ISM 2020

The International Conference on Industry 4.0 and Smart Manufacturing

Abstract Booklet

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Table of Content

Keynote Talks

Paper Abstracts

Keynote Talks

Smart Steel Production

Markus Brummayer
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Abstract

voestalpine is a technology leader in the development and production of cutting-edge steel products and is a benchmark company for energy efficiency and environmental compatibility. With its top-quality products and system solutions using steel and other metals, it is a leading partner of the automotive and consumer goods industries as well as of the aerospace and oil & gas industries. voestalpine is also the world market leader in complete railway systems, as well as in the production of tool steel and special sections. Headquartered in Linz, voestalpine is represented by 500 Group companies and locations in more than 50 countries on five continents.
The foundation for voestalpine's technological leadership is research and development and a network of corporate expertise comprised of numerous affiliations with national and international universities, universities of applied technologies, centers of competence as well as a number of development partnerships with key customers. The new powerful technologies and advanced solutions related to Industry 4.0 and Smart Manufacturing are important key enablers for the Steel Industry. This presentation will focus on smart and sustainable steel production processes and workflows along the entire value chain, addressing both the needs and challenges via review and discussion of relevant examples.

Bio

Dr. Markus Brummayer, with an academic education in mechatronics, fluid mechanics and innovation management, started his career in the steel industry more than twenty years ago. At voestalpine Steel Division he has been deeply engaged in the development and optimization of production processes and product quality since 2003. His main R&D&I activities are focused on continuous slab casting and hot rolling. Furthermore, he has gained profound experience in cross-process quality optimization along the entire process chain. Within the voestalpine business unit slab (hot metal production, steelmaking and casting) he also coordinates the R&D digitalization topics. As an inventor, Markus Brummayer has contributed numerous patent applications thereby strengthening voestalpine's technological leadership. Markus Brummayer is a member of the European Steel Technology Platform (ESTEP) Smart Factory Working Group and the European Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) Digital Working Group. He is Chairman of the Strategic Board of the Center of Excellence for Smart Production FH Upper Austria and a strategic board member of the Pro2Future Research Center. In addition to his employment at voestalpine, Markus Brummayer was CEO of the Austrian Competence Center in Mechatronics (ACCM, now LCM).

Agent-Based Collaborative Intelligent Manufacturing in the Era of Industry 4.0

Weiming Shen
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Abstract

Agent technology represents a new paradigm for developing industrial software applications. During the past 25 years, a significant number of researchers and practitioners have been trying to apply intelligent software agents in the areas of engineering design, collaborative intelligent manufacturing, supply chain management, and smart product services. Recent developments and fast advancements of Cloud/Fog/Edge Computing, Internet of Things, Cyber-Physical Systems, Digital Twins, Big Data, and Blockchains provide new opportunities for applications of intelligent software agents in the manufacturing industry in the era of Industry 4.0, but also bring a lot of new research challenges. This talk presents some first-hand experience in developing agent-based collaborative design and manufacturing technologies and systems, and discusses future trends, R&D opportunities and challenges.

Bio

Dr. Weiming Shen is a Professor at Huazhong University of Science and Technology (HUST), China. Prior to joining HUST, he worked for 20 years at National Research Council Canada as Research Officer, Senior Research Officer, and Principal Research Officer. He is a Fellow of Canadian Academy of Engineering, Fellow of IEEE, Fellow of Engineering Institute of Canada (EIC). He is an internationally-recognized expert on Agent-Based Collaborative Technologies and Applications. He has published several books and over 500 papers in scientific journals and international conferences in the related areas. His work has been cited over 14,000 times with an h-index of 53. His book titled "Multi-Agent Systems for Concurrent Intelligent Design and Manufacturing" and a few related review papers are among the most cited on agent-based intelligent manufacturing. He is the Co-Editor-in-Chief of IET Collaborative Intelligent Manufacturing, an Associate Editor or Editorial Board Member of over ten international journals (including IEEE Transactions on Automation Science and Engineering; IEEE Transaction on SMC: Systems; IEEE SMC Magazine; Advanced Engineering Informatics; Computational Intelligence; Intelligent Buildings International; Service Computing and Applications) and served as guest editor for several other international journals. He is the Co-Chair of the IEEE Technical Committee on Computer Supported Cooperative Work in Design, has been Program Committee Co-Chair of the CSCWD conferences since 2001, and served as General Chair/Co-Chair or Program Committee Chair/Co-Chair for over 30 international conferences.

Agents meet the IoT: Towards Cognitive and Interoperable Ecosystems of Networked Smart Objects

Giancarlo Fortino
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Abstract

The future Internet of Things (IoT) will enable a new and wide range of decentralized systems (e.g. from smart homes to smart cities) where "things", able to sense/actuate, compute and communicate with other machines and with humans, will play a central role. The growing importance of such novel cyberphysical network and technology demands suitable and effective paradigms able to fulfill the general and specific requirements of IoT systems engineering. In this keynote, we propose the exploitation of the agent-oriented computing paradigm to support IoT systems analysis, design, and implementation. The synergic meeting of Agents with the IoT will make it possible the development of dynamic IoT systems of diverse scales. First, we introduce background and literature about IoT, with a specific focus on IoT systems development along with currently available agent-oriented approaches. Then, we present in detail our agent-oriented approach specifically based on the ACOSO (Agent-based COoperating Smart Objects) Methodology and related middleware, which provides an effective agent programming model and an agent execution heterogeneous platform along with ad-hoc IoT tools for the construction of an IoT system in terms of a Multi-Agent System. Some case studies concerning the development of IoT systems will be briefly described to show the flexibility and effectiveness of the proposed approach. Finally, future challenges will be delineated towards EDGE and Cloud-assisted agent-based approaches for IoT, specifically towards Agent-oriented IoT Data Mining at the EDGE and Industry 4.0.

Bio

Giancarlo Fortino (SM'12) is Full Professor of Computer Engineering at the Dept. of Informatics, Modeling, Electronics and Systems (DIMES) of the University of Calabria (Unical), Rende (CS), Italy. He has a Ph. D. degree and Laurea (MSc+BSc) degree in Computer Engineering from Unical. He is High-end Foreign Expert of China (term 2015-2018), Adjunct and Guest Professor at the Wuhan University of Technology (China), High-end Expert of HUST (China), CAS PIFI Visiting Scientist at Shenzhen (2019-2021), and Associated Senior Research Fellow at the Italian National Research Council – ICAR Institute. He has been also Visiting Researcher and Professor at the International Computer Science Institute (Berkeley, USA, 97-99) and at the Queensland University of Technology (Australia, 2009), respectively. He is in the list of Top Italian Scientists (TIS) by VIA-

academy and by Guide2Research, with h-index=52 and 10000+ citations according to GS. He is the director of the SPEME (Smart, Pervasive and Mobile Systems Engineering) Lab at DIMES, Unical and co-director of two joint-labs on IoT technologies established with Wuhan University of Technology and Shanghai Maritime University, respectively. His main research interests include Internet of Things computing and technology, agent-based computing, body area networks, human-machine systems, wireless sensor networks, pervasive and cloud computing, multimedia networks, and mobile health systems. He participated to many local, national and international research projects and was the deputy coordinator and scientific & technical project manager of the EU-funded (8Meuro) H2020 INTER-IoT project. He authored about 450 publications in journals, conferences and books. He chaired about 100 Int'l conferences/workshops as co-chair (he is currently the general chair of IEEE International Conference on Human-Machine Systems 2020 in Rome, Apr. 6-8, 2020), organized 60+ special issues in well-known ISI-impacted Int'l Journals, and participated in the TPC of about 500 conferences. He is the founding editor in chief of the IEEE Book Series on "Human-Machine Systems" and of the Springer Book Series on "Internet of Things: Technology, Communications and Computing", and currently serves (as associate editor) in the editorial board of IEEE Transactions on Affective Computing, IEEE Transactions on Human-Machine Systems, IEEE IoT Journal, IEEE Sensors Journal, IEEE Access, IEEE SMC Magazine, IEEE OJEMBS, IEEE OJCS, Journal of Networks and Computer Applications, Engineering Applications of Artificial Intelligence, Information Fusion, and others. He is the recipient of the 2014 Andrew P. Sage SMC Transactions Paper award. He is co-founder and CEO of SenSysCal S.r.l., a spin-off of Unical, developing innovative IoT-based systems for e-health and domotics. He is the Chair of the IEEE SMC Italian Chapter, Member-at-large of the IEEE SMCS BoG, Member of the IEEE Press Board of Directors, and founding chair of the IEEE SMC Technical Committee on "Interactive and Wearable Computing and Devices".

Hic sunt dracones? Developing software for networked production automation systems

Alois Zoitl
Johannes Kepler University – Linz, Austria

Abstract

Industry faces major challenges as product life-cycles shorten, product variability increases, and global markets become more volatile. To remain competitive, production facilities and equipment must be adaptable to respond quickly and efficiently to these changes. A key success factor in achieving these goals is the control and automation infrastructure. New distributed architectures are a possible approach to address these requirements. The amount of software in production automation systems is constantly increasing. This is reinforced by the demand for increased networking of these systems. Current technologies are already reaching their limits. This leads to increasing development efforts and costs. It seems as if control software turns into an indomitable beast which is very difficult to control. New interaction and communication patterns as well as new ways of programming automation systems consisting of networked control units are required. In the context of this talk we would like to give an overview of the current and future requirements for production automation systems. The current approaches to programming production automation systems will be considered. In particular, it will be shown how model-driven or low code software development can help to tame the beast and reduce development efforts. An important aspect here is Open Source Software, which still has great potential especially in the production automation system environment.

Bio

Alois Zoitl holds a PhD degree in Electrical Engineering with focus on dynamic reconfiguration of real-time constrained control applications and a master's degree in electrical engineering with the focus on distributed industrial automation systems from Vienna University of Technology. Currently he is a Professor for cyber-physical systems for engineering and production with the LIT | CPS Lab at Johannes Kepler University, Linz. Before that he was the scientific research group leader for Industrial Automation at the research institute fortiss in Munich, Germany. Before that he was the head of the research field Distributed Intelligent Automation Systems (Odo Struger Laboratory) at the Automation and Control Institute (ACIN), Vienna University of Technology. He is co-author of more than 150 publications (3 books, 6 book chapters, 19 journal articles) and the co-inventor of 4 patents in the mentioned areas. His research interests are in the area adaptive production systems, distributed control architectures, and dynamic reconfiguration of control applications as well as software development and software quality assurance methods for

industrial automation. Alois Zoitl conducted and lead several industry funded R&D projects as well as coordinated and participated in several public funded (national as well as European) R&D projects. He is a founding member of the open source initiatives Eclipse 4diac, providing a complete IEC 61499 solution, and OpENer. Furthermore, he is a member of the IEEE, the PLCopen user organization, and GMA. Since 2009 he is an active member of the IEC SC65B/WG15 for the distributed automation standard IEC 61499. He was named convenor of the group in May 2015

Session Talks

ID #4

New approach to the fire risk and firefighting in small ships, as consequence of latest developments in Industry 4.0 for the use of hybrid propulsion

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Abstract

The hybrid propulsion is a reality now, increasing her diffusion more and more. The basic concept of Hybrid propulsion is the use of battery packs to store energy and consequentially operate the propulsion system of the ship, in order to have zero emission navigation, especially in areas of environmental interest. Especially this propulsion is spreading in passenger ships, such as small passenger ferries or yacht, due to the importance of carrying people in a clean way. This propulsion makes extensive use of Li-Ion or Li-Po batteries, storing high quantities of energy, (MWh) to provide the propulsion, furthermore, the propulsion systems are usually operating with high voltage (660 V or more) to guarantee adequate efficiency at the system. As well know, the Lithium based batteries offer a good capability storing energy, but there is also a problem of risk of explosion in case of overheating. The author will investigate in the paper, the consequences of the hybrid propulsion in small ships, considering the case study of small passenger ships, examining the interaction among the industrial solutions adopted for the realization of the hybrid propulsion system and the specific requirements of the marine rules in terms of changes to the project, to increase the safety of the ship. The paper will examine the aspects of fire protection not only from the point of view of the passive fire protection but also from the point of view of the containment of problem of overheating, underlining the need of a smart and combined use of manufacturing solutions and remote control systems. The paper will show how the use of the hybrid propulsion is for sure interesting in terms of environment protection, but at the same time, it requires some important changes to the project approach that cannot be underestimated.

