, Axel Friedewald

Hamburg University of Technology (TUHH), Germany

Augmented reality-based digital assistance systems have proven their potential to support with instructions considering numerous application scenarios in the product life cycle. For the maintenance of machines and plants, however, their use becomes particularly efficient if the diagnosis at the operator's site can be effectively supported, so that the service provider and his experts can make accurate diagnoses for this maintenance job, plan the execution including the spare parts logistics precisely, and document as well as billing the maintenance case with low effort. For this purpose, a modular digital assistance system is presented that provides support adapted to the process phases.

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Digital twins in companies first developments and future challenges

Time: Wednesday, 08/Sept/2021: 6:15pm - 8:15pm

Improving a manufacturing process using recursive artificial intelligence

Jose Antonio Marmolejo-Saucedo, Roman Rodriguez, Fernando Sanchez, Uriel Romero, Regina Robredo, Manuel Garrido, Ana Paula Martinez

Panamerican University, Mexico

This work explores the improvements that can be made in the process of parameterization of discrete-event simulation models. A manufacturing process is modeled through queuing systems and alternative decisions to perform production, transport, and merchandise handling tasks. The use of recursive artificial intelligence is suggested to improve the quality of the parameters used in the simulation model. Specifically, a vector support machine is used for statistical learning. A relevant characteristic of the proposed model is the integration of different information technology platforms so that the simulation can be recursive.

Digital Twin in the agri-food supply chain: a literature review

Letizia Tebaldi, Giuseppe Vignali, Eleonora Bottani

Department of Engineering and Architecture, University of Parma, Italy

The present manuscript aims at presenting some preliminary results from a liter-ature review carried out on the existing documents dealing with Digital Twin models within the context of agri-food supply chain, in order to assess the state-of-art of such new technology for this promising field. The analysis considers both descriptive metrics (i.e., year of publication, research type, geographical origin and keywords analysis) and qualitative aspects (i.e., subdivision accord-ing to the supply chain phase involved and data-driven versus physic-based modelling of the Digital Twin solutions presented in the documents).

The Advent of the Digital Twin: A Prospective in Healthcare in the Next Decade

Jorge Luis Rojas-Arce, Eduardo Cassiel Ortega-Maldonado

Facultad de Ingeniería, Departamento de Ingeniería en Sistemas Biomédicos, Universidad Nacional Autónoma de México, Mexico City, Mexico

Industry 4.0 is facing a fast-development in its technologies, automatizing and restructuring processes in order to make them data-driven. However, its uses are not limited only to factories, and can be extended to healthcare. In the next decade, the Digital Twin (a digital

replica of a physical asset) is going to face a spread into mainstream media due to its potential applications in the healthcare sector, such as a 24/7 monitoring of the evolution of cancer and its treatment, a heart based on cloud{computing, an even receive medical treatment that adapts to every person. However, there are obstacles that researchers

need to face before the DT can reach its full-potential.

Reviewing the application of data driven digital twins in manufacturing systems: a business and management perspective

Ehsan Badakhshan, Peter Ball

University of York, United Kingdom

Simulation modelling has been a widely used tool for analyzing manufacturing systems and improving their performance. Although, little attention has been paid to the application of data-driven simulation modelling of the manufacturing systems. With the development of new-generation information and digitalization technologies, more data can be collected from the manufacturing shop floor. This has paved the way for employing data-driven simulation of manufacturing systems knowns as a digital twin. This paper reviews the literature and practice on digital twins in manufacturing systems from a business and management perspective to identify the gaps and recommend avenues for future research. The results show that 2018 has been a turning point in the literature with small scale case studies of digital twins emerging independent of commercial practice. Since 2018 the digital twin literature has moved on from descriptions and conceptual frameworks to focus on one product lifecycle phase with any reference to sustainability advance being confined to energy and resource efficiency. Practice has been advanced by manufacturers and IT vendors however the definition of digital twins lacks precision for ease comparison with the literature. Future avenues for research are identified in the areas of lifecycle phases and digital model fidelity.

A Digital Twin implementation for manufacturing based on open-source software and standard control systems

Christian Dalheim Øien, Håkon Dahl, Sebastian Dransfeld

SINTEF Manufacturing, Norway

The concept of Digital Twins (DT) can be utilized to solve complex prob-lems in manufacturing based on the principle of Cyber-Physical Systems (CPS). While there are several reference architectures for CPS, there seems to be a knowledge gap between such high-level outlines and actual shopfloor-level implementations. This paper focuses on process control applications of the DT concept and proposes a specific implementation set-up using fieldbus communication with computer, aiming to fulfil a set of defined require-ments. The set-up is tested in an industrial use-case and the resulting charac-teristics of the solution are presented. A resulting assertion is that a DT of a process must be as specialized and customized as the system controlling it.

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Human-centered Artificial Intelligence in Smart Manufacturing for the Operator 4.0

Time: Wednesday, 08/Sept/2021: 6:15pm - 8:15pm

Human in the AI Loop in Production Environments

Christos Emmanouilidis, Sabine Waschull, J.A.C. Bokhorst, J.C. Wortmann

University of Groningen, Netherlands

The integration of Artificial Intelligence (AI) in manufacturing is often pursued as technology push without clear understanding of implications for production performance, human and job effects, or challenges and opportunities of the interaction between human and non-human AI-enabled actors. This paper looks upon the AI-human interaction from the novel viewpoint of jointly considering the changing nature of human AI interaction and specific work design aspects, as necessary considerations for designing-in, rather than pushing, the integration of humans and AI in production settings. It outlines a model of human-AI interaction that goes beyond augmentation and is currently analysing real industrial cases to specify and apply design principles and success criteria for making this interaction effective. The contribution can be of practical value for system developers and work designers in how to target at the design stage human-centricity when integrating AI and humans in production environments.

Human-AI Collaboration in Quality Control with Augmented Manufacturing Analytics

Alexandros Bousdekis[1], Stefan Wellsandt[2], Enrica Bosani[3], Katerina Lepenioti[1], Dimitris Apostolou[1], Karl Hribernik[2], Gregoris Mentzas[1]

[1]Information Management Unit (IMU), Institute of Communication and Computer Systems (ICCS), National Technical University of Athens (NTUA), Greece; [2]BIBA - Bremer Institut für Produktion und Logistik GmbH; [3]Whirlpool EMEA

Augmented analytics is an emerging topic which deals with the enhance-ment of analytics with conversational interfaces as well as the exploitation of the human knowledge representation through intelligent digital assis-tants allowing users to easily interact with data and insights. The communi-cation with the user by voice poses new challenges to the development and execution of data analytics services. In this paper, we outline a framework for implementing quality analytics for decision augmentation through op-timized human-AI interaction. Our approach aims to reduce the number of quality issues through fast, mobile, and easy access to quality predictions for products and processes. An application case is the production of white goods is presented.

Digital Platform and Operator 4.0 Services for Manufacturing Repurposing during COVID19

John K. Soldatos[1], Nikos Kefalakis[1], Georgios Makantasis[1], Angelo Marguglio[2], Oscar Lazaro[3]

[1]INTRASOFT International, Luxembourg; [2]Engineering Ingegneria Informatica S.p.A; [3]Innovalia Association

This paper introduces digital solutions for manufacturing repurposing trans-formations that address the impact of COVID19 on production operations. The paper outlines how different Industry 4.0 solutions can be combined in a unified platform for manufacturing repurposing. Emphasis is paid on in-troducing worker and Operator 4.0 related solutions, including tools for plant risk assessment, shifts allocation, context-aware reskilling of employees and remote support processes. The latter are essential elements of a strategy for exploiting automation and Artificial Intelligence (AI) systems during COVID19 times and future healthcare crises.

Towards Active Learning Based Smart Assistant for Manufacturing

Patrik Zajec[1,2], Jože Martin Rožanec[1,2,3], Inna Novalija[2], Blaž Fortuna[2,3], Dunja Mladenić[2], Klemen Kenda[1,2,3]

[1]Jožef Stefan International Postgraduate School, Slovenia; [2]Jožef Stefan Institute, Slovenia; [3]Qlector d.o.o., Slovenia

A general approach for building a smart assistant that guides a user from a forecast generated by a machine learning model through a sequence of decision-making steps is presented. We develop a methodology to build such a system. The system is demonstrated on a demand forecasting use case in manufacturing. The methodology can be extended to several use cases in manufacturing. The system provides means for knowledge acquisition, gathering data from users. We envision active learning can be used to get data labels where labeled data is scarce.

Anatomy of a digital assistant

Stefan Wellsandt[1], Karl Hribernik[1], Klaus-Dieter Thoben[1,2]

[1]BIBA - Bremer Institut für Produktion und Logistik GmbH at the University of Bremen; [2]University of Bremen, Faculty of Production Engineering

Why is it helpful to have a digital assistant? This question's answer is not simple nor easy to find because artificial intelligence (AI) assistants, such as Alexa, Bixbi, or Siri, are amorphous compound technology and multi-purpose tools. Most of an assistant's components provide unique benefits on their own. Mobility, voice interaction, the delegation of administrative tasks, and rapid data analysis are typical benefits, but they are not exclusive to digital assistants. Understanding an assistant's benefits helps assistant designers and decision-makers who need to assess whether an assistant is a suitable workforce enhancement tool. Academic literature often describes an assistant's benefits superficially. This article presents an overview of a preliminary catalog of these benefits in manufacturing. It covers central access, customization, delegation and guidance, eyes-free and hands-free interactions, mobile assistance, the support of multiple interface types, permanent accessibility, and speed. We conclude that the cataloged benefits need more evidence, preferably created during experiments in natural manufacturing environments, to explore and experience the factors that determine the use of a digital assistant. These factors include trust in AI systems, impacts on teams and individuals, training and education, and capabilities of open and closed technologies. Disadvantages, limitations, and risks concern reduced worker autonomy, constrained language understanding, increased dependency on software, and harmful exploitation.

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Serious Games Analytics: Improving Games and Learning Support

Time: Wednesday, 08/Sept/2021: 6:15pm - 8:15pm

Towards a serious game on data sharing in business ecosystems

Ulriikka Järvihaavisto, Mikael Öhman, Riitta Smeds

Aalto University, Finland

In this paper we develop design principles for a serious game on data sharing in business ecosystems. Even though data has been said to be the new fuel of economy, we have not seen any large-scale trading of data in industrial settings. The purpose of the game is to experimentally study the dynamics of data trading in simulated business ecosystems, particularly under different kinds of governance structures: in centralized and decentralized ecosystems. The objective of the game is also to support the learning of MBA and university students. Through the game, the students can experience the risks and benefits of sharing data in ecosystems, an emerging and increasingly important topic in business life.

Accessibility Considerations in the Design of Serious Games for Production and Logistics

Jannicke Baalsrud Hauge[1,2], Ioana A. Stefan[3], Niina Sallinen[4], Jakob A.H.D. Baalsrud Hauge[2,5]

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Digital accessibility has been the focus of initiatives, policies and standards at European and international level in the last decade. However, adoption of accessibility guidelines and the development of accessible resources and ap-plications remain limited and education is a primary example of the multiple challenges that must be addressed. This research has highlighted the main barriers that should be overcome in order to make digital educational games accessible for learners with disabilities and it has brought forward the critical need of personalizing the game contexts and analytics to meet specific pro-files of learners with disabilities. Building upon the outcomes of two case studies, the authors propose a game analytics framework for learners with disabilities, in an effort to streamline game design processes that target ac-cessibility.

Experiencing the Role of Cooperation and Competition in Operations and Supply Chain Management with a Multiplayer Serious Game

Matteo Galli, Davide Mezzogori, Davide Reverberi, Giovanni Romagnoli, Francesco Zammori

University of Parma, Italy

We present an innovative, cooperative, and competitive multiplayer serious game, suited for the educational needs of supply chain and operation management post-graduate students. Hence, the objective is to satisfy the ever-increasing require-ment of students to have the ability to experience and practice the theory learned in traditional ways, for active knowledge acquisition. To cope with such needs, we designed and implemented a multiplayer online serious game, that provides players with a realistic industrial experience, and teaches them how to take a whole range of day-to day and medium-term challenging decisions. Learners are divided into teams, each one representing an Original Equipment Manufacturer (OEM), in every team the students will collaborate and will compete in the same market, and sharing a limited set of suppliers. To this aim they have to define a strategy to target the best market segmentation. Teachers have the possibility to investigate the decision patters of the learners, analyze KPIs and learning analyt-ics, to better understand the learning process and guide the learners in their educa-tional journey. By means of a preliminary questionnaire, the interest in using the serious game to study operation management was confirmed. In addition, the game was tested by a small group of students, who acknowledged the effective-ness of the game's dynamics as a tool to complement traditional teaching meth-ods.

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Smart Methods and Techniques for Sustainable Supply Chain Management

Time: Wednesday, 08/Sept/2021: 6:15pm - 8:15pm

Green supply chain management: a meta-analysis of recent reviews

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This paper provides a meta-analysis of the review papers targeting the theme of green supply chain management (GSCM). The chosen topic is of central interest among researchers in supply chain and logistics, and a number of review papers have appeared on that theme. Using a combination of bibliographic and biblio-metric analyses, this paper makes an attempt to delineate the most debated top-ics in GSCM, the most prominent themes and the need for future research in the field.

Suppliers selection ontology for viable digital supply chain performance

Kamar ZEKHNINI[1], Anass CHERRAFI[2], Imane BOUHADDOU[3], Abla Chaouni Benabdellah[4]

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Unprecedented challenges have confronted the contemporary era with serious negative effect on supply chain management performance. As known, organizations performance is dependent on their suppliers. For this reason, organizations have to improve their practices in suppliers' selection process considering resilience, sustainability and digitalization capabilities to retain competitive and ensure viable performance. In this context, following a literature analysis, this paper aims to propose an ontology-based model for suppliers' selection criteria with consideration of digitalization, sustainability and resilience capabilities. The incorporation of those paradigms while selecting appropriate suppliers enables the exploration of viable supply chain performance in regard to disruptions. The proposed method is useful to both academics and professionals because it addresses the prominent criteria taxonomy for an effective suppliers' selection in the disruption and digital era.

Development of an Eco-efficiency distribution Model: A Case Study of a Danish Wholesaler

Kenn Steger-Jensen[1,2], Hans-Henrik Hvolby[1], Malte Herold Jeberg[1], Simon Hummelshøj Sloth[1], Janus Haslund Løgtved[1]

[1]Aalborg University, Denmark; [2]University of South-Eastern Norway, Norway

We have developed a decision model to support the selection of the best distribution to optimize both earnings and minimize environmental impact. The model has been tested on a Danish goriest company that wants to sell their goods on the Norwegian market. In this connection, they must therefore choose how the goods are to be distributed. Via the decision model, it is possible to choose the distribution and which mode of transport they need for the individual markets, as it is not always the same modes of transport that are optimal for all markets. The model supports and shows that it is possible to optimize the company's earning capacity and minimize environmental impact by choosing the right distribution. National requirements for reduction of carbon can be expected to affect taxes and duties, which is why a sensitivity analysis has been prepared which shows the effect of increasing carbon taxes on the contribution margin in the optimal modes of transport.

Evaluating the deployment of collaborative logistics models for local delivery services

Andrea Bari[1], Fabio Salassa[1], Maurizio Arnone[2], Tiziana Delmastro[2]

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The current pandemic situation and lockdowns have given rise to various problems not only of public health but also of organization of daily activities, especially in the purchase and delivery of goods. As a response to newly generated needs for customers' demand, in this work, we try to evaluate several aspects for the deployment of collaborative logistics models aimed at the optimization of local delivery services.

Minimising total costs of a Two-Echelon Multi-Depot Capacitated Vehicle Routing Problem (2E-MD-CVRP) that describes the utilisation of the Amsterdam city canal network for last mile parcel delivery

Bartje M. Alewijnse, Alexander Hübl

University of Groningen, Netherlands

An increase in e-shopping and (last mile) parcel deliveries has contributed to a rapid growth of urban freight transportation. This generates major impacts on city sustainability and liveability. Current solutions for urban logistics concern road traffic, but multiple Dutch cities have an extensive range of city canals that could be used for freight transportation over water. It was investigated how the city canal network of Amsterdam can be utilised for last mile parcel delivery, and what the related effects are. A MILP formulation of a Two-Echelon, Multi-Depot, Capacitated Vehicle Routing Problem (2E-MD-CVRP) was developed. The model describes a network in which ships transport parcels to pre-determined satellite locations in the city centre, where the parcels are transferred to cargo e-bikes for the last mile of the delivery to the customer. The model was optimised by minimising the total costs, using the Genetic Algorithm (GA). The algorithm was able to find solutions but could not always stay within the constrained search space. Different possible network scenarios were evaluated, describing the consequences with respect to emissions, costs, and traffic flows. The results show promising economic, social, and environmental outcomes for a network with ships and cargo e-bikes instead of delivery vans. A daily and investment cost reduction of 16% and 36% respectively and a CO2 emission reduction of 78.26% can be realised.

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Blockchain in the Operations and Supply Chain Management

Time: Thursday, 09/Sept/2021: 12:00pm - 2:00pm

A Blockchain-based Manufacturing Service Composition Architecture for Trust Issues

Qianhang Lyu, Yunqing Rao, Jiawei Wang, Peng Qi

Huazhong University of Science and Technology, China, People's Republic of

Cloud platform is found to be an appropriate way to meet the need to improve the performance of information sharing among manufacturing companies. However, there is still a huge gap to be bridged for collaboration among different stakeholders due to interest conflict or distrust. Especially when the whole system is firmly controlled by centralized third parties. Blockchain is a technology based on cryptography, distributed system and consensus mechanism, which is meant to be a critical method used in value convergence to strengthen connections among enterprises and effectively solve trust issues to a certain extent. Obviously it would benefit for platform performance to elevate operational transparency as well as immutability, which are precisely the comprehensive properties of blockchain. This paper proposes a blockchain-based cloud platform manufacturing services composition architecture and elaborates the business collaboration system in detail. Manufacturing resources on the cloud platform are in the form of services to be accessed by any registered users in the system. The blockchain stores and broadcasts transaction and match results generated in the core cloud services layer. Furthermore, a quality of service(QoS) attribute model is built to evaluate the service composition problem and genetic algorithm is adopted to solve it. Finally, a simulation experiment is presented as the application of proposed system.

Blockchain for Product Authenticity in the Cannabis Supply Chain

Sven Januszek, Andreas Siegrist, Torbjørn H. Netland

ETH Zürich, Switzerland

Cannabis is an emerging industry and like other strictly regulated prod-ucts prone to fraud. Its medical application and increased regulatory pressure call for secure supply chains and product authenticity. Blockchain's capability to strengthen end-to-end traceability in supply chains has the potential to provide the required levels of assurance. In this study, we, describe effective ways of how to integrate Blockchain technology within the cannabis supply chain and other required technologies to ensure product authenticity. Our results show that block-chain is a powerful and promising technology that can effectively improve supply chain transparency and support regulatory compliance. Nevertheless, blockchain alone can only ensure data security and does not capture the linkage between the physical product and its data, which is an important consideration regarding prod-uct fraud. For this reason, we conclude that blockchain is an enabling technology that still needs to be supported by further supplementary technologies, such as nuclear magnetic resonance-based screening technology, Internet of Things, and communication standards. Used together, these technologies can ensure product authenticity in cannabis supply chains.

An Approach for Creating a Blockchain Platform for Smart Labeling and Tracing Wines and Spirits

Sotiris P. Gayialis, Evripidis P. Kechagias, Grigorios D. Konstantakopoulos, Georgios A. Papadopoulos, Ilias P. Tatsiopoulos

National Technical University of Athens, Greece

The traceability and labeling of products have been issues faced for decades in various industrial and commercial sectors. One of the most important product categories that require effective traceability and, at the same time, anti-counterfeit labeling, are wines and spirits. The ineffective traceability of such products poses extremely serious risks both to the national economy and the health of consumers. This paper aims to propose an approach for creating a blockchain-enabled traceability and labeling platform in order to ensure the origin, quality and authenticity of wines and spirits. The platform will combine a number of advanced technologies, namely blockchain, anti-counterfeit labels, smart contracts and sensors in order to offer effective traceability at all stages of the supply chain of wines and spirits. The paper initially presents the research background and continues with analyzing the methodological approach for the development of the platform, its functionality, and the expected benefits from its implementation.

Blockchain design for digital supply chain integration

Kari Korpela[1], Petr Novotny[2], Alevtina Dubovitskay[3], Tomi Dahlberg[4], Mika Lammi[5], Jukka Hallikas[6]

[1]DBE Core, Helsinki, Finland; [2]IBM T.J Watson Research Center; [3]Lucerne University of Applied Sciences and Arts, Switzerland; [4]University of Turku; [5]Kouvola Innovation, Finland; [6]LUT University, Finland

Supply-chain process involves multiple actors and intermediary companies that need to coordinate but often lack interoperability and do not fully trust each other. Supply-chain digitalization, including use of cloud services and domain-specific standards, enables significant efficiency improvements of the whole process. We conduct a case-study by collecting and analyzing the data from a large business consortium, represented by experts in the fields of industry, logistics, banking, and ICT. Based on the outcomes of the case study, we propose an architecture of a blockchain-based system for a practi-cal intermodal logistics project and discuss future research direction.

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Blockchain-based master data management in supply chains: a design science study

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Master data management is an essential task for organizations and even more critical when collaborations are pursued. Using centralized platforms to manage master data across business partners is straightforward but also entails risks. Besides the dependency on intermediaries, data sovereignty is limited and a single point of failure persists. With new decentralization trends and the uprising blockchain technology, there is potential for optimized and sovereign master data management across entities. We conduct a design science study to assess blockchain technology's suitability to store and share master data in supply chains. The developed artifact was quantitatively evaluated, focusing on costs and transaction time to further contribute insights to blockchain technology's economic suitability. The Ethereum-based application was implemented in evan.network and Ropsten test networks. The results substantiate the previous theoretical statements in the literature with reliable numerical data, which indicate that permissioned blockchain networks are more scalable and low-cost than permissionless networks. We also highlight further research opportunities.