ID #6

A GEMMA-GRAFCET Methodology to enable Digital Twin based on Real-Time Coupling

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[b]Xcelgo A/S, Ry, Denmark

Abstract

Digital Twin (DT) represents the next wave in modelling, simulation and optimization technology. A key enabling technology of the DT is the real-time coupling of the digital models with the controllers of the physical plant. To implement the DT through real-time coupling, common approaches and vocabularies are desirable for the automation software to facilitate the exchange of information between the PLCs and the digital models. However, the scarce adoption of guidelines and standards within the industrial practice of PLC programming complicates this context. To face this challenge, this paper proposes a methodology for PLC code to standardize the vocabulary and the management of the operational modes of industrial automation systems. The methodology consists of a GEMMA-GRAFCET representation and a Hierarchical Design Pattern. By implementing the approach to a case study, it is demonstrated that the methodology generates a standard interface for the communication between PLCs and digital models within a DT architecture.

ID #8

Life cycle phases and design morphology for the implementation of a cooperative inventory pooling-system

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Abstract

Cooperative inventory pooling-systems are a promising solution for increased efficiency in spare parts management by reducing necessary inventory levels and costs. However, there is no methodical approach to enable interested companies to realize the advantages. No required modules and necessary tasks in the life cycle of the cooperation are specified. In this contribution, a specific life cycle model for a cooperative inventory pooling-system is presented. Necessary tasks and modules are described for each phase. We identified three inventory-pooling specific sub phases that are essential for the final implementation of the cooperation. Furthermore, we developed a morphology for the design of the cooperative inventory pooling-system, which provides a framework to describe the cooperation in its structural elements. The method and the framework introduced in this paper allow a structured and systematical implementation of cooperative inventory pooling-systems.

ID #9

A “low-cost” subtractive method for freshly finished 3D concrete printed structures

Joseph Canou[a], Maylis Uhart[b], Pierre Diaz[c]

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Abstract

Until now, construction is an area where most activities are artisanal. Concrete is linked to the masonry trade where few machines are used. Moreover, this material is mainly used for building construction, but it can be used for other applications like urban furniture for example where a mold is necessary to pour and maintain the concrete until it is dry. This method can be expensive for unique part because of the implementation time. Moreover, the part geometry is limited by the mold shape. For a few years, the additive manufacturing is used with the concrete material, mainly to build house walls but without finishing step to have smooth or assembling surfaces. So, it is composed by the layers of concrete and it is difficult to assembly two parts for example because of the shape but also dimensional accuracy. For these reasons, in the frame of the HINDCON project, a low-cost subtractive task has been introduced, to perform post-printing machining with respect of geometrical constraints.

ID #10

Machine Learning and Statistics: A Study for assessing innovative Demand Forecasting Models

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Abstract

Besides increasing dynamics in market demands, companies strive to avoid short-term changes in their supply chain planning. Therefore, an essential lever to improve supply chain performance is the optimization of the demand forecast. In this regard, artificial intelligence is a widely adopted technique in Industry 4.0 that is associated with high expectations. Against this background, six different forecasting models from statistics and machine learning were evaluated in respect to forecast quality and effort for implementation. The results underline the potential of innovative forecasting models as well as the necessity for an intensive and application-specific evaluation of the advantages and disadvantages of the available approaches.

ISM

ID #11

Towards Mastering Variability in Software-Intensive Cyber-Physical Production Systems

Rick Rabiser, Alois Zoitl

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Abstract

Software-intensive Cyber-Physical Production Systems (SiCPPS), like metallurgical plants or manufacturing plants, are highly variable systems of systems that frequently evolve. They typically involve a large number of heterogeneous components (mechanical, electrical, mechatronic, software) that can be configured and combined in different ways. Variability results not only from hardware and software components but also development processes, disciplines (mechanical, electrical, software engineering), methods, and tools. Dealing with variability in industry currently depends too much on mostly tacit domain expert knowledge and custom-built tools focusing on very specific artifacts and software and hardware platforms. Existing research in the area of SiCPPS does not explicitly and systematically deal with variability. Promising software engineering methods and tools, e.g., from the area of Software Product Lines, need to be adapted for the particular challenges in SiCPPS. In this research preview paper, we discuss open research issues, research goals, and propose a research agenda towards mastering variability in SiCPPS.

ID #12

Enhanced Agility for Assembly Tasks via Self-Sufficient Mobile Working Stations

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Abstract

This paper introduces the standardized design and the use of self-sufficient Mobile Working Stations (MWS) for meeting upcoming requirements in providing agility for wide range assembly tasks. It describes how the physical equipment of an assembly line can be prepared for being fit for processing highly customized or even fairly new products outside the existing production portfolio in a very short time. Herein all relevant mechanical, informational and safety related aspects for a new setup have to be obtained. This includes a maximum in functionality and universality of the single MWS and the environment of the factory as a whole as well as the use of a Real Time Locating System (RTLS) for providing the always up to date positions of the MWS or other moveable elements in such an agile factory. The paper closes with an outlook to related ongoing research topics.

ID #13

MTConnect-based decision support system for local machine tool monitoring

Carlos Felipe Erazo Navas[a b], Alejandro Echavarria Yepes[b], Sepideh Abolghasem[a], Giacomo Barbieri[b]

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[b] Department of Mechanical Engineering, Universidad de los Andes, Carrera 1a No. 18A-10, Bogotá, Colombia

Abstract

Cyber-Physical Machine Tools (CPMT) are becoming ubiquitous parts of manufacturing sectors. CPMT offer immense potentials in the current CNC machine tool through integrating the machine tool and the machining process using computation and networking to enhance interconnection and autonomy. This study contributes to literature by presenting a variety of MTConnect applications in facilitating the decision making process at different production levels. We do this through addressing the challenges of data communication and management with CNC machine tool. Using the MTConnect protocol, we gathered near real-time data from a CNC machine. Next, the collected data are utilized to develop a local monitoring system that facilitates the decision-making process with applications on: i) production planning, ii) preventive maintenance, and iii) energy consumption analysis. In each application, various analyses and visualization techniques are presented to show the capabilities of the decision support system (DSS) for the operator. Finally, the advantages of the local DSS to improve the interoperability of the CNC through MTConnect are discussed.

ID #14

Waste reduction in printing process by implementing a video inspection system as a human machine interface

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Abstract

Human mistakes are the main cause of most of the production failures and rejections for bad impressions in the printing industry, for this reason the industry has been working on the development and design of complementary equipment with the aim of reducing the rejections caused by these errors using human-centered design that allows focusing on reducing these mistakes, improving interaction and cooperation between the user, the machine and the process. Contextual research showed that there is currently qualitative evidence regarding the improvement of prints by having a machine video inspection system, but there is no quantitative analysis of the true cost-benefit that exists from having a video inspection and justify its implementation. Therefore this work defines a preliminary study of a video inspection system, used as a complementary equipment to a flexographic rotary printing machine, to improve the printing process focus on machine-human interaction, in a printing company of Mexico City after a notable need for an effective improvement in the printing process in order to reduce waste in production and in rejections for poorly printed jobs. Five representative jobs will be selected, and the cost per meter of linear printing will be evaluated, to give a value to the waste, later the decrease due to production and rejections of a run will be counted for each of the five selected jobs, with and without the system of video inspection, and finally with a comparative analysis of costs, the profitability of the equipment will be determined, obtaining as a result the viability of the equipment, which is directly related to the value of the decrease, since there is an equilibrium point between this value and the value of the equipment, where from there the implementation of the video inspection system is justified; due to the current situation of COVID 19, it was not possible to carry out the necessary measurements to validate the system. Therefore, only the proposed methodology will be described.

ID #15

Reaching sustainability through a smart water crisis-proof industry

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Abstract

The current and future water crisis is not only affecting the household level, but it is rather tackling every activity that requires even a single drop of water for its development. Although whole countries have been implementing new water management schemes such as the Water Sensitive Urban Design in Australia, the 4 Taps in Singapore, and Sponge Cities in China, among others, there has been a lower interest in the side of the industry for changing the plan of action towards a more sustainable water management. Although many companies have adapted their infrastructure into the Sponge Cities model contributing to a better administration of the resource by absorbing water from the rain, promoting a natural filtering by the soil and minimizing water waste, their inner processes still struggle to optimize the use of water. Models such as Zero Liquid Discharge and Zero Water Discharge are an important support, despite the resource, energy and infrastructure requirements. In the last decade these efforts have been targeted towards reaching sustainability and resilience. Nonetheless most of the systems are still highly vulnerable to suffer the effects of a human-detonated or natural-phenomena crisis, that is why the aim of this article is to present the concept of a Smart water crisis-proof industry that may be able to reduce water wasting into zero percent with the idea of a catchment device for providing additional scopes and potential water stock, that if implemented might help prevent and mitigate crisis and become a vehicle for reaching sustainability.

ID #17

Industry 4.0: advanced digital solutions implemented on a close power loop test bench

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Abstract

The paradigm of Industry 4.0 allows to increase the efficiency and effectiveness of the production. Companies that will implement advanced solutions in production systems will increase their level of competitiveness and will be able reach high market shares. The present paper is focused on the development of advanced digital solutions to be implemented on a close power loop test bench designed to test high power transmissions for naval unit. In particular, the test configuration consists of a back-to-back connection between two identical mechanical reducers. Since the efficiency of these systems are very high, it is not necessary to use large electric motors, thus managing to contain the operating costs of the testing phase. The particular test bench allows to size the electric motor simply based on the dissipated power by the kinematic mechanisms. By means of suitable sensors installed on the test bench it is possible to extrapolate countless technical data. The implementation of Industry 4.0 enabling technologies allows to evaluate the increase in efficiency compared to traditional systems in terms of reduction of noise and vibrations, efficiency of lubrication, reduction of consumption, installation and maintenance cost of the entire system.

ID #18

Extending the scope of reference models for smart factories

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Abstract

Industry 4.0 (I4.0), Smart Manufacturing, Industrial Internet, Intelligent Manufacturing, and so forth, are different designations for different initiatives, all contributing to the digital transformation of the industrial ecosystem. Besides several reference models/architectures have been developed, a framework to structure and understand the implications and to identify I4.0 action fields is still needed. A harmonized model would allow guiding the developments on how to organizationally prepare for the change. This paper attempts to clarify the implications and action fields of the I4.0, trying to reveal its mostly alleged dimensions and the main planes in which they intervene in the industrial ecosystem. Through the analysis of the most relevant architectures for I4.0, IoT and Cyber-Physical Systems (CPS), and the consequent awareness of which components are missing, the paper proposes a framework for digital factories towards smart cities that stresses the expansion of the I4.0 horizontal integration into human, cities infrastructural, and societal dimensions.

ID #20

Future of Raw Materials Logistics

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Abstract

The world population has always been on the rise and currently stands at 7.5 billion people. [1] As the world's population grows, so do the resources needed to ensure general prosperity. The basis of all products is the provision of sufficient raw materials [2], but various raw materials are only available in limited quantities. This limitation forces us to use them in a sustainable and efficient way, which poses new challenges for the industry. Due to the growing demands, the supply chain is in a constant state of change and in the coming years there will (have to) be a rethink due to the changing conditions.

- What could the raw materials logistics of the future look like?
- What problems are facing raw materials logistics chains and how should these challenges be dealt with?

The aim of this article is to create reliable scenarios for the development of raw material logistics chains based on a comprehensive literature analysis. As a result, three scenarios are created for development based on the scenario analysis and recommendations for action for the supply chain are derived from them.

ID #21

Scalable model for industrial coffee roasting chamber

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Abstract

The temperature profile of the coffee beans during the roasting phase determines the colour, aroma and flavour of the coffee. In order to reproduce these desired characteristics, the control of the coffee beans temperature has a key role in the roasting process.
A proper model of the plant is required to design an intelligent control. Recently, several physical models that share the main physical equations have been proposed, but they have physical parameters specific of each process. In such scenario, each plant requires an ad hoc identification of the model parameters. This work proposes a model of the roasting chamber that can be used on plants of different sizes by scaling only geometrical parameters directly measurable on the roasting plant. The proposed model was identified on a 120 kg plant and then applied to a 360 kg one. The obtained results show in both cases similar accuracy (FIT = 75.49%, MPE=4.66%).

ID #22

Using Mixed Reality in Intralogistics - Are we ready yet?

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Abstract

The Industry 4.0 vision proposes a seamless integration of several modern concepts and technologies, such as the Internet of Things (IoT), artificial intelligence, or robotics, to capture and contextualize data to improve the manufacturing processes. In this respect, Industry 4.0 is all about information and connectivity. Mixed reality (MR) takes the data collected by IoT systems and helps workers by visualizing contextualized data in real time. Human-Computer Interaction research has shown that MR can be advantageous in various application scenarios. However, there is a gap between research and practice when it comes to real world scenarios. So the question arises whether MR is already suitable for efficiently supporting employees in their daily work in industrial settings. To answer this question, we examined two maintenance scenarios in the field of intralogistics: (i) the maintenance of roller conveyors and (ii) the alignments of containers in shuttle warehouses using the Microsoft HoloLens. This paper (i) describes the scenarios and the specific challenges they pose, (ii) presents the prototypes that have been developed, and (iii) discusses the results of user studies that have been conducted to evaluate the practical applicability by presenting inhibiting and facilitating factors. In summary, although MR technology itself seems to be very promising in the scenarios presented, further research on hardware ergonomics and intuitive interaction design is needed.

ID #23

First Results of a Survey on Manufacturing of the Future

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Abstract

Today's production methods are challenged by changing paradigms from a static constraint mass production and mass customization to continuing personalization and regionalization of product, production and markets. It is yet unclear what future production systems will be the most appropriate, how they will look like and how the current, uncertain trends in manufacturing can be tackled most effectively. In this paper, first results from a comprehensive questionnaire on >The Intelligent Production of the Future< , performed by a consortium of researchers from the Institute for Computer Science and Control (SZTAKI) and the Fraunhofer Institute for Manufacturing Engineering and Automation IPA are outlined. During this survey, stakeholders and peers from more than 70 companies and research institutions in Germany, Austria and Hungary have been asked to share their impressions, describe their opinions and rate central statements on future production systems, methodologies and trends. The paper outlines the most important topics of future production systems and lessons learned during the evaluation of the survey.

ID #24

Digital Manufacturing for Smart Small Satellites Systems

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Abstract

The term Industry 4.0 – manufacturing with exploitation of digital technologies – comprises several challenging topics, among others intuitive machine programming, advanced maintenance-enabling technologies as well as flexible logistics. This paper gives an overview on recent research and development of our institute (Zentrum für Telematik, ZfT) in this field, the results of which are combined in an Industry 4.0 demonstration factory for the assembly of small satellites systems. We present a total of six tools to be used in such advanced manufacturing systems and their individual advantages. Based on our experience with industrial project partners, customers and visitors of our demonstration factory as well as on the evaluations of the jurors of several awards, we give a qualitative estimate of the effort required to port the individual tools to new production environments. Finally, utilizing our in-house expertise in the New-Space and Industry-4.0 sectors, we give an insight into the benefits achievable using digital manufacturing for small satellite assembly.

ID #25

Improvement of manufacturing technologies through a modelling approach: an air-steam sterilization case-study

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Abstract

A milestone of Industry 4.0 is the improvement of the design procedures requiring models of complex processes. Models can be used to simulate the process, being accurate even if complex, and to predict process behaviour for control action, requiring simplicity and stability. In the last years, machine learning approaches came up alongside of the standard identification techniques for prediction purposes. In this work we propose two models of an industrial autoclave to describe the evolution of temperature and pressure. The first model (PhM) involves a physical structure with data-driven adaptation of the parameters, the second one is a Long Short-Term Memory network (LSTM), trained ensuring Input-to-State stability. Both models obtained good performance: FIT of 94.26% (91.55%) for the temperature (pressure) with PhM; 84.59% (78.31%) for the temperature (pressure) with the LSTM. Future developments involve the synthesis of an MPC based on the LSTM to be tested in simulation via PhM.

ID #26

The association between network centrality measures and supply chain performance: The case of distribution networks

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Abstract

We analyze transport data on the worldwide distribution network for 1.2 million vehicles manufactured and distributed by a large German car manufacturer in half a year. To identify central nodes in this network, we calculate various centrality measures from social network analysis. We then analyze the association of these centrality scores and the key performance measures related to stay-times and inventory for ports, distribution centers, and plants. Our main result shows that nodes with high degree centrality perform worse than less central nodes. The main theoretical contribution of our research is to confirm for the very first time that network theory applies to distribution networks, i.e. that network structure influences network node performance.

ID #27

Towards digital cognitive clones for the decision-makers: adversarial training experiments

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Abstract

There can be many reasons for anyone to make a digital copy (clone) of own decision-making behavior. This enables virtual presence of a professional decision-maker simultaneously in many places and processes of Industry 4.0. Such clone can be used as one's responsible representative when the human is not available. Pi-Mind ("Patented Intelligence") is a technology, which enables "cloning" cognitive skills of humans using adversarial machine learning. In this paper, we present a cyber-physical environment as an adversarial learning ecosystem for cloning image classification skills. The physical component of the environment is provided by the logistic laboratory with camera-surveillance over the conveyors. The digital component of the environment contains special modifications of Generative Adversarial Networks, which include a human-operator as a trainer, an autonomous Pi-Mind clone as a trainee (a discriminator) and a smart digital adversary as a challenger (generator of sophisticated decision situations, emergencies and attacks, which supposedly catalyzes the cloning process).

ID #28

A Multi-Layer Architecture for Near Real-Time Collaboration during Distributed Modeling and Simulation of Cyberphysical Systems

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Abstract

We present a Web-based multi-layer architecture and implementation to enable near real-time collaboration within partially distributed engineering teams in this paper. Our architecture named Distributed Modeling and Simulation (DisMoSim) enables collaborative 3D modeling and simulation of complex cyberphysical systems (CPS) across different servers, offices, lab spaces, or organizations. More specifically, DisMoSim creates networks of DisMoSim nodes that communicate using Web protocols with little or no perceptible delay. Each node provides different CPS services, e.g., user interface nodes provide collaborative 3D modeling; computational nodes provide simulations of multi-body dynamics or kinematics; storage nodes allow persisting and sharing models and simulation results; hardware-in-the-loop nodes connect physical testing workbenches to provide real-world sensor measurements as simulation input; software-in-the-loop nodes provide control signals to simulate hardware controllers.
In the following, we derive a set of design goals and propose our DisMoSim architecture. We illustrate how we used our multi-layer conceptual architecture to implement a variety of CPS services for an example scenario. By this, we demonstrate the practicability and versatility of our approach and conclude by discussing limitations and future work.

ID #29

Sensor Shirt as Universal Platform for Real-Time Monitoring of Posture and Movements for Occupational Health and Ergonomics

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Abstract

With the continuing development in integrating electronics into textiles in the field of smart textiles and wearables, new innovations for monitoring the human environment and new possibilities for human-machine interaction are constantly emerging. Depending on the type of sensor technology used, monitoring human motion and its environment allows applications in various fields, like occupational safety, protection and rehabilitation in the form of protective work clothing. In this paper the development of a sensor shirt is described, which records the movement and position of the upper body by several inertial sensors and transmits the sensor values via Wi-Fi. Based on the developed prototype, this paper shows the typical problems in the development of intelligent clothing and presents possible concepts which can be implemented already in the design phase. First measurements of the prototype show the potential of the shirt as well as possible future applications in the field of occupational safety and human-machine interaction.

ID #30

A literature review and cluster analysis of the Aachen production planning and control model under Industry 4.0

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Abstract

Industry 4.0 technologies influence how production is planned, scheduled, and controlled. In literature, different classifications of the tasks and functions of production planning and control (PPC) exist, of which one is the German Aachen PPC model. This paper conducts an exploratory literature review by reviewing 48 publications on a full-text basis. Based on the review, a cyber-physical PPC architecture is proposed, which incorporates current Industry 4.0 technologies, current optimisation methods, optimisation objectives, and disturbances, relevant for the realisation of a PPC system in a smart factory. A classification scheme is developed as a basis for two cluster analyses that reveal researched and unexplored tasks and functions of the Aachen PPC model. Current approaches focus on the in-house PPC, particularly on the control using real-time information from the shop floor. Future research directions are proposed for the unexplored tasks and functions of the Aachen PPC model.

ID #32

A Comparison of Different Linearized Formulations for Progressive Flooding Simulations in Full-Scale

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Abstract

In the framework of Industry 4.0, simulation plays a key role in processing sensors data to predict the future behaviour of a complex system. Aiming to increase ship efficiency and safety, simulations can be used in normal conditions but also during an emergency. In this context, progressive flooding simulations can be applied onboard large passenger ships to support master decisions after a collision or grounding casualty. Among the methods present in literature, the techniques based on linearized differential equations have been recently proposed and tested in model-scale. Here, the effects of three different linearized techniques are studied on a large passenger ship. The main issues connected to different mathematical formulations are highlighted, to enhance the reliability of the onboard progressive flooding simulation and better exploit data collected by sensors to increase ship safety in the framework of Shipping 4.0.

ID #33

Optimization of condition-based maintenance strategy prediction for aging automotive industrial equipment using FMEA

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Abstract

Maintenance plays a highly important role in achieving production targets and system performance. Electromechanical equipment and facility infrastructure within motor manufacturing industries are expected to perform at optimal efficiency during the operational phase of production. A major problem in the automotive production plan from motor industry statistics is associated with unexpected downtime, which is largely linked to aging equipment. During production downtime, much time is lost to fault finding, repairs, and replacement of faulty components within production lines. This transforms into low throughput in production, and performance gradually declines during the operational life cycle of the equipment. This paper presents an approach taken to prevent such instances in the automotive manufacturing industry, which considers an optimized condition-based maintenance approach to predict the condition of each component and assembly line using Failure-Mode-and-Effect-Analysis (FMEA). The condition-based performance level prediction is designed to help in formulating maintenance schedules and strategies that eliminate unplanned downtimes.

ID #34

Efficiency Improvement in polycrystalline solar panel using thermal control water spraying cooling

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Abstract

The increasing demand for electricity generated from main grids has necessitated the use of multiple microgrids, which serve as subsystems of the utility power. More recently, solar farms are being utilized for electricity generation, since solar irradiation is a green and sustainable renewable energy source. This energy source has witnessed high global growth figures, as more countries explore this alternative power source in the fourth industrial revolution. Solar panels are exposed to high temperatures due to the heat absorbed from the sun and this heat negatively impact its thermal control that lags its power generation. The excessive heat absorbed from the sun limits energy generated by the solar cells. Colling of solar panels is essential, especially on concentrated Photovoltaic (PV) systems. The paper focuses on an optimization option of an automated water spraying method that has effectively addressed a major gap experienced by the solar panel under hot weather conditions. The Introduction of a microcontroller-based thermal control water spraying system using an Arduino board was found to improve the efficiency of the solar cells. In the study, a solar collector cooling algorithm was designed and developed using a thermal control feedback system, which increased the efficiency of the solar panel array by 16.65%.

ID #35

High-quality sheet metal production using a model-based adaptive approach

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Abstract

Automatic panel benders of Salvagnini Maschinenbau GmbH enable high-quality and high-efficient production of sheet metal components. To achieve the steadily increasing requirements on precision, a model-based adaptive concept has been developed controlling the complete production process as a digital twin, from CAD data to the final sheet metal part. First, an overview of the underlying simulation models with different levels of detail is given. The models consider the elastoplastic deformation of the metal sheets as well as the elastic machine components and mechatronic models of the powertrain. Secondly, an overview is given of the adaptive production concept allowing the real-time adaption of the machine to changing process parameters like material properties. Finally, all production steps are controlled by a digital twin based on this model-based adaptive strategy. The paper demonstrates the successful transfer of scientific results to an industrial application.