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Data-driven methods for Supply Chain optimization

Time: Thursday, 09/Sept/2021: 12:00pm - 2:00pm

A robust data driven approach to supply planning

Benoit, Loger, Alexandre Dolgui, Fabien Lehuédé, Guillaume Massonnet

IMT Atlantique, France

We develop two robust optimization models to plan the supply operations of an assembly line when the latter are subcontracted to an external service provider. The uncertainty sets are constructed from available information on picking times both in a classical budget-based robust approach and by using Support Vector Clustering. Numerical experiments are conducted on test instances derived from a practical case to illustrate the effectiveness of the proposed approach. The results show that the robust optimization approach is efficient to reduce the impact of picking time uncertainties on production and that the SVC-based model outperforms the classical budget-based model.

An Information Sharing Framework for Supply Chain Networks: What, When, and How to Share

Eunji Lee, Stefan Minner

Technical University of Munich, Germany

In decentralized supply chains, firms often deal with asymmetric information. One company's private information can be relevant for the other company to make better decisions. Therefore, what to share, when to reveal, and how to share the information are of interest. There has been an increasing interest in supply chain coordination issues under asymmetric information in the past two decades. However, few of them consider strategic information sharing among the supply chain members. Thus, this paper aims to review the development of information sharing in supply chain management. We classify the existing literature into three categories, namely (i) supply chain coordination under information asymmetry, (ii) information sharing technologies, and (iii) a strategic information-sharing framework regarding what, when, and how to share. The related supply chain literature is reviewed based on the different focuses when dealing with information asymmetry. We report the research development and gaps of each category. Further, we propose some future research directions based on the findings from the literature review.

Responsible Manufacturing with Information Disclosure under Regulatory Inspections

Yifan Cao, Bin Shen

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Different legislations are enacted to monitor and promote social sustainability perfor-mance. If any unsustainable manufacturing practice is found by the regulatory body, the firm will suffer from huge loss. As pressured by socially responsible purchasing and regulatory pressure, some manufacturing firms have begun to disclose social sus-tainability in their manufacturing process in audit reports periodically. In this paper, we examine how should a manufacturing firm choose its optimal socially-sustainable manufacturing effort, and how should the manufacturing firm set prices to successfully transmit social sustainability signals to first-stage consumers. We conduct a two-stage game-theoretic analysis to examine a manufacturing firm's socially-sustainable manufacturing effort and dynamic pricing decisions under regulatory pressure. Consumers are classified into socially conscious and non-socially conscious consumers. We find that when the gap of consumer's attitude towards responsibility is moderate, if the manufacturing firm insists on targeting both socially conscious and non-socially con-scious consumers in the first period, consumers will believe that the firm is of low re-sponsibility in manufacturing. Then in the second period when socially-sustainable manufacturing effort becomes a symmetric information, the belief that the manufactur-ing firm is irresponsible will hurt the manufacturing firm's profit. Thus, it is beneficial to target at socially conscious consumers in the first period so as to transfer quality in-formation to consumers. Our findings help a firm to wisely make socially-sustainable manufacturing effort decisions and set an informative price so as to transfer responsible manufacturing information to early consumers.

Understanding supply chain visibility through experts' perspective: A Delphi based approach

Tarun Kumar Agrawal[1], Ravi Kalaiarasan[1], Jan Olhager[2], Magnus Wiktorsson[1]

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Visibility in production logistics and across supply chain has become a key concern for organizations. Its need has been further emphasized due to the current COVID 19 crisis. Organizations find it challenging to prepare the internal logistics and supply chain, and quickly respond to such unexpected events, pertaining to low visibility. Against this backdrop, the paper systematically documents different factors influencing supply chain visibility and crucial information that should be collected and shared among supply chain partners for better visibility. A multi-stage Delphi analysis is being conduct-ed with twenty-six supply chain experts from various globally recognized enterprises with manufacturing units located worldwide. The study starts with a short open-ended questioner to collect a comprehensive list of antecedents, drivers, barriers, effects and visibility information based on qualitative response from the experts. The results indicate that risk management, environmental sustainability and supply chain control are some of the key drivers, lack of IT infrastructure and maturity are some of the barriers, integrated systems and technology maturity are among the key antecedents and gaining planning capability and better customer service are some of the positive effects of supply chain visibility as per the experts opinion. In addition, information related planning, supplier location and deviation is among the crucial ones that require collection and sharing for better supply chain visibility. This research study is among the few that empirically explores factors influencing supply chain visibility and generate new insights to why the barriers can be difficult to overcome in complex supply chain settings.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Data-Driven Solutions for the Newsvendor Problem: A Systematic Literature Review

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The newsvendor problem captures the trade-off between ordering decisions, stocking costs and customer service level when the demand distribution is known. Nonetheless, in real case scenarios, it is unlikely that the decision maker knows the true demand distribution and its parameters, encouraging the use of datasets for empirical solutions that will achieve more precise results and reduce misleading decisions. Motivated by the availability of large amount of quality datasets, advances in machine learning algorithms and enhancement of computational power, the development of data-driven approaches has been emerging over the recent years. However, it is still unclear in which settings these data-driven solutions outperform the traditional model-based methods. In this paper, a systematic literature review is conducted for the descriptive analysis and classification of the most relevant studies that addressed the newsvendor problem and its variations under the data-driven approaches. The methods developed to solve the problems with unknown demand distribution are categorized and assessed. For each category, our paper discusses the relevant publications in detail and how they evidence the data-driven performance better. By identifying the gaps in the available literature, the future research directions are suggested.

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Digital twins based on systems engineering and semantic modeling

Time: Thursday, 09/Sept/2021: 12:00pm - 2:00pm

Semantic Modeling Supports the Integration of Concept-Decision-Knowledge

Yili Jin[1], Jinzhi Lu[2], Guoxin Wang[1], Ru Wang[1], Kiritsis Dimitris[2]

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The semantics of product design enables to visualize the function of the product and promote communications between the products and the designers. However, the existing theories and methods of product design are lack of research on integration of modeling concepts, domain specific knowledge, and decision-makings. For this reason, this paper proposes a C-D-K theory which is supported by a semantic modeling approach. Firstly, KARMA modeling language, which is a semantics modeling approach, is used to support the formalization of concept space (C) and decision space (D), in which space C is expanded based on the RFLP design framework, and space D is based on PEI-X decision workflow to realize decision problem modeling. Then based on the Open service lifecycle collaboration (OSLC) specification, domain specific knowledge is represented based on the unified expression of resources in the knowledge space (K), which is used to integrate knowledge to semantics models constructed by KARMA language. Finally, the feasibility and effectiveness of the proposed semantic modeling approach are verified by the case of an unmanned detection vehicle design. From the result, we find the semantics modeling approach enables to integrate semantic models and knowledge based on the C-D-K theory.

Supporting Digital Twin Integration Using Semantic Modeling and High-Level Architecture

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Digital twin (DT) provides a solution for supporting the interconnection between the physical world and the virtual world. When implementing DT integration, it is challenging to implement interface definition, information and service integration across DTs. This paper proposes a semantic modeling approach with a High-Level Architecture (HLA) to support the DT integration. The semantic modeling approach based on Graph-Object-Property-Point-Role-Relationship (GOPPRR) meta-meta models is used to realize the integrated formalisms of heterogeneous DTs. HLA is used to support interface definition and service integration between virtual entities of DT. Finally, a case of an unmanned aerial vehicle (UAV) landing on ship is used to verify the flexibility of this approach. From the results, we find the GOPPRR ontology and HLA specification enables to provide a unified formalism of the DTs of UAV and the ship, and to implement data exchange dur-ing the distributed simulation execution.

STARdom: an architecture for trusted and secure human-centered manufacturing systems.

Jože M. Rožanec[1,2,3], Patrik Zajec[1,2], Klemen Kenda[1,2,3], Inna Novalija[2], Blaž Fortuna[2,3], Dunja Mladenić[2], Entso Veliou[5], Dimitrios Papamartzivanos[4], Thanassis Giannetsos[4], Sofia Anna Menesidou[4], Ruben Alonso[6], Nino Cauli[7], Diego Reforgiato Recupero[6,7], Dimosthenis Kyriazis[8], Georgios Sofianidis[8], Spyros Theodoropoulos[8,9], John Soldatos[10]

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There is a lack of a single architecture specification that addresses the needs of trusted and secure Artificial Intelligence systems with humans in the loop, such as human-centered manufacturing systems at the core of the evolution towards Industry 5.0. To realize this, we propose an architecture that integrates forecasts, Explainable Artificial Intelligence, supports collecting users' feedback and uses Active Learning and Simulated Reality to enhance forecasts and provide decision-making recommendations. Cyber-security is addressed as a general concern. We align the proposed architecture with the Big Data Value Association Reference Architecture Model. We tailor it for the domain of demand forecasting and validate it on a real-world case study.

Model-based Systems Engineering Supporting Integrated Modeling and Optimization of Radar Cabin Layout

Shiyan She[1], Jinzhi Lu[2], Guoxin Wang[1], Jie Ding[1], Zixiang Hu[3]

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The equipment layout optimization of a UAV(Unmanned Aerial Vehicle) radar cabin can decrease cable length in order to promote the quality of radar and UAV system. Model-based Systems Engineering (MBSE) is widely used for UAV development, particularly for the layout design of UAV radar cabin. In this paper, a semantic modeling approach based on KARMA language is proposed to create the system model of the radar cabin layout based on an MBSE approach for for-malizing Requirement, Function, Logical and Physical structure (RFLP). Moreo-ver, the KARMA models for UAV radar cabin layout modeling are transformed to the Genetic Algorithm (GA) in MATLAB toolkit for radar cabin layout opti-mization by code generation. Based on the layout information generated from the KARMA models, the optimized layout solution is generated by the MATLAB toolkit. From the case study, we find the KARMA language enables to formalize the radar cabin design based on nine diagrams of SysML specification. And op-timizations can be executed automatically after getting data generated from KARMA models. Thereby, the proposed semantic modeling approach improves design efficiency and quality during radar cabin design.

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Digital Twin-driven Approach for Smart City Logistics: The Case of Freight Parking Management

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According to the United Nations' prediction, the world is expected to have 43 megacities that host more than 10 million inhabitants by 2030. City logistics for freight distribution is a challenging and crucial problem for these cities. Recent disruptive approaches such as Smart City provide us a new angle to investigate the problem as well as for decision making. It creates a pervasive and mobile computing environment that allows the city itself to be overlaid with sensing and actuation, embedded with "smart things" to develop an "ambient intelligence." By choosing this angle, this work investigates the problem of freight parking management for last-mile delivery in smart city, called Smart City Logistics Parking (SCLP). A use case is conceptualized and modeled via a bottom-up approach. The bottom-layer aims to represent the structure of the SCLP, i.e., the physical elements constituting the SCLP physical infrastructure into a digital representation, a.k.a a Digital Twin of the SCLP. Property Graph modeling is applied at this step as a meta-model to formulate the object relationships with properties. The upper-layer makes use of associated ontologies to add semantics to the structural description of the SCLP. The built model is then implemented into a Digital Twin experimental platform, namely Thing in the Future (Thing'in in short) from Orange Labs. The modeling work presented in this paper encourages future works on simulation of the decision-making processes based on the Digital Twin platform.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Regular session : Maintenance improvement and lifecycle management

Time: Thursday, 09/Sept/2021: 12:00pm - 2:00pm

Perspectives on the future of maintenance engineering education

Jon Bokrantz, Anders Skoogh

Chalmers University of Technology, Sweden

In this article, we aim to remedy the effects of skill-biased technological change within maintenance engineering and enable productivity gains from novel digital technologies such as Artificial Intelligence. We do this by outlining the critical role of education and the need for renewal and increased access to higher education within maintenance, followed by reviewing the literature on maintenance engineering education over the past two decades (2000-2020). In our systematic literature review, we identify nine key themes that have occupied maintenance researchers in their educational efforts, e.g. design and development of curricula, programs, and courses; identification of competence requirements and learning characteristics; and new educational formats such as gamification and innovative laboratory sessions using novel digital technologies. Following our review, we propose research- and policy-oriented recommendations for the future of maintenance engineering education.