ID #36

Explaining Learning Models in Manufacturing Processes

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Abstract

The use of advanced machine learning (ML) models for manufacturing could potentially reduce the pre-production testing and validation time for new processes. Once we decide that ML is indeed a suitable tool to apply in smart manufacturing processes, the challenge lies in training, validating, and testing an ML model in a pre-production environment so that engineers can be confident that the model building effort can be successfully transitioned to actual production. This paper aims at explaining the in-works of a given in-situ classifier for predicting the quality welds in ultrasonic welded battery tabs. Predicting the quality of new samples cannot attain full certainty due to characteristics of the data the model was trained on (e.g., noisy or wrongly labeled). By developing explainable methods to such connectionist learning models (also known as black boxes), we show why the classifier outputs were predicted, making these predictions better understood and trustworthy.

ID #37

Creating an Open-Source Augmented Reality Remote Support Tool for Industry: Challenges and Learnings

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Abstract

Remote support tools offer great savings potential for maintenance work and simplify communication between on-site workers and remote experts in the back-office. Despite the predicted benefits and the existence of an increasing number of commercial augmented reality (AR) remote support tools, the technology still struggles with various challenges, mainly caused by technical limitations, safety concerns or industry-specific constraints. In this paper, we describe the implementation of an open source AR remote support application with a strong industry focus. The software was developed based on the feedback of four industry partners with different needs in the field of maintenance work. Therefore, we set the focus on configurability to provide the right tools for each use case. The developed remote support tool was then compared with traditional support measures in a user study.
This paper presents the lessons learned from the expert discussions with our company partners and the results of the user study.

ID #38

Generation of 2.5D Deposition Strategies for LMD-based Additive Manufacturing

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Abstract

Additive manufacturing is a key technology of Industry 4.0. In the context of Laser Metal Deposition (LMD), the problem of automating the generation of the layer-by-layer deposition strategies is relevant because the laser path pattern and the process parameters determine the mechanical quality of the resulting part and the efficiency of the process. Many of the existing approaches rely on path planning strategies created for subtractive manufacturing. However, these techniques generate path patterns not suitable for LMD. This manuscript presents deposition strategies which are specific for LMD processes, including the laser path and the process parameters at selected control points. This manuscript considers diverse infill patterns for general polygonal regions. This manuscript also reports the implementation of a 2D region avoidance algorithm, used to reposition the laser head between regions and between layers. These transitions are important because current hardware maintains the material feeding while the laser is OFF. Our implementation is validated by the fabrication and verification of actual metallic parts using our algorithms in an LMD process. Future work is required on optimization of material savings and overall process performance.

ID #39

A Human-Centered Assembly Workplace For Industry: Challenges and Lessons Learned

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Abstract

The increasing complexity of adapting established assembly processes to fast changing market demands is challenging European industry. Especially for highly individual products the automation of each assembly step is not feasible for both technical and economic reasons. Humans and machines have to work cooperatively in future factories. Like new programming methods for machines, human workers have to be trained for such changed situations. Therefore, this paper presents challenges and lessons learned from a 4-year research project dealing with the reduction of training effort for assembly processes by researching easily configurable, digital assistive systems. These digital assistive systems arranged on a novel 'human centered workplace' range from product-specific work instructions shown on a display and augmented reality solutions for training to collaborative robots. The overall architecture comprises a fully integrated software eco-system for engineering and operating assistive systems, a prototypical assembly station as well as a corresponding transformation process.

ID #40

Multi-mode Systems for Resilient Security in Industry 4.0

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Abstract

In the era of the Internet of Things and Industry 4.0, machines and devices are increasingly getting connected. These connections go hand in hand with security vulnerabilities and potential threats to these devices. In regular IT systems, we typically provide updates to eliminate vulnerabilities. In industrial automation and control systems, especially in mass production, legacy systems are widespread and installing updates causes downtime. Availability is one of the top goals; stopping a machine in case of a cyber-security threat is often too expensive. But, system integrators and asset owners should not have to wait until product or component suppliers release appropriate updates. Due to safety and warranty requirements, developing and distributing updates can take a long time. In the meantime, attackers can pose threats by taking advantage of devices' known vulnerabilities. In this paper, we propose the design of resilient systems based on multi-modal architectures with several operational modes. When vulnerabilities of systems become known, or when systems get even attacked at some point, mode switching can overcome the time between vulnerability disclosure or attack, and the availability of corresponding security patches. Therefore, system integrators and asset owners can actively protect themselves by implicitly or explicitly switching to modes with reduced attack surfaces and, thus, with limited ranges of activity for attackers.

ID #41

A model for the economic assessment of disassembly-line integration in traditional manufacturing processes

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Abstract

Managing End-of-Life (EoL) products and reintroducing materials and components within the production loop become crucial for guaranteeing the Circular Economy business model. In such a way, the proper management of disassembly process for recovering components and materials from returned EoL products is essential as well as strategic: disassembly is the main gateway of information and can ensure economic returns. This paper aims to provide a model for the economic assessment of the introduction of a manual disassembly line in a traditional and already operating assembly line of manufacturing industries. Therefore, recovered components and materials could directly feed the assembly lines and the recycling processes. The model takes in input probabilistic factors, as products' characteristics, and provides the operating times and component recovery indicators, as well as allows the sizing of the right number of operators needed in the new disassembly line through the optimisation of the industrial cost. An interesting natural evolution of this study is the development of a model-based simulator, with the aim of providing a user-friendly tool to industrial practitioners to estimate the economic feasibility and convenience of introducing a disassembly line.

ID #42

An analytical framework for assessing cognitive capacity and processing speed of operators in industry 4.0

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Abstract

The fourth industrial revolution introduced a new paradigm in manufacturing systems. The digital network is at the basis of the smart manufacturing and the physical context is strictly related to the artificial intelligence. This new manufacturing context drastically changed the role of the operator since the increasing adoption of innovative devices in manufacturing process modified the work activities and the operator is employed in more cognitive than physical tasks.
Therefore, the purpose of this paper consists in developing an analytical framework to assess the human cognitive capacity occupancy and the human processing time of correct information known as the quality performance.
The analytical framework presented allows to assess the human mental workload imposed by the task and how the processing speed of correct information changes when quality performance varies.

ID #43

Biased random-key genetic algorithm for cobot assignment in an assembly/disassembly job shop scheduling problem

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Abstract

Nowadays many manufacturing companies try to improve the performance of their processes by including innovative available technologies such as collaborative robots. Collaborative robots are robots where no safety distance is necessary, through cooperation with human workers they can increase production speed. In this paper we consider the collaborative robot assignment combined with the job shop scheduling problem. To solve this problem, we propose a genetic algorithm with a biased random-key encoding. The objective function for the optimization is a weighted function that factors in production cost and makespan that should be minimized. We propose a special encoding of the solution: the assignment of cobots to workstations, the assignment of tasks to different workstations and the priority of tasks. The results show how much the weighted objective function can be decreased by the deployment of additional collaborative robots in a real-world production line. Additionally, the biased random-key encoded results are compared to typical integer encoded solution. With the biased random-key encoding, we were able to find better results than with the standard integer encoding.

ID #44

Implications of embedded artificial intelligence - machine learning on safety of machinery

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Abstract

The Artificial Intelligence (AI) and the Machine Learning (ML) is a rapidly evolving technology and up until recently has not been a subject of machinery safety. The purpose of this work is to evaluate how embedded artificial intelligence – machine learning can affect the safety of machinery and machinery systems in the development of their applications. This work can be useful to machinery designers to develop their particular applications as it describes how the new hazards, associated with embedded AI – ML, should be considered within the framework of the risk assessment process. The proposed study underlines the new dimension of complexity linked to artificial intelligence and machine learning that could lead to a revision of European legislation in terms of the introduction and/or modification of essential health and safety requirements (EHSR) in the Machinery Directive, in order to guarantee safety levels at least equivalent to those currently achieved.

ID #46

pyBNBowTie: Python library for Bow-Tie Analysis based on Bayesian Networks

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Abstract

In addition to more conventional but often less precise methods, the risk assessment as part of the risk management process can be performed with the bow-tie analysis method. A bow-tie analysis describes the effects of causes on a top event and the resulting consequences. Bayesian networks, on the other hand, offer a mathematically concise way of describing dependencies between events under uncertainty. The mapping of bow-tie analysis into Bayesian networks is intended to make their superior calculation options available.
While the mapping algorithm of a bow-tie method into a Bayesian network is described in the literature, no computer program carrying out this mapping has been found so far. In this text, a Python library, that is validated using published examples, is presented and made publicly available for mapping bow-tie methods into Bayesian networks.

ID #47

Trace reconstruction in system logs for processing with process mining

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Abstract

System logs contain information about the behavior of the system. To perform anomaly detection based on this log data, the normal behavior of the system must be learned. With process discovery a process model can be learned from log data. However, system logs do not fulfill the requirements that process discovery algorithms place on log data. To solve this problem, trace reconstruction is used to extract traces from the log data, which are then used for process discovery in a further step. This research proposal therefore proposes combining different methods for grouping log messages. A short experiment shows that the reconstruction of traces from simple log data is possible in principle.

ID #48

Functionalized additively manufactured parts for the manufacturing of the future

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Abstract

Innovation technology is giving the opportunity to fabricate products and parts in alternative ways and with special characteristics, which do not strictly depend on the primary manufacturing process. In particular, smart manufacturing seeks for flexible systems and customizable products, recognizing additive manufacturing (AM) processes as a key element. To successfully integrate AM into the production chain it is necessary to overcome its limitations in terms of final product quality and reliability, wisely choosing post-processing operations. This work outlines how it is possible to significantly improve AM product performance using an environment friendly process, such as burnishing, coupled with a numerical simulation model encouraging customer integration and developing a flexible manufacturing process capable to conform with the main idea behind Industry 4.0.

ID #49

Route Duration Prediction in a Stochastic and Dynamic Vehicle Routing Problem with Short Delivery Deadlines☆

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Abstract

We are facing a real-world vehicle routing problem where orders arrive dynamically over the day at an online store and have to be delivered within short time. Stochastic information in form of the expected number and weight of orders and the traffic congestion level is available upfront. The goal is to predict the average time needed to deliver an order for a given time and day.This information is desirable for both routing decisions in the short horizon and planning vehicle drivers' shifts with just the right capacity prior to the actual day.
We compare a white box linear regression model and a neural network based black box model on historic route data collected over three months. We employ a hourly data aggregation approach with sampling statistics to estimate the ground truth and features. The weighted mean square error is used as loss function to favor samples with less uncertainty. A mean validation R 2 score over 10 × 5-fold cross-validations of 0.53 indicates a substantial amount of unexplained variance. Both predictors are slightly optimistic and produce median standardized absolute residuals of about one.

ID #50

Development of Digitalization in Production Industry – Impact on Productivity, Management and Human Work

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Abstract

Digitalization is a process that started already years ago and shows increasing dynamics. Since latest the year 2011 – when the vision of Industry 4.0 was presented – digitalization dynamics increase also in production industry. Simultaneously, manifold and partially far reaching expectations on the digitalization's impact on productivity and its management as well as on employees and work design came up. To gain information on the current state of digitalization as well as the related experiences and expectations three studies have been conducted by ifaa in the years 2015, 2017 and 2019 in the German metal and electrical industry. Now integrated analyses of these studies and especially of some replicated questions have been conducted to recognize development tendencies and gain further knowledge on the digitalization's development. In this way, several development tendencies were found, and assumptions were derived for explaining them. These include expectations on productivity gain, importance of digitalization for selected fields of application, the use of lean methods and holistic approaches as well as the impact on employees, their number, and their flexibility.

ID #51

CFD modeling in Industry 4.0: New perspectives for smart factories

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Abstract

Industrial market is becoming increasingly competitive and companies need even more advanced resources to advantage over competitors. As an example, simulation is part of Industry 4.0 technologies and a key tool for lay out re-configuration, in order to realize a flexible product customization but also to optimize manufacturing processes. For these reasons Computational Fluid Dynamics (CFD) simulation can determine a competitive advantage for smart factories in the light of possibilities offered by new technologies.
The research is focused on a conceptual solution to integrate CFD simulation with technologies of the Industry 4.0, in order to open new opportunities for companies in terms of in terms of growth and competitiveness.

ID #52

Industry 4.0 and human factor: How is technology changing the role of the maintenance operator?

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Abstract

Industry 4.0 is revolutionizing not only the manufacturing industry but also maintenance strategies.
As consequence of the introduction of Industry 4.0 technologies, new skills are demanded to maintenance operators that has to be able to interact, as instance, with Cyber Physical Systems and robots. In this paper, we first investigate the state-of-the-art of Industry 4.0 technologies that are transforming operations and production management and finally we discuss how the role of maintenance operators is changed in a such digitalized environment.
We found that, the maintenance Operator 4.0 should be able to find relevant information and predict events by a proper use of Big Data analytics, in addition to the ability of interacting with computers, digital databases and robots. Finally, the ability to rapidly adapt his skills to innovations is also strongly demanded.

ID #53

Industry 4.0 tools in lean production: A systematic literature review

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Abstract

The present article focuses its attention on the tools of the Industry 4.0 with the purpose to analyze how these tools can be useful for the companies to increase factors like efficiency and productivity. In the age of the fourth industrial revolution, companies try to know how they can approach to the Industry 4.0, keeping attention on the tools which will be able to increase their results over time. This it will be possible if the companies will be able to integrate, not only the concept of Industry 4.0 with Lean Production, but even the human factor with the tools of the fourth industrial revolution. This integration will allow to increase companies' performance and to get higher results than competitors, increasing even their productivity and flexibility. The aim of the study is to know what tools of the Industry 4.0 are used by the companies, what are the reasons that push companies to use these tools and what advantages are from their use. The results achieved will show that the most important I4.0 tools integrated with lean production will be IoT and Big Data, which will allow companies to improve their flexibility and productivity. Finally, the human factor, as reported from some authors in the section 7, will be another important element which will allow companies to get great results.

ID #54

Lean production and Industry 4.0: Strategy/ management or technique/implementation? A systematic literature review

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Abstract

Lean production and Industry 4.0 are two concepts that have been studied in recent years, focusing mainly on the relationship that exist between them. Several authors state that lean manufacturing cannot be efficient without the implementation of Industry 4.0 technologies. For this reason, the aim of this paper is to understand how these concepts can be implemented in a company.
Results show that the academic research is divided between two different clusters: (1) strategic/managerial and (2) techniques/implementation.

ID #55

Industry 4.0 tools in innovative European firms: exploring their adoption and communication features through content analysis

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Abstract

Industry 4.0 is a popular topic in management literature, but it is also an interdisciplinary subject, maintaining a strong engineering connotation. Firm decision-making processes are more and more affected by Industry 4.0 which has introduced numerous tools that benefit and greatly support business activities. In this domain, the focus of this paper is the information made available to stakeholders on Industry 4.0 tools in use through a content analysis of the Annual Reports of the main European innovative firms (from the top ten of the Boston Consulting Group ranking). The analysis seeks to highlight how firms describe and qualify these tools in terms of impact (risk, strategy or environmental), the perspective used in illustrating them (managerial or engineering) as well as the temporal orientation of the information provided (present, past, future or none). Results show that innovative European firms pay attention and use these tools, in different ways and for different purposes. The paper has both theoretical and managerial implications. From a theoretical point of view, it contributes to study and further the literature on Industry 4.0 and its instruments, while from a managerial perspective, it gives a better understanding of how these innovative tools can be communicated to external stakeholders, especially investors.

ID #56

Implementation of Industry 4.0 technology: New opportunities and challenges for maintenance strategy

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Abstract

Industry 4.0 is revolutionizing decision-making processes within the manufacturing industry. Maintenance strategies play a crucial role to improve progressively technical performances and economical savings. The introduction of Industry 4.0 technology results in relevant innovations able to condition maintenance policies. Moreover, innovative solutions can be introduced, such as "remote maintenance" and the "self-maintenance".
In this paper, we investigate the state-of-the-art of technologies in a "smart factory" with the aim to understand how Industry 4.0 technologies are affecting maintenance policies and to discuss their implication in strategies.
We found important trends in maintenance policies, such as "remote maintenance" and the attractive option of the "autonomous maintenance". This study represents the first comprehensive investigation in these research themes, and it desires to produce a broader insight and knowledge of current trends and main difficulties, highlighting critical aspects and disadvantages for the implementation of innovative policies.

ID #57

Enabling technology for maintenance in a smart factory: A literature review

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Abstract

Industry 4.0 technologies are transforming the factory in an "intelligent" or "smart" factory. In a such context, a greater efficiency and innovative relationship is basically demanded within the whole production chain, including suppliers, producers, and customers.
To be more competitive, companies are becoming increasingly aware that maintenance plays a key role during the digital transformation from the perspective of both technology and management. In this work, we perform a literature review of published cases to investigate how maintenance is changing through technologies of Industry 4.0 currently used in maintenance. We found 34 papers in literature involved in analyzing relations between maintenance and Industry 4.0 technology. The analysis of such studies let us to establish the current technology state-of-art and identify the most suited technology that today is employed in maintenance tasks. In particular Industrial Internet of Things and Cloud Computing are more common in the analyzed studies, confirming how these concepts and technologies are at the basis of Industry 4.0

ID #58

The role of Industry 4.0 enabling technologies for safety management: A systematic literature review

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Abstract

Innovations introduced during the Industry 4.0 era consist in the integration of the so called "nine pillars of technologies" in manufacturing, transforming the conventional factory in a smart factory.
The aim of this study is to investigate enabling technologies of Industry 4.0, focusing on technologies that have a greater impact on safety management. Main characteristics of such technologies will be identified and described according to their use in an industrial environment. In order to do this, we chose a systematic literature review (SLR) to answer the research question in a comprehensively way. Results show that articles can be grouped according to different criteria. Moreover, we found that Industry 4.0 can increase safety levels in warehouse and logistic, as well as several solutions are available for building sector.

ID #59

The impact of Additive Manufacturing on Supply Chain design: a simulation study

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Abstract

Additive Manufacturing is a production technology, which completely differs from the traditional subtractive approach. Because its different nature, its application could cause strong changes in supply chains and it could affect the relationship between the supply chain players. This paper proposes a quantitative evaluation of the Additive Manufacturing effects on the supply chain performance, considering different system configurations. A simulation model has been implemented in order to reproduce the behavior of the players and compare different scenarios. Both additive and traditional technologies have been modelled in order to compare their efficiency. Moreover, different supply chain configurations have been tested to assess the additive production feasibility combined with different supply chain structures. Results confirm that Additive Manufacturing provides good improvements in supply chain performances offering significant benefits in the decentralized solution.

ID #60

Dynamic failure rate model of an electric motor comparing the Military Standard and Svenska Kullagerfabriken (SKF) methods

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Abstract

Electric motors are industrial systems' components widely diffused enabling all productive processes and safety equipment. They are affected by aging effect with a contribution based on the environmental condition on which they work. In order to design efficient maintenance plans, the behaviour of their main components, such as bearings and winding, has to be predicted. Therefore, a model-based methodology is applied aiming at codifying the failure rate of an electric engine, taking into account the thermal aging and relevant environment boundary conditions in which bearings and winding operate. The winding failure mode is coded by means of the Military standard technique while the bearings one is simulated comparing the Military Standard and the Svenska Kullagerfabriken (SKF) techniques. While the former predicts more conservative behaviours, the latter, taking into account lubrication conditions, dynamic loads and a better knowledge of materials quality, enables to capture the evolution of the operative conditions. The proposed reliability model can capture both the deterministic and stochastic behaviour of the electric motor: it belongs to the field of hybrid automaton application; the model is coded by means of the emerging software framework called SHYFTOO. The proposed model and the Monte Carlo simulation process that performs its evolution can support the development of a new class of electric motors: a cyber-physical oriented electric motor.

ID #61

Decay-parameter Diagnosis in Industrial Domains by Robustness through Isotonic Regression

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Abstract

In various industrial production environments a burn-in phase of a specific settling-length precedes a stable (i.e. steady-state, stationary) process mode. The identification of the corresponding physical parameters may be difficult to perform in the presence of strong noise. We propose a method using isotonic regression which circumvents the negative effects of heteroscedasticity related to naive estimation procedures adding robustness against different occurrences of scale on which the run-in effect is observed.

ID #62

Explaining a Random Forest With the Difference of Two ARIMA Models in an Industrial Fault Detection Scenario

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Abstract

In this paper a method is proposed to obtain explainability of the random forest model. Two Auto-Regressive Integrated Moving Average (ARIMA) models form the basis for this approach. The ARIMA models are used in a way similar to how local surrogate models are typically applied. The explanation of random forest's prediction is derived from the numerical differences of the parameters of the ARIMA models. To demonstrate the feasibility of this idea, an experiment that implements this approach is conducted. The data used for this are similar to an accumulated bathtub curve representing failure rates in a production process. The results of the experiment show that the approach is able to identify a linear trend in some parts of the data, and therefore locally provide anexplanation for the functional form of the underlying failure rate.

ID #63

Simulation of ground bearing pressure profile under hydraulic crane outrigger mats for the verification of 16-point combined loading

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Abstract

The modular construction approach relies heavily on mobile cranes. With the increase in weight of modules, the ground bearing pressure (GBP) applied by the hydraulic crane also increases. To avoid ground failure, the primary technique is to determine the GBP by calculating the resulting force at each outrigger and assuming it is distributed uniformly over the surface area of the mat under the outrigger. Finite element analysis (FEA) indicates that the pressure profile beneath the crane mat is not uniform in nature, which means the traditional method of calculating the GBP is inaccurate. In this study, a new method is proposed to determine the GBP profile. The proposed methodology can determine the GBP at 16 points, the four corners of each of the four outriggers. For a theoretical case study, a hydraulic crane Grove GMK 7550 with three different payloads is examined and the results are verified by using FEA.

ID #64

CONTEXT: An Industry 4.0 Dataset of Contextual Faults in a Smart Factory

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Abstract

Cyber-physical systems in smart factories get more and more integrated and interconnected. Industry 4.0 accelerates this trend even further. Through the broad interconnectivity a new class of faults arise, the contextual faults, where contextual knowledge is needed to find the underlying reason. Fully-automated systems and the production line in a smart factory form a complex environment making the fault diagnosis non-trivial. Along with a dataset, we give a first definition of contextual faults in the smart factory and name initial use cases. Additionally, the dataset encompasses all the data recorded in a current state-of-the-art smart factory. We also add additional information measured by our developed sensing units to enrich the smart factory data even further.
In the end, we show a first approach to detect the contextual faults in a manual preliminary analysis of the recorded log data.

ID #65

Evaluating the alignment of sequence diagrams with system behavior

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Abstract

In model-driven engineering, sequence diagrams are commonly used to describe a system's expected behavior in different scenarios. Indeed, the information flow described in sequence diagrams should actually take place during a real execution of the system in order to ensure its safety, security and correctness. If it does not, this may lead to serious consequences. In this short paper, we present a novel generic approach for addressing this issue by observing the live execution of a system and checking whether the exhibited information flow correctly follows what has been specified in sequence diagrams.

ID #66

Investigating the Potential of Smart Manufacturing Technologies

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Abstract

Over the past years, the topic of smart manufacturing has been in the focus of researchers and manufacturing experts. Smart manufacturing describes the technology-driven ability to solve existing and future problems in a collaborative manufacturing infrastructure, which responds in real-time to meet changing demands. However, many companies are still unsure what smart manufacturing entails and which potential (and challenges) it holds. To get an insight into the issues addressed, a technology laboratory for the development of innovative technologies and concepts for intelligent production along the product life cycle was established at University of Applied Sciences Upper Austria. This paper offers an insight into the challenges and lessons learned from a 6-year research project where a subset of smart manufacturing technologies have been collaboratively investigated, including Mixed Reality, Additive Manufacturing and Predictive Maintenance. With our work, we want to support companies in better assessing the potential of smart manufacturing.

ID #67

Driver Shift Planning for an Online Store with Short Delivery Times

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Abstract

In this work we derive daily driver shift plans for an online store which delivers goods to customers within short times. The goal is to minimize the total labor time (total shift lengths) over all shifts. Thereby orders must be assigned to shifts s.t. all orders are delivered in time. We model this optimization problem by means of a mixed integer linear program using a time-index based formulation. This model features strengthening inequalities that allow to solve it also reasonably well with an open source branch- and-cut solver. Furthermore we use a coarse-grained variant of the model to quickly derive high-quality heuristic solutions within one minute even for larger instances with up to two thousand orders. On a realistic benchmark instance set the overall approach is able to obtain solutions with remaining optimality gaps below 1%.