Wear and Tear: A Data Driven Analysis of the Operating Condition of Lubricant Oils

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Intelligent lubricating oil analysis is a procedure in condition-based maintenance (CBM) of diesel vehicle fleets. Together with diagnostic and failure prediction processes, it composes a data-driven vehicle maintenance structure that helps a fleet manager making decisions on a particular breakdown. The monitoring or control of lubricating oils in diesel engines can be carried out in different ways and following different methodologies. However, the list of studies related to automatic lubricant analysis as methods for determining the degradation rate of automotive diesel engines is short. In this paper we present an intelligent data analysis from 5 different vehicles to evaluate whether the variables collected make it possible to determine the operating condition of lubricants. The results presented show that the selected variables have the potential to determine the operating condition, and that they are highly related with the lubricant condition. We also evaluate the inclusion of new variables engineered from raw data for a better determination of the operating condition. One of such variables is the kinematic viscosity which we show to have a relevant role in characterizing the lubricant condition. Moreover, 3 of the 4 variables that explaining 90% of the variance in the original data resulted from our feature engineering.

A Periodic inventory model for perishable items with general lifetime

Fatma Ben Khalifa[1], Imen Safra[2], Chaaben Kouki[3], Zied Jemai[1,4]

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We study a perishable inventory system controlled by a (T, S) periodic re-view order up to level policy. Items have a general lifetime distribution, and the lead time is assumed to be constant. The demands arrive according to a Poisson process with rate λ. The customer is impatient. If he is not served, he will leave the queuing systems. Using the approximate solution of the steady-state probabilities, we were able to obtain the cost components' analytical expression. Next, we had compared the analytical results of our model with the simulation results. Finally, we made a sensitive analysis to evaluate the effect of the lifetime variation and cost parameters on the optimal cost and stock level S. Our model is an extension of the case of an exponential distri-bution. With the general lifetime distribution, we were able to have total flex-ibility for setting the lifetime variability. This approximation is closer to reali-ty, especially in random environment conditions. Results obtained by the an-alytical approximation model are close to those of the optimal policy with a mean of 7% accuracy.

Efficient Maintenance Planning: the MATISA Company Case Study

Jean-Robert COMPERAT[1], Vincent CLIVILLE[2], Lamia BERRAH[2]

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More and more equipment manufacturers are contracting with cus-tomers for maintenance planning (MP) of their equipment; this maintenance be-ing either corrective, preventive or predictive. Due to the costs involved, custom-ers are increasingly asking for a business case justifying the maintenance plan. This paper describes a study conducted with the MATISA Company, a track con-struction and renewal train manufacturer, and the business case for the equipment MP put forward to a customer. The concept developed consists of a method ena-bling the Company to provide a systematic explanation of the adopted mainte-nance strategy based on a joint cost-availability analysis regarding the 'critical' components. We begin by presenting MATISA practice, followed by a brief re-view of equipment maintenance principles. We then present the MATISA busi-ness case, and conclude with some remarks about the prospects for the method adopted and its generalizability from this experimental study.

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Understanding Schedule Progress Using Earned Value and Earned Schedule Techniques at Path-level

Christian Capone, Timur Narbaev

Kazakh-British Technical University, Kazakhstan

Project monitoring and control is one of the core processes of effective production planning and scheduling. As part of this process, earned value management (EVM) is used to measure and forecast the duration and cost of production projects and activities. Using the EVM-based earned schedule (ES) value, the schedule variance (SV(t)) metric is calculated. This metric is further used to analyze the schedule progress. Based on this, potential schedule delays and slack times are calculated on both project-level and path-level. However, commonly in practice, they are derived from SV(t) values on the project-level. Moreover, the research on an individual path level or comparison of SV(t) on the project-level with the ones of the path-level is limited.

This study proposes such a comparative analysis. The findings reveal misleading results regarding the project-level schedule analysis outcomes due to inconsistency in the computations from both path- and project-levels. For example, when the project-level analysis suggests a schedule delay the path-level analysis shows the project has no delay. Using a hypothetical production project, this study demonstrates how and when such inconsistent outcomes may arise. This study pioneers such concepts as “false positives” and “false negatives”. Based on its findings, the study discloses prospects for future research in this area.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Regular session : Additive Manufacturing and mass customization

Time: Thursday, 09/Sept/2021: 12:00pm - 2:00pm

Impact of failure rate uncertainties on the implementation of Additive Manufacturing in spare parts supply chains

Mirco Peron[1], Nils Knofius[2], Rob Basten[3], Fabio Sgarbossa[1]

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The world of spare parts may be revolutionized by the advent of additive manufacturing (AM). Thanks to the possibility to manufacture spare parts on-demand, AM has attracted great attention in the last years as a substitute of conventional manufacturing techniques (CM). However, both researchers and practitioners point out two main limitations that might hinder the tran-sition from CM to AM for the manufacturing of spare parts: AM parts' high production costs and uncertain failure rate. While the former limitation will most likely be overcome in the near future, the latter remains an open issue, so far uninvestigated. We therefore aim to investigate the effect of uncertain failure rate estimates on the optimal inventory level and on the total costs of spare parts management. To do so, we adapt a periodic inventory manage-ment policy available in the literature to include failure rate uncertainties and perform a parametrical analysis to investigate their impact varying the mean values of the failure rate, the lead times, and the unitary backorder and production costs. From the results it emerged that the effects of the failure rate uncertainties on the optimal inventory level and on the total costs of spare parts management increases exponentially, leading to a divergence up to 250% for both.

Mass customization: Customizing for the human aspect of operations management

Håkon Lund, Stine Sonen Tveit, Lars Skjelstad

SINTEF DIGITAL, Norway

There is a tendency that the consumer market is getting more and more individu-alized as an effect of people craving customized products, and producers seeing this as an opportunity for earning more money on a product or service custom-ized to a customer's specific needs. This customization has a tendency of increas-ing the complexity tied to the product, not necessarily for the consumer, but typi-cally for the producer. As the complexity of products are moved closer to the producer, the job of producing and/or assembling the end-product gets more complicated. For instance, a higher degree of flexibility will be needed, if com-pared to traditional mass production where one typically produces in bulk. This will again demand more from the organization and its employees in form of more responsive systems, machines, processes, and not least employees. In this paper we suggest a framework for assessing the individual job satisfaction at the shop floor, and therefore take one step in the direction of customizing the daily work of employees in mass customizing companies.

Impacts of Additive Manufacturing on Supply Chains: An Empirical Investigation

Albraa A. Noorwali[1,2], M. Zied Babai[2], Yves Ducq[1]

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Over the last decade, Additive Manufacturing has received an increased attention as many manufacturing companies have increasingly adopted new technologies to capture new opportunities. This research identifies the impacts of Additive Manufacturing (AM) on the supply chain when compared to the case of the conventional manufacturing. Through an empirical investigation conducted with 14 multinational companies in the manufacturing sector, the impacts of AM are analysed by focusing on post-processing operations, lead times, cost implications and the use of the make-to-order & make-to-stock strategies. The empirical investigation reveals two major benefits of AM, namely: the ability to produce complex parts and the reduction of the inventory levels. However, the empirical results were mixed for some other impacts of AM. In fact, although many experts agreed on the general benefits of AM, a significant number did not see much difference from the conventional methods. We also provide empirical evidence that, under AM, lead-times do not reduce as opposite to what is reported in the literature, which might be due to the extra time required for quality checks and post-processing.

A Knowledge-Based Approach for Decision Support System in Additive Manufacturing

Qussay Jarrar, Farouk Belkadi, Alain Bernard

Ecole Central de Nantes, Laboratory of digital Sciences of Nantes, ECN-LS2N-UMR 6004

The large amount and different types of data and knowledge generated within the Additive Manufacturing (AM) value chain are highly challenging in terms of management and organization. Understanding the interconnections between all these immaterial corpuses is important for decision making and process optimization issues. Moreover, AM has more parameters than conventional manufacturing processes, and many of these parameters are difficult to assess and monitor. Therefore, it becomes important to develop computer-based solutions that are able to aid the decision maker and to support the management of all information along the AM value chain. In this paper, a knowledge-based decision support framework using ontological models and mechanisms is proposed for the above objective. Cost estimation is conducted as an application of the proposed framework.

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A Bibliometric Analysis Approach to Review Mass Customization Scientific Production

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Mass customization is an important manufacturing concept aimed at integrating product varieties to provide customized services and products based on individual needs. This concept has emerged in the 1980s as demand for product variety increased, and the research in this area has been present for the last three decades. This article aims to study the scientific production around mass customization through metadata analysis of all articles indexed in the bibliographic database Web of Science. We conducted the science mapping and bibliometric analysis using the "bibliometrix" R Package. Also, we conducted a graphical analysis of the bibliographic data using VOSviewer software. Based on a predefined filter, a final sample consisted of 802 articles published in the period from 1996 to April 2021. This study identified the most relevant sources, authors, and countries active and influential through a five-stage workflow consisting of study design, data collection, data analysis, data visualization, and data interpretation. Keyword analysis revealed the related emerging research topics. Co-citation and co-occurrence analysis was performed to underline research streams.

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Robotics Technologies for Control, Smart Manufacturing and Logistics

Time: Thursday, 09/Sept/2021: 12:00pm - 2:00pm

Automatic Drones for Factory Inspection: The Role of Virtual Simulation

Omid Maghazei, Torbjørn H. Netland, Dirk Frauenberger, Tobias Thalmann

ETH Zurich, Switzerland

Manufacturers experiment with the use of drones for various processes such as surveillance, inspection, cycle counting, and intralogistics, but implementation into routine operations remains rare. One reason for low adoption rates relates to the manual control requirements of most drone systems. This paper studies the use of automatic drones in manufacturing. A virtual simulation of drone flights in a manufacturing facility was developed to identify and evaluate the potential of automatic drones for thermal inspection of injection molding machines. This paper reports the implementation of the virtual simulation and discusses how such simulations can inform the use of automatic drones for factory inspections.

Geometric error modeling and sensitivity analysis of a laser pipe-cutting system based on Lie group and Sobol method

Yuze Jiang, Wenyu Yang, Liang Qin, Tong Ding

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Laser pipe-cutting system, a special machine tool, has been widely used in the precision machining of metal pipe. The geometric errors remarkably affect the machining accuracy of products. Error modeling and sensitivity analysis are key issues to improve the product quality. In this paper, the geometric error model of the laser pipe-cutting system which contains 70 geometric errors is established based on multi-body theory and Lie group. The coupling effects caused by two chucks are considered as the spatial angular deviation in modeling. The sensitivity analysis for the geometric error model is conducted to identify the essential sensitivity errors based on an improved Sobol method with quasi-Monte Carlo algorithm. The results show that not only the linear positioning errors, but also the squareness errors and parallelism errors play crucial roles in the machining accuracy. Based on the result, the essential sensitivity errors are calibrated and the machining accuracy is improved.