ID #68

Equipment Design Optimization Based on Digital Twin Under the Framework of Zero-Defect Manufacturing

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Abstract

A digitalized Smart Factory can be considered as a data island. Moreover, engineers have focused on the development of new technologies and techniques not only for transforming information to data but also to achieve efficient data utilization to further optimize manufacturing processes. However, the Zero-Defect Manufacturing concept has emerged, where the main goal is production optimization. The cornerstone in achieving the factories of the future is to further optimize the design of new assets so as they comply with the unique requirements of the customers. Therefore, this paper proposes the conceptualization, design, and initial development of a platform for the utilization of data derived from industrial environments for the optimization of the equipment design. The main aspects of the proposed framework are the data acquisition, data processing and the simulation. The applicability of the proposed framework has been tested in a laboratory-based machine shop utilizing data from a real-life industrial scenario.

ID #69

Real-life scheduling with rich constraints and dynamic properties an extendable approach

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Abstract

The industries' demand for appropriate solution approaches to solve complex, dynamic scheduling problems with a large amount of jobs (and operations) is steadily increasing. To meet these expectations, we developed a flexible and extendable optimization approach to deal with a variety of real-life, dynamic scheduling problems. The goal of the solution approach is to calculate feasible, good solutions for large problem instances in a short amount of time. In this paper, we describe the current state of the data model and algorithms to solve large scheduling problems with complex constraints and dynamic properties, e.g., machine capacity types, breaks on machines, setup times, etc., and give a short overview of the developed solution concept. Finally, we discuss further extensions of the given approach as well as future research directions.

ID #70

Large scale predictability analysis of process variables from injection molding machines

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Abstract

This paper analyzes the process variable data from injection molding processes to identify the key process variables, which can be predicted by other process variables, which highlights the interdependence among different process variables in various production scenarios. The available data from injection molding machines provide information for the run-time, setup parameters of machines, and measurements of different process variables through sensors. For predictive modeling, we employed different linear regression models with the recursive backward feature selection and SVM regression models using a radial kernel to predict nonlinear process variables. We also applied the linear and SVM regression models for outlier data in the process variables assuming that the upper bound outliers represent the perturbed state of process variables during production. These perturbations are affected by material type, machine type (age and performance), regime changes, or other external effects and subsequently affect the predictability of process variables and production output. Such cases are different compared to the normal or controlled range of process variables. Our analysis shows that the predictability varies for different material types due to the interdependence of the associated process variables. We further highlight that various process variables exhibit nonlinear relationships and cannot be predicted using linear models. We additionally look for the interdependence of process variables used previously by three studies as input features to predict product quality.

ID #71

Developing an OPC UA Server for CNC Machines

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Abstract

This paper addresses the concept of Industry 4.0 from the perspective of the molds industry, a key industry in today's industrial panorama. With its constant modernization, several technologies have been introduced, in particular regarding machining equipment. With each brand and model requiring different (proprietary) interfaces and communication protocols, this technological diversity renders the automatic interconnection with production management software extremely challenging. In this paper a methodology to build monitoring solutions for machining devices is defined, based on the main equipment and operations used by molds industry companies. For a standardized approach, OPC UA is used for high-level communication between the various systems. As a key result of this paper, and given the variety of monitoring systems and communication protocols, the developed approach combines various different machine interfaces on a single system, in order to cover a relevant subset of machining equipment currently in use by the molds industry. This kind of all-in-one approach will give production managers access to the information needed for a continuous monitoring and improvement of the entire production process.

ID #72

SRTP assessment of passenger ships: a simulation tool

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Abstract

Recent years have seen increasing attention being paid towards the problems related to safety and security onboard ships. As a result, the International Maritime Organization has issued several new Regulations regarding ships' systems that must be considered during the vessel design phases. In particular, one of the most important approaches introduced by this set of rules consists of the Safe Return to Port (SRtP) concept: basically, the ship itself represents its best lifeboat. Essential systems on-board passenger ships shall be designed in order to both guarantee their functionality and allow the return of the ship to the nearest port during specific emergency situations. Consequently, it is evident that designers should pay great attention to these systems since the early stages of the project. In this framework, proper IT design tools able to simulate systems functionality can represent a valuable aid to ensure compliance with the SRtP requirements. In this paper, the basic principles of SRtP Regulations are thoroughly presented. Furthermore, an IT tool, specifically implemented to address the suggested design approach for ship systems, is analyzed.

ID #73

Business Process (4IR) Centric Optimization Modelling

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Abstract

Current best practice methodologies of energy utilization are limited to core production processes, excluding non-core processes. Energy determinations are limited to specialized functions and do not cover the entire business. This research introduces business process modelling to evaluate the holistic business energy demand, inclusive of core production and support functions, of a coal fired power plant. The methodology includes, modelling and statistical techniques, in developing the holistic baseline model, with predictive capacities to forecast the energy impact of changes to the business. Post a validation cycle, the results provide for insights on the impact of optimization, including Cleaner Production, IoT and technology substitution on the coal to energy business. The results include CO2 impact, energy impact and resource (people) impacts as forecast by the model. The model is unique in that it is system agnostic and can be used to forecast any energy production configuration.

ID #74

COVID-19 supply chain resilience modelling for the dairy industry

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Abstract

Precipitated by the COVID-19 pandemic, the extant global supply chain is transitioning from an efficiency fixated system to a system orientated on resilience. Key factors advancing this transformation include localisation and digitalisation. A system dynamics model is formulated to facilitate the investigation of the aforementioned factors impact on the cost structure of the dairy sector. A 3 level, 2 factor experiment reveals the confounding effect of the two factors to be a decrease in the mean cost across the system mediated primarily by the cascading benefits of digitalisation on innovation, continuous improvement and the concomitant efficiency enhancement. Analysis of the simulation results establishes that employment is augmented by digitalisation and localisation but constrained by skills scarcity. An extended model incorporating a more comprehensive description of the dairy sub-sector would be indispensable to informing policy and strategic and tactical decision making for resilience based designs.

ID #75

A Classification-based Solution For Recommending Process Parameters of Production Processes Without Quality Measures

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Abstract

For production of sheet metal parts for car bodies, an adjustment of process parameters is required to maintain the desired part quality in presence of scattering blank properties. The digital transformation enables the application of data-driven methods for finding process parameters instead of a time-consuming experience-driven trial-and-error approach. However, due to cost and technical limitations, it is still hard to measure quality for every part. Removing data points of low-quality parts helps recommending proper process parameters. In this paper, we propose classification-based solution for recommending process parameters. In data preprocessing, the solution utilizes anomaly detection and knowledge-based methods to remove potential data points of low-quality parts without quality measures. On the processed data, a classification model is trained to predict process parameters according to blank properties. Our solution detects 30% low-quality parts and gives competitive performance (92.26% prediction accuracy) compared to a model trained on data comprising quality measures.

ID #76

Early life reliability growth testing with non-constant failure intensity

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Abstract

Early-life reliability is a key characteristic for complex technical products as it addresses the very first time span of product use. Any unreliability in this phase jeopardizes both customer satisfaction, as well as warranty costs and finally the economic success. Review of several early-life warranty cases shows a mix of classical reliability issues, i.e., problems occurring during usage time, and quality related issues that often manifest themselves during initial inspections by product quality or even the customer, i.e., at usage time t = 0. Classical reliability growth models do not explicitly consider these two different sources of unreliability but require zero failures at time zero and provide time-dependent reliability estimates. We present a model which shares the concept of time-dependent reliability measures but considers in addition the initial quality issues. By taking advantage of well-known reliability growth models and basic statistical principles we were able to provide a flexible approach useful for practical application.

ID #77

Smart Production Planning and Control: Technology Readiness Assessment

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Abstract

There is a clearly identified need to support SMEs to be aligned with technology advances in the context of Industry 4.0 throughout the end-to-end engineering across the entire value chain. Thus, this study aims to adapt and utilize the Smart SME Technology Readiness Assessment (SSTRA) methodology to enable SMEs to gain available information and data to process it in a standardized manner to analyze the technology readiness to implement industry 4.0. The SSTRA framework and methodology is implemented in a real case study with a focus on the smart production planning & control phase. Also, the conceptual model for Smart production planning & control development is proposed and validated. Feedback shows how this method can be effective to implement throughout the worldwide smart SMEs development to support the strategic transition to Industry 4.0 era.

ID #78

An Empirical Study of Task-Specific Limitations of the Overview+Detail Technique for Interactive Time Series Analysis

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Abstract

Interactive visualisation and analysis of time series data is a critical part of many data-driven optimisation processes, particularly in Industry 4.0 and Smart Manufacturing. Time series visualisation enables data analysts or domain experts to visually identify problems such as missing values, sensor drift, precision degradation, or faulty data, before or after algorithmic analysis. A common technique to support the visual exploration of large time series is the overview+detail (O+D) technique. O+D provides both detail and context information by displaying a detailed view showing the actual data and a thumbnail overview for showing its context.
User studies have shown that users analyse and navigate data sets more efficently and effectively with than without O+D, but that this strongly depends on the task and the nature and amount of the data to be displayed.
We present results of a quantitative user study that was performed on Amazon Mechanical Turk with 95 participants to identify scenarios in which O+D could not effectively solve the challenge of visualising large time series. By this, we identify potential usability issues of O+D for typical time series analysis tasks and discuss their origins. For each of these usability issues, we also propose alternative interaction and visualisation designs or other strategies to maintain good usability, even for challenging task types and data densities.

ID #79

Evaluation of Information and Communication Technologies towards Industry 4.0

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Abstract

The development of Industry 4.0 generates an important effect on production systems, especially on levels of competitiveness and on the integration of value chains. The speed of this transformation takes various forms depending on the branches of industrial production, impacts on SMEs and large companies differently and, at the same time, deepens the development gap in the different regions of the global productive world.
In order to detect which are the central aspects of the fourth industrial revolution, this article introduces a model created by the authors, which allows the evaluation of the level of technological development that the manufacturing industry is adopting nowadays in Argentina.
From evaluating existing ICTs in the local industry, it is possible to detect the needs for product development, adoption and innovation and their integration in value chains.

ID #80

Prototyping Machine-Learning-Supported Lead Time Prediction Using AutoML

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Abstract

Many Small and Medium Enterprises in the domain of Make-To-Order- and Small-Series-Production struggle with accurately predicting lead times of highly customisable orders. This paper investigates an approach using AutoML integrated into existing enterprise systems in order to enable Lead Time Prediction based on Machine Learning models. This prediction is based on both order data from an ERP system as well as real-time factory state informed by an IIoT platform. We used simulation data to feed the AutoML model generation and developed a lightweight web-based microservice around it to infer lead times of incoming orders during live production. Using industry standards, this microservice can be seamlessly integrated into existing system landscapes. The simplicity of AutoML systems allows for swift (re)training and benchmarking of models but potentially comes at the cost of overall lower model quality.

ID #81

IEC 61499 Device Management Model through the lenses of RMAS

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Abstract

The RMAS (relational-model multi-agent system) architecture has been proven promising towards the introduction of autonomic intelligence for industrial agents, and suitable for the enforcement of some parts of the reference model in the IEC 61499 standard, for distributed adaptive automation and control systems, namely the Resource model and the Function Block model. In this paper, the analysis is extended to the Device Management model. The RMAS is overlaid on the structures of this model in order to demonstrate that it can constitute factual and promising means for the expression of essential self-* capabilities of autonomic industrial agents. The analysis here conducted covers also some aspects of the XAI (explainable artificial intelligence), due to their relevance in industrial context. RMAS results a fundamental step for the factual introduction of AI in industrial playground, as a technology framework for the explainability, controllability, and quality of the intelligent automation solutions for industry.

ID #82

Smart Factory Security: A Case Study on a Modular Smart Manufacturing System

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Abstract

Smart manufacturing systems are an attractive target for cyber attacks, because they embed valuable data and critical equipment. Despite the market is driving towards integrated and interconnected factories, current smart manufacturing systems are still designed under the assumption that they will stay isolated from the corporate network and the outside world. This choice may result in an internal architecture with insufficient network and system compartmentalization. As a result, once an attacker has gained access, they have full control of the entire production plant because of the lack of network segmentation. With the goal of raising cybersecurity awareness, in this paper we describe a practical case study showing attack scenarios that we have validated on a real modular smart manufacturing system, and suggest practical security countermeasures. The testbed smart manufacturing system is part of the Industry 4.0 research laboratory hosted by Politecnico di Milano, and comprises seven assembly stations, each with their programmable logic controllers and human-computer interfaces, as well as an industrial robotic arm that performs pick-and-place tasks. On this testbed we show two indirect attacks to gain initial access, even under the best-case scenario of a system not directly connected to any public network. We conclude by showing two post-exploitation scenarios that an adversary can use to cause physical impact on the production, or keep persistent access to the plant. We are unaware of a similar security analysis performed within the premises of a research facility, following a scientific methodology, so we believe that this work can represent a good first step to inspire follow up research on the many verticals that we touch.

ID #83

Taxonomy of generative adversarial networks for digital immunity of Industry 4.0 systems

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Abstract

Industry 4.0 systems are extensively using artificial intelligence (AI) to enable smartness, automation and flexibility within variety of processes. Due to the importance of the systems, they are potential targets for attackers trying to take control over the critical processes. Attackers use various vulnerabilities of such systems including specific vulnerabilities of AI components. It is important to make sure that inappropriate adversarial content will not break the security walls and will not harm the decision logic of critical systems. We believe that the corresponding security toolset must be organized as a trainable self-protection mechanism similar to immunity. We found certain similarities between digital vs. biological immunity and we study the possibilities of Generative Adversarial Networks (GANs) to provide the basis for the digital immunity training. We suggest the taxonomy of GANs (including new architectures) suitable to simulate various aspects of the immunity for Industry 4.0 applications.

ID #84

A bibliometric analysis on collaborative robots in Logistics 4.0 environments

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Abstract

Logistics activities were included in the wave of changes brought with the advent of the fourth industrial revolution. Several applications can be recognized for several activities, aiming all at efficiently optimizing processes and consequently production and volumes. Among them, collaborative robots involved for instance in picking, palletizing or assembly operations are quickly spreading, as also demonstrated by the increase in the number of publications available in literature. In response, this paper presents the results of a bibliometric analysis carried out on 64 scientific papers which deal with this topic within the logistics field. Analysis were made through two different software applications, namely Microsoft Excel™ and VOSviewer. Results are quite optimistic as they delineate great opportunities for collaborative robots to establish their position in the industrial context.

ID #85

Clustering and classification of manufacturing enterprises regarding their industry 4.0 reshoring incentives

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Abstract

Due to drivers like Industry 4.0, reshoring recently receives more attention. In order to increase understanding, in this novel field of research, k-means clustering is performed to find groups of enterprises, which differ regarding their reshoring incentives. Based on these clusters, manufacturing enterprises are classified by the combination of an intra variance analysis and prior knowledge. Therefore, an own enlarged sample, encompassing 94 German industrial enterprises with global sourcing and production activities is used. It is investigated that five clusters segment the sample optimally and that the importance of innovation as well as trust and sustainability are decisive for the classification of German manufacturing enterprises regarding their reshoring incentives. These findings contribute to the body of knowledge about reshoring incentives in terms of methodology and content, since unsupervised learning is used for the first time within that context and enables insight into previously unexplored structures of the reshoring phenomenon.

ID #86

Capacity planning of a mixed-model assembly line for prefabricated housebuilding elements

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Abstract

This paper deals with new opportunities of Industry 4.0 applications for capacity planning on mixed-model assembly lines for industrialized housebuilding. We formulate a linear programming model for capacity planning on several parallel production lines and show how this model is fed with accurate data. The solution of the linear program in turn generates a detailed allocation of personnel and workload assignment for a given planning period. We discuss the planning approach and describe the implementation on a real world environment.

ID #87

Optimization of the Use of Biomass Residues in the Poplar Plywood Sector

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Abstract

This work of research deals with the optimization of the use of biomass residues within an enterprise working in the poplar plywood sector. Productive process analysis showed that biomass residues deriving from production represent more than 54% of the raw material, sensibly influencing production costs. The management of these production residues needs the definition of optimal strategies in order to increase system efficiency. Every residue is characterized by specific features that distinguish it from other scraps: chemical composition, moisture content, calorific value and price. These characteristics determine the next use of each residue: some of them are burnt to produce thermal energy, others are reused into the productive process and others can be sold in the market. The main objective of this study is represented by the definition of the optimal quantities of the biomass residues for the different purposes in order to maximize the enterprise profit and the definition of the implementation tool in order to apply operatively the defined models. In particular, the proposed tool permits a reduction of the production costs (i.e energy saving) and a consequent increasing of the profit of 15% with respect to the current production policy.

ID #88

Review and analysis of blockchain projects in supply chain management

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Abstract

Supply chains have become increasingly complex, making it difficult to ensure transparency throughout the whole supply chain. In this context, first approaches came up, adopting the immutable, decentralised, and secure characteristics of the blockchain technology to increase the transparency, security, authenticity, and auditability of assets in supply chains. This paper investigates recent publications combining the blockchain technology and supply chain management and classifies them regarding the complexity to be mapped on the blockchain. As a result, the increase of supply chain transparency is identified as the main objective of recent blockchain projects in supply chain management. Thereby, most of the recent publications deal with simple supply chains and products. The few approaches dealing with complex parts only map sub-areas of supply chains. Currently no example exists which has the aim of increasing the transparency of complex manufacturing supply chains, and which enables the mapping of complex assembly processes, an efficient auditability of all assets, and an implementation of dynamic adjustments.

ID #89

Beyond federated learning: On confidentiality-critical machine learning applications in industry

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Abstract

Federated machine learning frameworks, which take into account confidentiality of distributed data sources are of increasing interest in smart manufacturing. However, the scope of applicability of most such frameworks is restricted in industrial settings due to limitations in the assumptions on the data sources involved. In this work, first, we shed light on the nature of this arising gap between current federated learning and requirements in industrial settings. Our discussion aims at clarifying related notions in emerging sub-disciplines of machine learning, which are partially overlapping. Second, we envision a new confidentiality preserving approach for smart manufacturing applications based on the more general setting of transfer learning, and envision its implementation in a module-based platform.

ID #90

A survey study on Industry 4.0 readiness level of Italian small and medium enterprises

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Abstract

The Industry 4.0 (I4.0) paradigm is considered one of the most trending topics in the academic and industrial context, that involves emerging technologies that can make the processes increasingly integrated and provide digital solutions for supporting companies towards the greater flexibility required by the market. To date, the scientific literature strongly addressed the development of enabling technologies and the assessment of their impacts in different industrial contexts. However, there is a lack of studies providing empirical evidence about how manufacturing companies are facing the digital transformation, in particular for smaller industrial realities. For this reason, this paper aims to study the knowledge, readiness, and dissemination level of the I4.0 paradigm and enabling technologies for Italian Micro, Small, and Medium Enterprises (MSMEs). A web-based survey was conducted, and 77 companies were interviewed. The survey results underline that MSMEs still have limited knowledge about I4.0 and are not well prepared for its implementation.

ID #91

System simulation as decision support tool in ship design

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Abstract

Due to new regulations about emissions, ship design needs to face in these years the challenge of implementing new technologies on-board vessels. All these technologies cut in different ways SOx, NOx and CO2 emission and affect different ship's systems. Pollution reduction can be archived by implementing emission reduction systems, like scrubbers, or switching from traditional residual bulk fuels to different ones. To evaluate impact of each solution on-board, a system engineering approach must be applied since early-stage design. In this paper a simulation tool able to support ship design is presented. Thanks to a system simulation, different possible solutions for power generation are evaluated in three different cases, distinguishing specific weight factors for each evaluation criterion. Then, a rank of the different solutions is done in order to reflect the weight of the attributes in defining alternative layouts for the generation power plant.

ID #92

An adaptive machine learning methodology to determine manufacturing process parameters for each part

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Abstract

The identification of appropriate manufacturing process parameters typically relies on rule-based schemes, expertise, and domain knowledge of highly skilled workers. Usually, the parameter settings remain the same for each part in an individual production lot once an acceptable quality is reached. Each part, however, has slightly different properties and part-specific parameter settings have the opportunity to increase quality and reduce scrap. We propose a simple linear regression model to identify process parameters based on experimental data and extend that model with ideas from time series analysis to achieve highly-accurate, part-specific parameter settings in a real-world manufacturing use case. We show the usefulness of exploiting the (autocorrelated) structure of regression residuals to improve the predictive performance of regression models in manufacturing environments.

ID #93

DaQL 2.0: Measure Data Quality based on Entity Models

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Abstract

In order to make good decisions, the data used for decision-making needs to be of high quality. As the volume of data continually increases, ensuring high data quality is a big challenge nowadays and needs to be automated with tools. The goal of the Data Quality Library (DaQL) is to provide a tool to continuously ensure and measure data quality as proposed in [5]. In this paper, we present the current status of the development of the new DaQL version 2.0. The main contribution of DaQL 2.0 is the possibility to define data quality rules for complex data objects (called entities), which represent business objects. In contrast to existing tools, a user does not require detailed knowledge about the database schema that is observed.

ID #94

Parallel Metaheuristics for Shop Scheduling: enabling Industry 4.0

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Abstract

Production scheduling is one of the most critical activities in manufacturing. Under the context of Industry 4.0 paradigm, shop scheduling becomes even more complex. Metaheuristics present the potential to solve these harder problems but demand substantial computational power. The use of high-performance parallel architectures, present in cloud computing and edge computing, may support the develop of better metaheuristics, enabling Industry 4.0 with solution techniques to deal with their scheduling complexity. This study provides an overview of parallel metaheuristics for shop scheduling in recent literature. We reviewed 28 papers and classified them, according to parallel architectures, shop configuration, metaheuristics and optimization criteria. The results support that parallel metaheuristic have potential to tackle Industry 4.0 scheduling problems. However, it is essential to extend the research to the cloud and edge computing, flexible shop configurations, dynamic problems with multi-resource, and multi-objective optimization. Future studies should consider the use of real-world data instances.

ID #95

Thirty Years of Flexible Job-Shop Scheduling: A Bibliometric Study

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Abstract

Industry 4.0 introduced a new change in paradigms and technologies in the industry. In the shop schedule, it gains a holistic viewpoint and online demands, real-time and reactive methodologies. Developments in the scheduling area are critical to success. First addressed by Brucker and Schlie in 1990, the Flexible Job-Shop Scheduling Problem has been attracting researchers and practitioners over the last decades. This body of research may be helpful to address the industry high flexibility scheduling problems. This article uses a bibliometric approach to study three decades of research on this problem. The main results identify the most prolific research areas, journals, institutions, countries, and authors, and co-citation networks that revealed the most influential authors, as well as their most relevant works. A conceptual analysis based on keywords burst and occurrences helped to identify the latest research evolution and trends; allowing to recognize alignments and gaps within Industry 4.0.

ID #96

Integrated production-distribution scheduling with energy considerations for efficient food supply chains

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Abstract

Quantitative approaches for the integration of production and distribution planning are attracting the interest of scholars and companies in recent years. They can significantly improve supply chain performance and sustainability. In this paper, we propose an optimization model for the integrated scheduling of production and distribution activities, with reference to a real-life company in the food sector. The model takes into consideration changeover times and perishability, and aims to jointly minimize energy, storage and distribution costs. Its applicability is shown through a set of computational experiments, carried out on instances generated from historical data. Two different rescheduling strategies, where the first one reproduces the current behaviour of the firm, are compared. The results show that the current practices of the company can be improved, and the model is a valid tool for supporting operational business decisions.