Redundancy Resolution in Kinematic Control of Serial Manipulators in Multi-Obstacle Environment

Wanda ZHAO[1], Anatol PASHKEVICH[1,2], Damien CHABALT[1,3]

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The paper focuses on the redundancy resolution in kinematic control of a new type of serial manipulator composed of multiple tensegrity segments, which are moving in a multi-obstacle environment. The general problem is decomposed into two sub-problems, which deal with collision-free path planning for the robot end-effector and collision-free motion planning for the robot body. The first of them is solved via discrete dynamic programming, the second one is worked out using quadratic programming with mixed linear equality/non-equality constraints. Efficiency of the proposed technique is confirmed by simulation.

Seed-and-Prune Approach for Rapid Discovery of Tensegrity-like Structures of the Desired Shape

Sergei Savin

Innopolis University, Russian Federation

In this paper, a new tensegrity generation method, based on a combination of a random search, quadratic programming and connection pruning is proposed. The method exploits the structure of the static equilibrium equations of tensegrity structures with static nodes, allowing to form linear equality constraints. By abandoning the requirement of struts being disconnected we arrive at a simple convex program, where the existence of solution represents the existence of the sought structure. We propose a way to generate node positions and to prune the connections in order to shape the resulting tensegrity-like structures in the desired form.

Tensegrity Morphing: Machine Learning-based Tensegrity Deformation Predictor for Traversing Cluttered Environments

Eduard Zalyaev, Sergei Savin

Innopolis University, Russian Federation

In this paper we introduce a neural network-based approach to tensegrity morphing: the task of actively changing the shape of a tensegrity structure to "fit" between obstacles in a cluttered environment. We specifically focus on a class of forming tasks, when the robot is required to pass between two parallel plate-like obstacles, and develop a robust solution both for generating dataset and for training predictor. Proposed predictor is able to predict both the shape of the tensegrity structure and the desired rest lengths of the actuated elastic elements, which can serve as motor commands when a quasi-static configuration-space trajectory tracking is used. We demonstrate high accuracy on validation dataset, and show the conditions when predictor overfits.

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Smart Supply Chain and Production in Society 5.0 Era

Time: Thursday, 09/Sept/2021: 12:00pm - 2:00pm

Supply Chain Optimization through Cooperative Negotiation by Using Backward Scheduling

Yoshitaka Tanimizu[1], Rika Kanbara[2]

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In recent years, mass customization is an important issue in manufacturing industries. They may require a make-to-order (MTO) manufacturing system throughout the whole supply chain. Our previous researches proposed a basic three-layered supply chain model for dynamic configuration of supply chains including an MTO manufacturing system. The model consists of three model components named a client, a manufacturer, and a supplier. A negotiation process among the model components were proposed in order to enter into a lot of contracts. This paper presents a cooperative negation method between a manufacturer and a supplier. The objective is to provide a negotiation method for entering into a large amount of contracts with a client. A manufacturer adjusts the requirement of part order for a supplier by reallocating manufacturing operations backwards from the delivery time required by a client. We developed a prototype of simulation system for a three-layered supply chain. We carried out large number of computational experiments by changing experimental conditions and verified the effectiveness of the proposed negotiation method.

A study on sharing logistics network design considering demand uncertainty

Asumi Ito, Toshiya Kaihara, Daisuke Kokuryo, Nobutada Fujii

Kobe University, Japan

The evolution of e-retailing is driving a rise in logistics costs and risk of late de-livery. Collaborative logistics has become the key to help businesses eliminate in-efficiencies, improve responsiveness to market changes, and reduce overall sup-ply chain costs by adjusting transportation capacity efficiently. In this study, we propose a stochastic mixed integer linear programming model that incorporates shipper's transportation operations via truck sharing service. The model supports strategic network design decisions in uncertain market environments by optimiz-ing the number of trucks under uncertain demand. Through several case studies on a small-scale truck sharing network, we show the influence of demand uncer-tainty on the network performance in terms of the on-time delivery ratio and the gross profit margin ratio. We also show the influence of the sharing platform fea-tures such as the transaction price and the number of available trucks, on shippers as well as a platformer in terms of the turnover of trucks.

A New Representation and Adaptive Feature Selection for Evolving Compact Dispatching Rules for Dynamic Job Shop Scheduling with Genetic Programming

Shady Salama, Toshiya Kaihara, Nobutada Fujii, Daisuke Kokuryo

Kobe University, Japan

Dispatching rules are extensively addressed in the dynamic job shop scheduling literature and are commonly adopted in many industrial practices. The manual design of dispatching rules is a tedious process that requires a great deal of time and experience. Due to the growth in computational power, the design process is automated using various machine learning and optimization techniques to evolve superior dispatching rules compared to human-made ones. Genetic Programming (GP) is one of the most promising approaches in the field of automated design of scheduling rules, especially under dynamic conditions. Considering a large set of terminals that reflects various job and machine attributes helps GP to obtain efficient rules, but in return extends the search space. Also, the impact of terminals can vary greatly among various scenarios, objective functions, and evolutionary stages. Therefore, an efficient feature selection mechanism can support the GP searching ability by eliminating irrelevant terminals and facilitating the process of high-quality rule search by focusing more on the promising regions in the search space. In this paper, we propose a new representation for the GP individuals that reflects the importance of each terminal in this rule. Also, an adaptive feature selection mechanism is developed that uses the information gained from the previous evolutionary step in restricting the search space at the current generation. Experimental results show that the proposed approaches assist the GP to obtain compact rules in a shorter computational time without sacrificing the performance compared with the standard GP algorithm and another representation from the literature.

Coalition Analysis on Two Manufactures and Two Retailers Supply Chain via Cooperative Game Theory

Taiki Saso, Tatsushi Nishi

Okayama University, Japan

In this study, we consider a coalition analysis on the pricing problem for a decentralized supply chain model in which two manufacturers and two retailers with price competitions. In the pricing game, we analyze the equilibrium solutions with perfect competition, grand coalition and partial cooperation between manufacturers and retailers. The results show the externality between coalitions for supply chain members. Therefore, the pricing game is represented as a partition function game.

The stable profit allocation in each alliance structure is obtained based on cooperative game theory for the partition function game. We derive the new finding that if there are multiple partial alliances within the same alliance structure, the profit within the partial alliance is smaller than the profit when there is only one partial alliance. Then, it is shown that the pessimistic and optimistic Shapley values of the manufacturers are lower than the optimistic personal alliance value of the manufacturer when the product substitutability is lower and the store substitutability is higher.

APMS 2021 Conference | Artificial Intelligence for Sustainable and Resilient Production Systems

Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

A proposal of scheduling method based on decision criteria considering electric power costs and productivity

Masayuki Yabuuchi[1], Toshiya Kaihara[1], Nobutada Fujii[1], Daisuke Kokuryo[1], Mio Nonaka[2], Kotone Senju[2]

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In recent years, the price of electricity in Japan has increased, and then manu-facturing industries are required to implement production plan in consideration of the electric power costs. In response to this demand, production scheduling has to be implemented in consideration of several decision criteria such as productivity and electric power costs. In this paper, we propose a production scheduling with satisficing trade-off method in order to maintain productivity and reduce electricity costs, and evaluate the effectiveness of the proposed method.

Reshaping the Supply Chain for Society 5.0

Rosanna Fornasiero[1], Andrea Zangiacomi[2]

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This work aims to reflect on the evolution of Supply Chain (SC) towards So-ciety 5.0 paradigm proposing a set of SCs to enhance the active role of all stakeholders involved leveraging on digital technologies. Social macro-trends indeed strongly impact on companies' business creating the urgent need to significantly adapt the way their SCs are organized and interlinked. The work is based on a consultation with experts representing different kind of companies, industrial sectors, function, role in the SC and research fields. Results lead to the identification of possible SCs for the future, and among them, three solutions seems to particularly fit current challenges related to the evolution of society: Human-centric SC, SC for active citizens and SC in urban context. According to the identified SCs, specific issues are presented and possible solutions basing on new technologies have been mapped with the support of experts. The need to integrate strategies at industrial and soci-etal level urge thus for a new holistic way where business eco-system capa-bilities merge with civil society needs in order to have people wellbeing as a major priority.

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Data-Driven Platforms and Applications in Production and Logistics: Digital Twins and AI for Sustainability

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

Applying Machine Learning for Adaptive Scheduling and Execution of Material Handling in Smart Production Logistics

Erik Flores-García, Yongkuk Jeong, Magnus Wiktorsson

KTH Royal Institute of Technology, Sweden

Combining Smart Production Logistics (SPL) and Machine Learning (ML) for adaptive scheduling and execution of material handling may be critical for enhancing manufacturing competitiveness. SPL and ML may help identify, adapt, and respond to scheduling changes originating from disturbances in and enhance the operational performance of material handling. However, the literature combining the SPL and ML for material handling is scarce. Accordingly, the purpose of this study is to propose a framework applying ML for the dynamic scheduling and execution of material handling tasks in SPL. The study proposes an architec-ture including Cyber Physical System (CPS) and Internet of Things (IoT) applying ML for the dynamic scheduling and execution of material handling. Then, we describe the ML inputs, interactions, and work flow for realizing the proposed architecture. After, the study presents digital services in a simulation environment exemplifying the dynamic scheduling and execution of material handling in SPL. The study concludes with essential implications to the manufacturing industry

Exploring Economic, Environmental, and Social Sustainability Impact of Digital Twin-based Services for Smart Production Logistics

Goo-Young Kim[1], Erik Flores-Garcia[2], Magnus Wiktorsson[2], Sang Do Noh[1]

[1]Sungkyunkwan University, South Korea; [2]KTH Royal Institute of Technology, Sweden

Digital Twins are increasingly perceived as critical enablers for improving operational performance and sustainability of Smart Production Logistics. Addressing the lack of empirical research on this topic, this study explores the economic, environmental, and social sustainability impact of Digital Twin-based services for Smart Production Logistics. The study presents findings from a Smart Production Logistics demonstrator in an academic environment, and underscores the contributions and limitation of current understanding about Digital Twin-based services in relation to its impact on economic, environmental, and social sustainability. The study presents valuable implications for managers responsible for material handling.

Design and Implementation of Digital Twin-Based Application for Global Manufacturing Enterprises

Jonghwan Choi[1], Jinho Yang[1], Joohee Lym[1], Sang Do Noh[1], Yong-Shin Kang[2], Yu La Joe[3], Sang Hyun Lee[3], Jeong Tae Kang[3], Jungmin Song[4], Dae Yub Lee[4], Hyung Sun Kim[4]

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Nowadays, global competition in the manufacturing sector is increasingly fierce. Thus, global manufacturing companies must have a manufacturing system that ensures the production of reasonably priced, high-quality products, while meeting the needs of various customers. To address this issue, smart manufacturing should be implemented by adopting various information and communication technologies and convergence with existing manufacturing industries. One of the key technologies required for the implementation of smart manufacturing is a cyber-physical system (CPS). One of the major factors for the successful construction of a CPS is digital twin (DT). In this paper, we propose a standards-based information model for building a DT application, which is a key technology of a CPS-based integrated platform, by overcoming the heterogeneous device environment of global manufacturers and using data collected from various manufacturing sites. Furthermore, we propose a concept of modeling and simulation-based DT application. The DT application proposed in this study facilitates monitoring, diagnosis, and prediction at manufacturing sites using real-time data collected from various environments by ensuring interoperability. Moreover, its validity is verified by applying the technology to a global manufacturing company of automotive parts.

Assembly line worker assignment and balancing problem with positional constraints

Hyungjoon Yang, Je-Hun Lee, Hyun-Jung Kim

KAIST, Korea, Republic of (South Korea)

One of the most important operational issues in the assembly line is to assign tasks and workers to stations while balancing the workload of the workers. We consider the assembly line worker assignment and balancing problem (ALWABP) where the process time of a task depends on worker skill levels. We also consider new positional constraints in the ALWABP to secure the working area of the workers. Two mathematical programming models are proposed to as-sign workers and tasks when new products are introduced and when a worker is absent or leaves a position temporary, respectively. A heuristic algorithm for the first model is proposed due to its extremely high complexity. The experimental results show the efficiency of the proposed methods. Finally, we explain how the proposed models can be used with a digital twin.

When Softbots meet Digital Twins: Towards Supporting the Cognitive Operator 4.0

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[1]Federal University of Santa Catarina, Brazil; [2]Tecnológico de Monterrey, Mexico; [3]University of Southern Santa Catarina, Brazil

Digital Twins (DTs) represent one of the most powerful technologies related to Industry 4.0 implementation. Combined with the advances in Computer Science and Production Management, DTs have become an emerging trend in many applications. Despite the DT potentials, Industry 4.0 is pushing companies to adopt solutions that provide higher human satisfaction to increase operational excellence. One approach to handle this involves how workers should interact with systems (like a DT) and smart machines. Softbots is a prominent direction to underpin this goal. This paper presents the ongoing results of a research that exploits how softbots can be combined with DTs to create a more “symbiotic” Human-Machine/Computer Interaction (HM/CI) and a smarter decision-making environment.

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Nantes, France (Online) | Sun. September 5, 2021 - Thu. September 9, 2021

Operations Management in Engineer-to-Order Manufacturing

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

A systematic approach to implementing multi-sourcing strategy in engineer-to-order production

Deodat Mwesiumo[1], Bella Nujen[2], Mikhail Shlopak[3]

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Engineer-to-order (ETO) manufacturers operate in an increasingly volatile, uncertain, and complex business environment, which has added more complexity to their already complex supply chain operations. As they navigate the ramifications of the COVID-19 pandemic, they need knowledge-based guidance on selecting and implementing approaches to increasing resilience. Based on a clinical management design, this study develops a systematic approach for a case firm that recently transitioned from single sourcing to multi-sourcing. The goal is to strike a balance between the total cost of acquisition and supply chain resilience. The study reveals that effective implementation of multi-sourcing in ETO production requires involving the purchasing and supply function (PSF) right from the design stages. Besides, it is essential to deploy a cloud-based procurement system that facilitates interactions between PSF and the suppliers, as well as other critical organisational functions involved in an ETO project.

Requirements for Sales and Operations Planning in an Engineer-to-Order Manufacturing Environment

Swapnil Bhalla[1], Erlend Alfnes[1], Hans-Henrik Hvolby[1,2], Olumide Emmanuel Oluyisola[1]

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Sales and Operations Planning (S&OP) is the process through which enterprises develop tactical plans for aligning supply and demand management activities, usually with the objective of maximizing profitability. Demand-supply balancing is particularly complex and challenging in Engineer-to-Order (ETO) manufacturing environments, which are characterized by highly customer-driven order-fulfilment processes, creating a dynamic and uncertain planning environment. Recent studies highlight that ETO environments and their contextual influence on S&OP have been overlooked within extant S&OP research. This paper addresses this by investigating how the characteristics of ETO manufacturing influence the design of S&OP. Through a case study of a maritime equipment manufacturer, the paper identifies requirements that are imposed on the S&OP process by the characteristics of an ETO planning environment. These requirements serve as basis for identifying three main research areas that can support the design of S&OP in ETO environments, namely, customer enquiry management, multi-project management and spare parts management. The findings are summarized in a high-level framework for S&OP in ETO production and related research areas.

The unexpected consequences of the Covid 19 on managing ETO projects

Kristina Kjersem[1], Marte F. Giskeødegård[2]

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This paper presents findings of the consequences of the recent Covid 19 pandemic on the shipbuilding industry. Through qualitative interviews with key stakeholder on their experiences, the paper identifies an increased emphasis on contracts as regulative for collaboration. This increased focus on legalism in the shipbuilding industry was already triggered by the recent oil crisis yet escalated to a new level by the rules and regulations imposed by the pandemic. The paper argues that the ramifications of this pandemic cannot be understood without interpreting it in respect to the ongoing market transi-tion the industry was already facing when the pandemic hit the world. The findings of increased formal regulation of collaboration, requires further studies and have implications also for the ETO literature.

Servitization in Engineer to Order Companies: a Systematic Literature Review

Antonio Masi, Margherita Pero, Nizar Abdelkafi

Politecnico di Milano, Italy

Servitization allows manufacturing companies to enrich their value proposition with value adding services, to differentiate themselves from compet-itors, while leading them to capitalize more on new digital technologies. Extant literature suggests that servitization practices such as maintenance services, train-ing and advisory, or rental and leasing solutions are more widespread in machin-ery and construction industries. These sectors typically adopt Engineer-to-Order (ETO) to satisfy customers' demand by offering complex, tailor-made products. To the best of our knowledge, however, studies that investigate servitization in the context of ETO are scarce. This paper aims to fill this gap by conducting a systematic literature review to capture how and why servitization has been adopted by ETO companies. Based on our findings, we build a theoretical frame-work that we partly validate through an analysis of secondary sources. We con-clude the paper by mentioning some of the possible future research directions.

Value Stream Mapping for knowledge work: a study from project-based engineering-to-order organization.

Daria Larsson[1,2], Arne Gildseth[2], R.M. Chandima Ratnayake[1]

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This paper presents a tailor-made value stream mapping (VSM) methodology for engineering projects with a focus on knowledge work. The VSM is a lean-management method for analyzing value-adding processes through material and information flow mapping. The tool helps organizations to reduce engineering hours, lower project cost and improve project margins. A documented systematic procedure for VSM for an office environment has been identified in the literature; however, there is no universal approach for VSM methodology for knowledge work, specifically engineering design. This paper addresses these issues, by proposing a systematic procedure for conducting VSM for engineering design projects, along with a case study. First, the manuscript describes the examples of VSM attempts in knowledge work reported in the literature. Next, it demonstrates a case study, conducted in a project-based engineering-to-order (ETO) organization, where the main goal was to identify waste through a current project value stream map (CPVSM). Based on the findings, a future project value stream map (FPVSM) was developed and is presented in the article.

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Product and Asset Life Cycle Management for Smart and Sustainable Manufacturing Systems

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

Sustainable maintenance performances and EN 15341:2019: an integration proposal

Chiara Franciosi[1], Irene Roda[2], Alexandre Voisin[3], Salvatore Miranda[1], Marco Macchi[2], Benoit Iung[3]

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Maintenance is a key process contributing to sustainable manufacturing operations. According to this vision, recent scientific studies underline the need for indicators to assess maintenance sustainable performances. In the normative field, the EN 15341:2019 standard about Key Performance Indicators of the Maintenance Function was recently released covering all major aspects of maintenance and physical assets management, giving more emphasis to sustainability. Nevertheless, a complete set of indicators covering the environmental and social dimensions of maintenance sustainability under the sustainable manufacturing perspective is still missing. Therefore, in this paper the relevant factors to be considered for integrating the existing standard and to achieve a complete maintenance performance measurement system tackling sustainability are identified by analyzing the wider literature and normative frameworks about sustainable manufacturing performances. A validation in the industrial reality is identified as a next step to assess the factors' applicability in terms of measurability.

System-level Overall Equipment Effectiveness for improving Asset Management performance: a case study application

Alberto Franzini, Adalberto Polenghi, Irene Roda, Marco Macchi

Politecnico di Milano, Italy

The discipline of Asset Management (AM), which focuses on the manage-ment of physical assets in an integrated and holistic way along their life cy-cle, can be adopted by companies to promote sustainability since it enhances asset reliability and availability for the whole duration of its usage. Within the manufacturing industry, a relevant AM-related performance indicator is the Overall Equipment Effectiveness (OEE), which measures the efficiency of equipment. However, traditionally OEE measures the performance of in-dividual equipment only, while neglecting the system perspective, which is core in AM. Only few contributions propose an extension towards a system-level performance indicator. After the OEE-related system-level indicators from the scientific literature are reviewed, an application of one of them in an industrial case is presented, selected as the indicator best fitting the char-acteristics of the industrial case itself, which is a disconnected flow manu-facturing line. The application of the system-level indicator allows compar-ing it with the traditional OEE. Results show that a system approach better supports AM since the information carried out by the indicator is more com-plete and adherent with the actual asset and system characteristics. In turn, the system-level perspective is assumed just as a first step towards a holistic performance improvement as it is required by AM. A step forward to fulfill the sustainable performance is the integration of measurements of other sus-tainability-related impacts leading to effective asset-related decisions.

The Concept of Sustainable Maintenance Criteria Assessment

Małgorzata Jasiulewicz-Kaczmarek[1], Katarzyna Antosz[2]

[1]Poznan University of Technology, Poland; [2]Rzeszów University of Technology

In recent years, companies have had to change their approach to the production and consumption of goods in order to meet the requirements of sustainable development. These companies, by changing the way products are manufactured, strive to increase its efficiency, while reducing the consumption of raw materials, reducing costs and reducing their impact on the environment. An inherent element supporting such activities is the implementation of an appropriate maintenance processes. Maintenance as a business function is a crucial part in achieving the status of a sustainable company. Keeping in view the importance of maintenance, in this study the concept of sustainable maintenance criteria assessment is presented. The development of the criteria assessment method requires consideration of two aspects. First, one should determine the way data will be obtained and the method of their evaluation (e.g. index, descriptive, point). Secondly, the way in which aggregations of partial assessment should be defined within each criterion. To solve this problem the maturity matrix was used.

A holistic approach to PLI in Smart Maintenance towards sustainable Manufacturing

Harald Rødseth[1], Endre Sølvsberg[2], Anna Steine[1], Per Schjølberg[2], Espen Henriksen-Polanscak[3]

[1]Oceaneering, Norway; [2]Norwegian University of Science and Technology, Norway; [3]HTS Dynamics, Norway

With the digital transformation of the maintenance function with emerging technology such as machine learning, Smart Maintenance will contribute to increased plant capacity as well as reduced maintenance costs. Profit Loss Indicator (PLI) has been tested for preventive maintenance combined with anomaly detection. Yet, it remains to include PLI into Smart Maintenance processes to ensure standardized application. PLI will also contribute towards sustainability in terms of improved production performance through reduced waste and time losses. This will also contribute to an improved working environment. The aim of this article is therefore to develop a smart maintenance process for PLI. This article demonstrates the main processes of smart maintenance that are harmonized with EN 17007 and sustainability. In addition to PLI, a hybrid approach for anomaly deployment as well as a dynamic FMECA (failure mode, effect and criticality analysis) are included in Smart Maintenance. Also, the result is partly tested where PLI is calculated for a Norwegian use-case. It is concluded that more elements for the smart maintenance processes must be further modelled and tested with industrial use-cases.

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Cost Projections for the Product Life Cycle at the Early Stages of Product Development

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The paper is concerned with predicting the total cost of a new product and simulating cost reduction at the early stages of product development. The costs of a new product development project, product promotion, production and after-sales service are predicted using parametric modelling. The identi-fied relationships are also used to search for possibilities to reduce the cost of faulty products and after-sales service through increasing prototype tests. As a result, the trade-off between the cost of a product development project and costs of production and warranty are sought. Company resources and prod-uct specification can be formulated in terms of variables and constraints that constitute the systems approach for a problem related to cost optimization. This problem is described in the form of a constraint satisfaction problem and implemented using constraint programming techniques. An example shows the applicability of the proposed approach in the context of searching for the desirable level of the cost related to prototype tests, faulty products and after-sales service.

Semantic Interoperability and Sustainability an Industry 4.0 Product Life Cycle issue

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Four concepts stand out in the current landscape of modern industrial production. The product life cycle, sustainability, Industry 4.0 and semantic interoperability. The article will be focused on creating a link between the four and expresses the strong causal relationship between them in order to optimise production processes. To that point, a 3D model will be developed to bridge sustainability and product life cycle inside an organization. Then, knowledge formalisation techniques will be discussed for construct-ing a mutual understanding of the semantics in the context on Industry 4.0 throughout the developed model.

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Regular session : Improvement of design and operation of manufacturing systems

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

Improving manufacturing system design by instantiation of the Integrated Product, Process and Manufacturing System development reference framework

José Ramírez, Arturo Molina

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With Industry 4.0 and the changing dynamics of markets, assisting in designing, modifying, or improving manufacturing systems at different scales becomes nec-essary, both in large manufacturers and SMEs. Enterprise modelling architectures support the specific description of various layers to assist in the product lifecycle development by reusing general models that can be tailored to particular scenarios through instantiation processes. This work improves the development of manu-facturing systems through partial and particular instantiated models based on the Integrated Product, Process and Manufacturing System Development reference framework. Furthermore, this model benefits from the characterization of differ-ent industrial sectors to collect tools and activities to avoid developing manufac-turing systems anew. In this way, the proposed solution is to create partial mod-els to assist in the design of different manufacturing scenarios: (i) product trans-fer, (ii) technology transfer and (ii) manufacturing system design. Case studies are instantiated to prove the effectiveness of this framework, in which the particu-lar project activities are developed, and finally, the results assessed by qualitative and quantitative parameters to allow performance measurement.

A formal skill model facilitating the design and operation of flexible assembly workstations

Lauren Van De Ginste[1,3], Alexander De Cock[2], Axl Van Alboom[1,3], Yogang Singh[1,3], El-Houssaine Aghezzaf[1,3], Johannes Cottyn[1,3]

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In the Industry 4.0 area, there is an increasing demand for highly customized products in small batch sizes. Final assembly operations are frequently targeted to embed flexibility and compensate for the growing manufacturing uncertainties. Therefore, an adequately designed and operated flexible assembly workstation is crucial. Converting the flexibility needs into design and operational decisions requires versatile formal models delivering generic descriptions of needs and capacities. Skills form the central connector between products, processes and resources. Here, a skill-centered model for describing resource activities, the related production needs and flexibility impacts is introduced. The model fits both plug and produce and design optimization settings and goes beyond current skill-based modelling by offering a framework which, by design, does not limit the applications and easily adapts to the desired level of detail. One key strength is its ability to combine abstract and executable skills. Next to the product-action skills, also assistive skills related to operator support, parts storing, ergonomics etc. can be easily modelled. The use of the model is illustrated by an example based on an industrial use case from Flemish industry.

Multi-criteria filtering approach for comparison and analysis of scheduling alternative scenarios: case study on an open pit phosphate mine

NAJOUA ALAOUI[1,2], AHLAM AZZAMOURI[1], SELWA EL FIRDOUSSI[1], PIERRE FENIES[1,2]

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Open-pit phosphate mine is characterized by a stack of layers with different chemical characteristics (Source qualities SQ). The extraction process in-volves various elementary operations performed by a dedicated or polyva-lent machines. The tactical mining scheduling consists to define the blocs to be extracted and assign the machines over the planning horizon. However, the interdependencies and complexity characterizing this problem make the decision-making process so difficult. This paper proposes a multi-criteria ap-proach integrated in an Interactive Decision Support System (IDSS) based on an original sequential approach selecting the most performant mining scenar-ios. Indeed, a discrete event simulation-based model developed and encapsu-lated in this IDSS proposes various scenarios. With a developed multi-criteria filtering approach, each scenario is approved by a feasibility study to verify that a scenario can satisfy the demand for merchantable qualities (MQ). Then, the feasible scenarios are analyzed based on their robustness when facing disturbed demand vectors and compared by other effectiveness and efficiency criteria. To preserve, only the two or three most performant scenarios.

Evaluation of Complex Manufacturing Systems in the Context of Aggregated Operating Curves

Ulf Bergmann[1], Matthias Heinicke[2], Gerd Wagenhaus[1], Sascha Schmidt[1]

[1]Otto-von-Guericke-University, Germany; [2]Targus Management Consulting AG, Germany

For the right configuration of production systems it is crucial to know the opti-mum operating point by way of a functional correlation between work in process and output rate or throughput time respectively.

As a matter of fact, executives and managers are quite familiar with this correla-tion which, however, rarely leads to its formal-mathematical application. Among others, this is due to the specific prerequisites arising from the application of gen-eral laws from queuing theory and operating curve theory.

Therefore, this paper will discuss our approach for a practical determination and description of suitable reference value systems using aggregated operating curves. The main focus will be directed towards the system's behaviour of com-plex production systems in versatile batch production, as it is frequently encoun-tered in mechanical and plant engineering.

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Conceptual maps of reliability analysis applied in reconfigurable manufacturing system

Tian ZHANG, Lazhar HOMRI, Jean-yves DANTAN, Ali SIADAT

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Reliability has always been an important factor for any manufacturing com-panies. An appropriate level of reliability in a manufacturing system could mean less maintenance cost, higher efficiency and steadier production state. Because each machine in a manufacturing system has its individual level of reliability, reliability on the system level would depend largely on how the machines are configured. In traditional efforts on reconfigurable manufac-turing system (RMS) reliability assessments, mean time between failure (MTBF) is usually adopted as reference index of reliability. Also, in exist-ent research efforts when applying reliability analysis in manufacturing system, reliability is merely a single and over-simplified index in the framework. But there exist various forms of reliability inside a RMS, and the complexity of this concept would keep increasing with the develop-ment of new technology in manufacturing industry. To analyze reliability in RMS in a more comprehensive way, we built conceptual maps as a first step for research agenda -- from the perspective of top layer, reliability analysis and RMS.

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Regular session : Crossdock and transportation issues

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

Berth Allocate Problem with Multi-Entry Considering Marine Fish Freshness

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In this paper, we analyze the berth allocation problem for vessels calling at fish-ing ports by considering the current higher consumer demand for seafood fresh-ness in the vast inland areas of China. At first, according to the previous investi-gation on the site of Zhoushan Fishing Port, we propose a mathematical model to maximize the overall profit with a multiple-entry policy of the vessels. The opti-mal berth allocation and re-entry of vessels can be obtained. We integrate the ves-sel's owner, the manager of the port, and the fish market vendor together, regard-ing the tripartite overall profit as the objective function. Based on this, taking into account the relationship between seafood unloading time and overall income, a mathematical model of mixed-integer linear programming (MILP) is constructed to accurately describe the berth allocation decision framework under which fish-ing vessels are allowed multiple arrivals.

Cross-Dock Location: An Airbus Helicopters Case Study

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In this paper, we evaluate the implementation of a cross-docking strategy at Air-bus Helicopters (AH). To this end, firstly, we conduct a literature review on cross-dock location, and the facility location problem (FLP). Then, we describe briefly the AH current supply chain and based on literature review we develop a mixed integer linear programming (MILP) model adapted to this case. We apply this model to optimize the AH current supply chain. Results show that total costs could be potentially reduced by 21% by implementing a cross-docking strategy at AH. Finally we conduct a sensitivity analysis on input costs in order to evaluate the robustness of the solution obtained. It is found that results obtained are sensi-tive to variations on the input transportation costs.

A Hierarchical Network Approach for Long-Haul Parcel Transportation

Camille Gras[1,2], Van-Dat Cung[1], Nathalie Herr[2], Alantha Newman[1]

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With the advent of e-commerce, many studies have been carried out on urban logistics

and last-mile parcel delivery. In this work, we study another stage of parcel delivery: long-haul parcel transportation with the integration of the sorting operation allowing a better consolidation of parcels in containers. The transportation is optimized over a complex two-level hybrid hub-and-spoke network of 225 sites with 2500 demands. The parcel transportation is made with a heterogeneous fleet as there are two types of vehicles which are balanced over the network on a daily basis with the management of empty trucks. We are not aware of a framework for long-haul parcel transportation in the literature that is sufficient to handle all aspects of the industrial problem that we address. In terms of finding a solution, we propose a hierarchical algorithm with aggregate demands whose performance is related to the value of a truck filling rate threshold. Roughly speaking, the demands above this threshold can be routed directly while the ones below this threshold have to follow the hierarchical structure of the network. The routing of the two types of demands is optimized, first separately and then together in a multi-step process in which the subproblems are solved via Mixed Integer Linear Programs. Numerical experiments are carried out on large-size real datasets provided by a postal company. Various threshold values are tested to find out which one is the best, in terms of solution quality obtained and computational time.

Assessment of MaaS (Mobility as a Service) apps in Metropolitian Area of São Paulo, Brazil

Gabriel Santos Rodrigues[1], João Gilberto Mendes dos Reis[1], Regis Cortez Bueno[2], Wilson Yoshio Tanaka[2], Adriano Maniçoba da Silva[2], Sivanilza Teixeira Machado[2]

[1]Universidade Paulista; [2]Instituto Federal de Educação, Ciência e Tecnologia de São Paulo - Câmpus Suzano

The popularization of mobile internet and transport applications have been making passenger transport real-time information available to the general public. In the Metropolitan Area of S˜ao Paulo (MASP), the largest urban agglomeration in South America, with 21 million inhabitants carrying out their activities every day, these systems have been changing the user's behaviour. The purpose of this study is to evaluate the perception and use of these applications called Mobility as a Service (MaaS) for the passenger in MASP. To do so, we conducted a survey with 138 respondents in May 2020 regarding the services: Google Maps,Moovit and Citymapper. They evaluated what the application they prefer to, how the applications functions are used by theirs and the public transportation frequence of use and after the anwers were used in a descripitive statistics analysis. The results indicated a predominance of youth users that plan their trips using public transportation and seek real-time information through these applications.

Using flexible crossdock schedules to face truck arrivals uncertainty

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This paper discusses the use of robust schedules for facing uncertainty arising in crossdock truck scheduling problems. Groups of permutable operations bring sequential flexibility in the schedule, allowing to deal with late or early truck arrivals as starting times can be determined in a reactive manner. We focus on the evaluation of a robust schedule considering both the worst maximal lateness of the trucks and the worst total sojourn time of the pallets. We also show how a robust schedule can be evaluated online, taking into account the actual arrival times of the trucks.

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Regular session : Maintenance improvement and lifecycle management

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

Asset Management, Industry 4.0 and Maintenance in Electrical Energy Distribution

Sam Gontran Amelete[1], Raynald Vaillancourt[1,2], Georges Abdul-Nour[1], François Gauthier[1]

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This article presents the effects of Industry 4.0 (I4.0) combined with Asset Management (AM) in improving the life cycle of complex systems in Electrical Energy Distribution (EED). The boom in smart networks leaves companies in this sector no choice but to move forward I4.0. The contribution of I4.0 to the progress of AM in maintenance in EED will therefore be demonstrated by a case study using simulation. The case study will concern the benefits of using Advanced Metering Infrastructure (AMI), the heart of smart grids, at Hydro-Québec Distribution (HQD), the primary supply authority in Quebec. The HQD network includes 4.3 million clients, on a territory of approximately 250,000 km2 and 680,000 overhead transformers. The results are conclusive: the number of outages will drop by 7% annually and maintenance costs will fall by at least 5% per year.

Health Indicator Modeling and Association Rule Mining for stoppages prediction in a refinery plant

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. Predictive maintenance practices represent a relevant feature for improving the useful life of the systems and decreasing costs. Hence, the modelling of the Health Indicator is a useful support in order to define the Remaining Useful Life of a system. In this work, an approach for the Health Indicator modeling of an oil refinery sub-plant is proposed; in addition, the Associa-tion Rule Mining is applied, in order to identify the components frequently requiring a work order prior to a stoppage of the plant: in this way, the Re-maining Useful Life determined via the Health Indicator is used to inspect such components and, possibly, avoid the stoppage.

Productivity improvement in manufacturing systems through TPM, OEE and collaboration between maintenance and production: a case study

Rui Pedro Costa[1], Isabel da Silva Lopes[2]

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The following paper describes a project where Total Productive Maintenance (TPM) methodology was used in order to improve an automotive industry production line availability and quality. After performing a diagnosis, major flaws were revealed about maintenance and production communication, as well as missing information about the production of defects and maintenance interventions. It was necessary to solve these problems before being able to analyze production inefficiencies, define and implement improvement actions. This project showed the significant impact on costs and quality that can be achieved by the use of TPM, OEE, and collaboration between production and maintenance. But beyond that, it showed that despite industry 4.0 being on the agenda, there is low use of communication technologies and, therefore, significant gains can still be achieved through basic analysis of recorded data if they are properly organized and standardized. It appears that special attention must be paid to the collection of data, to ensure its proper use for decision making.

Stochastic dynamic programming for earliness-tardiness single machine scheduling with maintenance considerations

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We study in this paper the problem of simultaneously scheduling resumable jobs and preventive maintenance on a single machine to minimize the earliness-tardiness cost. The machine is subject to random breakdowns according to Erlang distribution and minimal repair is considered. The age of machine is renewed after each preventive task. A stochastic dynamic programming solving approach is presented. Its algorithm is illustrated meaning and illustrative example.

An assessment of order release models in Hybrid MTO-MTS flow shop with bottleneck

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The traditional configurations of market response, make-to-order (MTO) and make-to-stock (MTS), are no more suitable in today's competitive context, forcing companies to a transition towards hybrid solutions. Unfortunately, this has been neglected, in particular at the operational level where the Order Review and Release issue counts only two related articles but restricted to job shops. Therefore, researchers are moving towards flow shop configuration, particularly addressing the issue of bottleneck. Literature links this topic to the Theory of Constraints by Goldratt and Cox [13], from which Drum Buffer Rope (DBR) has been designed as a production planning and control tool. The objective of this paper has been defined as verifying how the decision on the release model changes considering the designed hybrid flow shop model. Simulation results are not clearly in favor of one over the other, since besides severity, there is another important factor to consider: the choice of control at dispatching level, and its connected trade-offs. In particular, implementing this control with bottleneck-based rule is effective for MTO performances, especially in case of high severity, but less effective for MTS ones. Instead, when control at dispatching is absent, MTS have better results and the workload control as release rule is preferred, leading also to the best lead times for low severity.

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The New Digital Lean Manufacturing Paradigm

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

Reflections from a hybrid approach used to develop a specification of a shopfloor platform for Smart Manufacturing in an engineered-to-order SME

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This paper describes the steps that an engineered-to-order SME firm took to identify their requirements for a shopfloor Manufacturing Execution Sys-tem (MES). The firm had limited experience and followed a hybrid Design Thinking / Lean approach to develop and test use cases that could be re-viewed with stakeholders in the factory to confirm their value in support-ing the critical economical outcomes of single piece flow in the factory. The firm created a set of requirements based on use cases and a roadmap for the further development of the MES. During the investigation, the foundation work necessary to develop a shopfloor platform was supported by a digital maturity assessment tool. The higher-level analytical micro-services were dependent on easily accessible transactional data from the system. The work's limitations are that implementation is not part of this study and that the approach taken must be compared with more traditional approaches.

Digital Tools for lean manufacturing: the need for proper implementation

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Purpose: The literature on Lean Manufacturing and Industry 4.0 has identified a strong link between the two paradigms and a positive impact on operational performances. Industry 4.0 offers digital tools to support LM tools and practices. However, empirical and in-depth analyses to validate such propositions are still scarce in the literature. Therefore, the observation of the implementation of Industry 4.0 tools for Lean Manufacturing with a focus on the factors needed for properly introducing them in firms is the next logical step to further strengthen this area of research. This study aims to understand the required factors needed to take into consideration for a successful implementation of the tools in the manufacturing process. Methodology: We rely on a multiple case study performed in 6 Italian Manufacturing companies that adopt digital tools for Lean Manufacturing. Findings: Our findings highlighted the central role of skills, the need for a specialized team to oversee the implementation in addition to better formulation of the tool's offer-ings by the suppliers through successful case studies. We also tried to connect individually each tool with the operational performance it aims at improving

The automation of lean practices: digitalized or digitally wasted?

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Lean manufacturing has experienced massive changes under the influence of Industry 4.0, with the automation of lean practices becoming common among manufacturing companies in many countries and different industries. Automating lean practices promises a number of opportunities for growth and competitiveness. One of the key advantages of lean automation has been acknowledged to be the significant reduction of waste. Meanwhile, there is also a discussion of a new form of waste: digital waste. However, do companies consider digital waste a part of production waste? It is also unclear if automation of lean practices is a trigger for digital waste with a negative impact on value creation. This paper aims to investigate companies with automated lean practices and the particular case of digital waste in automated processes. The research is based on case studies of manufacturing based in Sweden.

Study of the Predictive Mechanism with Big Data-Driven Lean Manufacturing and Six Sigma Methodology

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In order to achieve the sustainable development, the predictive mechanism with big data-driven Lean Manufacturing and Six Sigma methodology is proposed in this paper. The sustainable development for serious competition is often studied, however, the predictive mechanism with big data-driven Lean Manufacturing and Six Sigma methodology is seldom mentioned in publications. This paper reports the predictive mechanism from the perspective of big data-driven Lean Manufac-turing. The key techniques including PLC communication, DMAIC roadmap, SPC technique and Hypothesis Testing are utilized to eliminate the waste and ob-tain continuous improvement. The demonstration of calculator production indi-cates the predictive mechanism can effectively eliminate the waste and improve the output by 60% with the sufficient capability of Cp>1.33 and Cpk>1.

Industry 4.0: expectations, impediments and facilitators

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Industry 4.0 encompasses the main technological innovations transforming the physical, digital and biological pillars and promoting changes that affect the econ-omy as a whole. In each company, the transition to the use of new technologies is established in a different way and the diagnosis of strategic objectives in the me-dium and long term to understand the organizational scenario can facilitate this process. The philosophy of Lean Manufacturing appears in the literature and in this research as an important facilitator. The methodology used to carry out this article was exploratory, qualitative and quantitative, through a survey applied to 51 managers in the industrial area of companies in the automotive segment in Brazil. The main results showed that the increase in productivity and cost reduc-tion are expected gains, that the low level of use of new technologies, connectivi-ty, knowledge about the theme, among others, are configured as impediments to the transition, highlighting that the association of Lean Manufacturing and the technologies of Industry 4.0, can accelerate this process, minimize possible risks and facilitate solutions for implementation.

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The Role of Emerging Technologies in Disaster Relief Operations: Lessons from COVID-19

Time: Thursday, 09/Sept/2021: 3:00pm - 5:00pm

Technologies helping Smart Cities to build Resilience: focus on COVID-19

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The sustainable development goal #11 (SDG#11) deals with making cities inclusive, safe, resilient and sustainable. SDG#3 deals with “Strengthen the capacity of all countries, in particular developing countries, for early warn-ing, risk reduction and management of national and global health risks” So, the COVID-19 pandemic can be properly considered as one of the matters of concerns of the SDG#11 and #3 targets. It is reiterated the necessity of disaster and emergency health risk reduction and the building of resilience within the context of sustainable development concerns. Resilience is a concept also contemplated within the paradigm of smart planning and smart cities. The urban domain is the system to explore the tools used to cope with the current COVID-19 pandemic and consequently, to aid in building resilience. Innovation and the relevance of SDG#9 are clear since the urgen-cy of improvements in general and domestic technology and access to uni-versal and affordable internet have to be guaranteed to achieve the objective of building resilience. A general although categorized vision of the main technologies, applications and functionalities within the Smart City do-main is discussed with the aim of identifying the way they support COVID-19 and integrate with three SDGs that were considered fundamen-tals for resilience building. We hope that this work will contribute to gov-ernance systems and citizens to be better prepared for future outbreaks.

Key success factors for supply chain sustainability in COVID-19 pandemic: an ISM approach

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In this study, we aimed to reflect on and explore what remains to be done to make the supply chain sustainable in the face of business downturn amid COVID-19 pandemic. We pay particular attention to the heavy engineering industry in South Africa; having a supply chain network extended globally. The paper begins with a brief introduction of ill effects of COVID-19 on supply chains followed by the research questions that drives this study.

We took help of literature review to select the critical success factors which were further refined using experts’ opinion and further used them as an input in Interpretive structural modeling (ISM) technique.

The ISM model and MICMAC analysis yielded some interesting findings that can aid organizations in building resilient supply chains that are sustainable in nature.

We conclude that organizations need to develop a culture of collaboration; since greater collaboration among value chain members is required to create a more resilient supply chain.

Shelter location-allocation problem with vulnerabilities of network and disruption of shelter during response phase of disaster

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In this paper, we define and formulate the shelter location-allocation problem considering both the network vulnerability of the affected area and the shelter's disruption during the disaster management's response phase. We capture the vulnerability metric using the traveling cost and location vulnerability for shelter disruption using the shelter's operating cost. We formulate the problem as a mixed-integer linear programming (MILP) model and present an evacuee-allocation plan considering vulnerable network connectivities between the populated areas and the shelter locations. We finally apply and solve the problem using real-life case data obtained during the Nepal earthquake in 2015 and compare our models with Rahman's same data [9].

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