ID #97

Conceptual Design of an Integrated Solution for Urban Logistics using Industry 4.0 principles

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Abstract

The paper proposes a conceptual model of an integrated solution for urban logistics and passenger flows to reduce the number of fossil combustion powered commercial vehicles traveling within city, solely for goods transportation, thus contributing to reduce negative effects of urban logistics activities, namely pollution, noise, traffic congestion and accidents. For this solution, a bus network is used to combine the cargo flow with the passenger flow within the cities. After a literature review, a user-centered approach supported by interviews with key stakeholders was followed to define the concept, followed by solution modelling using the Unified Modeling Language (UML) notation. Thus, the high-level requirements will be presented based on a use-cases diagram and the data model based on a class diagram. Also, the automatic order check-in and check-out process on the bus is designed, using Industry 4.0 and IoT principles. This process is relevant since it speeds up the handling of orders in transshipments, reduces the possibility of human error, while at the same time enhancing control and promoting real-time knowledge of the delivery status of orders. The results of this study expand the knowledge in an area with scarce literature. In practical terms this study presents valuable contributions, since it specifies a solution for urban logistics that can have environmental and social impact in the context of urban areas.

ID #98

A systems dynamics approach to SME digitalization

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Abstract

In the current global scenario Small and Medium Enterprises (SME's) contribute to the GDP of nations through employment opportunity, productivity and growth. The small and medium business space is a challenge to operate, more especially in these times of COVID-19. The world of digital delivers opportunities for optimization in order to survive these challenges. The South African situation runs parallel to these observations despite formidable support from stakeholders in creation of "Innovation hubs" and other mechanisms to ameliorate. This calls for a close investigation of smart business solution enabled digitally to address the needs of the enterprise and provide support. This article aims to explore System Dynamics (SD) modelling to provide strategic business support to small business. The research presents an approach to SME support comprising skills development and digitalization as applied through an innovation hub. The SD model is adopted to simulate the impact to an SME's development.

ID #99

Heuristic approaches for scheduling jobs and vehicles in a cyclic flexible manufacturing system

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Abstract

This paper addresses the scheduling of automated guided vehicles (AGVs) in a cyclic flexible flow shop environment. The vehicles travel along a single loop. All production machines are located alongside the track in the required order, with a possibility for multiple machines per stage. All AGVs are to be scheduled for a specific starting time and will then continuously circle the track. Pickup and delivery times are included in the travel time of a vehicle, stops are forbidden. Jobs may start upon arrival if their predecessor has been started for processing. Therefore, job completion times are dynamic. The considered objectives are the minimization of the number of AGVs and of the total makespan. For the regarded problem, different local search variants are proposed. Optimal results are produced using a brute force enumeration algorithm. Finally, fixed permutation schedules are compared to processing jobs according to a first-come-first-serve rule.

ID #100

Architecture for Data Acquisition in Research and Teaching Laboratories

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Abstract

In the recent years, several research activities focused on the design, development and deployment of software architectures addressed to the monitoring, management and control of industrial plants, since the ongoing digitalisation of manufacturing companies demanded guidelines and cutting-edge solutions to the research community. In this context, more and more research centres' laboratories have been hence asked to run in parallel different architectures, relying on different research activities, whose feeds consist of the same signals from the machine pool. When these laboratories belong to universities, the request for data from students and trainees is added to the request for data from research activities. this often results in a network congestion with severe implications on the data integrity. For this reason, the authors have designed and implemented an open modular software architecture able to minimise the requests to the machines and to embody Service Oriented Architecture functionalities. The architecture has been named SHIELD, indeed SHIELD Has Integrated Existing Laboratory Data.

ID #101

Stacking and transporting steel slabs using high-capacity vehicles

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Abstract

A crucial task of steel plant logistics is the transportation and intermediate storage of semi-finished casting products, so-called steel slabs. We consider a fleet that consists of high-capacity vehicles. The vehicles are used to transport steel slabs within the steel plant, i.e., between facilities and distinct areas of the slab yard, and they can carry out stacking operations autonomously. The slab yard stores a majority of all steel slabs. It is organized in rows that function as a two-dimensional stacking area. Each row consists of multiple stacks built up by steel slabs that are located on top of each other. Retrieving steel slabs from stacks amounts to solving an extended block relocation problem (BRP). We study a combined approach for solving both the routing of steels slabs within the plant and the stacking of steel slabs in storage as part of their retrieval during a vehicle's pickup operation.

ID #103

Prioritising requirements of informational short food supply chain platforms using a fuzzy approach

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Abstract

Short food supply chains emerged from initiatives for reducing distances and intermediaries in food supply chains, substantiated in part by a shift in consumer's perceptions on sustainability of global systems. Short food supply chains attract consumers due to the reduced distance to the origin of food. Informational platforms can help these types of supply chains achieve desirable network effect and add value for relevant stakeholders. This paper explores prioritisation of requirements for informational short food supply chains. It uses seventeen requirements selected by a panel of experts. Prioritisation is accomplished through a Fuzzy MoSCoW method. Results suggest that track and trace, real-time operations and supply chain related data exchange, and real-time supplier data exchange are must have/top ranked functional requirements for informational short food supply chains. Real-time sustainability related data exchange is categorised as should have and is likely to rank higher as short food supply chains increasingly embrace sustainability.

ID #104

Protecting Intellectual Property Rights of Industrial Software

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Abstract

The importance of software is increasing and software has become the main driver of innovation in many industrial products. The value of software is growing dramatically, which requires effective mechanisms to protect intellectual property rights (IPR). Current approaches are expensive by means of involved effort or run-time performance, or they not as secure as required. Recent research results show promising results in the area of precisely identifying hardware environments, software obfuscation, and prevention of disassembling and tampering. The vision of a secure, effective and easy to use software protection is the core driver for the research project DEPS. The vision is that industry can securely deliver software together with their hardware products without the risk of infringement of intellectual properties rights due to illegal copies, reverse engineering, and modification.

ID #105

Anonymization as homeomorphic data space transformation for privacy-preserving deep learning

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Abstract

Industry 4.0 is largely data-driven nowadays. Owners of the data, on the one hand, want to get added value from the data by using remote artificial intelligence tools as services, on the other hand, they concern on privacy of their data within external premises. Ideal solution for this challenge would be such anonymization of the data, which makes the data safe in remote servers and, at the same time, leaves the opportunity for the machine learning algorithms to capture useful patterns from the data. In this paper, we take the problem of supervised machine learning with deep feedforward neural nets and provide an anonymization algorithm (based on the homeomorphic data space transformation), which guarantees privacy of the data and allows neural networks to learn successfully. We made several experiments to show how much the performance of the trained neural nets will suffer from the deepening of the anonymization power.

ID #106

Human Aspects in Collaborative Order Picking – Letting Robotic Agents Learn About Human Discomfort

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Abstract

Human aspects in collaboration of humans and robots, as common in warehousing, are considered increasingly important objectives in operations management. This work aims to let robots learn about human discomfort in collaborative order picking of robotic mobile fulfillment systems. To this end, a multi-agent reinforcement (MARL) approach that considers human discomfort next to traditional performance objectives in the reward function of robotic agents is developed. As a first step, we assume a human-oriented assignment problem in which the robotic agents assign orders to human workers at order picking work stations. The results show that among the four evaluated assignment policies, only the proposed MARL policy effectively considers human discomfort. While the approach may need to be refined to obtain near-optimal solutions for the trade-off between humans aspects and efficiency objectives, it also shows a practicable pathway for related problems of human-robot collaboration, inside and outside of warehousing.

ID #107

Context-Aware Blockchain-Based Sustainable Supply Chain Visibility Management

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Abstract

Supply chain visibility allows a state of being able to see end to end in a supply chain. Sustainable supply chain visibility is premised on sharing of mutually benefiting information, to achieve associated sustainability objectives including those related to economic, environmental and social goals. Sustainable supply chains strive for distinctive visibility with its attendant benefits that include improving and strengthening the supply chain for competitive advantage. Advances in technology such as blockchain technology can help facilitate effective management of sustainable supply chain visibility and in delivering associated benefits. The relational characteristics of blockchain and sustainable supply chain visibility has recently been reported in the literature with some emphasis on the capacity, capability and context of sustainable supply chain visibility. This paper explores a notion of context-awareness and blockchain in relation to sustainable supply chain visibility. A landscape for an architecture of a blockchain-based sustainable supply chain visibility management platform centred on context-awareness is suggested. The main thrust of the considerations is provisioning of secure, auditable and mutually benefiting sustainable supply chain information sharing, for distinctive visibility, in heterogeneous context-aware scenarios whilst recognising the underlying characteristics of sustainable supply chain visibility.

ID #108

LiSC Model: an innovative paradigm for Liquid Supply Chain

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Abstract

Supply chain is studied all over the world by a number of researchers who propose description models, analyze quantitatively its efficiency and, more recently, create its digital twins. In the last years, according to some unpredictable events which upset the global economy, supply chain showed the capacity to change itself according to the new constraints but, also, the new opportunities raised. Classical models developed to describe supply chain are not powerful enough to model what today I4.0 pillars allow if we use open innovation as an extraordinary amplifier. Thus, the supply chain changes shape and connections. In this perspective, the paper propose and describe a new construct of supply chain called: Liquid Supply Chain (LiSC). It takes into account also the extraordinary effects of pandemic diffusion of Covid-19 virus and its influence on the companies. A critical comparison with other existing models is proposed and discussed.

ID #109

Drift Detection Analytics for IoT Sensors

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Abstract

The Industrial Internet of Things (IoT) has an unique opportunity to have a greater impact on the manufacturing sector. Monitoring the health of the expensive equipments in the factory is critical for the business and the opportunities where IoT can be truly transformational. Most often the industries operates on a primitive way of monitoring these equipments on a Statistical Process Control (SPC) Limits. The major flaw in this monitoring system is unable to detect drifts within the static limit and upon triggering of the limits, it is usually too late for the team in the manufacturing floor to take preventive actions before the system goes down. In this paper, we developed a generic model for detecting drifts and identifying potential outliers. The model uses a double linear regression method to identify both aggressive and progressive drift, as well as adjusted boxplot method to detect outliers in both symmetric and skewed distributions. Unlike conventional drift detection approaches, this model has low computational complexity and can be applied to both batch and stream data. This paper will also introduce the infrastructure and architecture on enabling near real-time analytics using the IoT platform and streaming cluster, which reduces the data latency available for analysis to 10 minutes. Enabling real-time monitoring allows the end users to react to the alarms in a timely manner. This system has proven that it is able to provide early detection before the impact was observed as compared to the existing system. Manufacturing operation team could establish a new business process to respond to the early drift alarms by using quality shift left approach.

ID #110

Digital divide, skills and perceptions on smart working in Italy: from necessity to opportunity

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Abstract

This is a pioneering study on how smart working could influence the way of working in Italy. The COVID19 pandemic is making workers discover opportunities that should have been seized 30 years ago. Once the emergency is over, the world and working methods will never be the same. The Coronavirus emergency has accelerated a reflection on smart working to govern the necessary changes in the organization of work also in the medium term. For this reason, the aim of the present research was to carry out a survey on smart working on the entire Italian national territory. Although the study is a pilot study, the survey results are encouraging giving the opportunity to reflect and define strategies. For this reason, is imaginable and desirable that further relevant national initiatives will be started during the year to investigate needs, define good practices on smart working and promote this "new" way to work.

ID #111

Temperature simulation and control for lab-scale convection dehydrators

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Abstract

We are in the age of Smart Industry or Industry 4.0. Its application is very important in situations that can be simulated and allow process control in university teaching lab practices. Therefore, this research is focused on the "Temperature simulation and control for lab-scale convection dehydrators" that can be used to dehydrate fruits and vegetables as a practical application. The research was carried out by the Informatics laboratory of the Agroindustrial Engineering professional school of the Universidad Nacional de Moquegua, using National Instruments' LabView software version 2016 to simulate and control the temperature within a lab-scale convection dehydrator. The programming block diagram was developed along with the front panel of the temperature and control simulation for a lab-scale fruit and vegetable dehydration chamber in which the heat generator could be turned on and off when the temperature was below or above the set point, while keeping the dehydrator in operation. The results expected were successfully achieved for the programming of the dehydration chamber's temperature simulation and control, as the heat generator operates at the temperature set point by turning the system on and off.

ID #112

Preliminary design of AR/SOFC cogeneration energy system using livestock waste

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Abstract

This paper reports on a sizing procedure for integrated Anaerobic Reactor/Solid Oxide Fuel Cell cogeneration energy system powered by livestock waste, in order to meet the provisions of Industry 4.0, connected to the new paradigm of Agriculture 4.0. The algorithm accounts on two main computational blocks, associated to the biogas production plant and to the SOFC energy unit respectively. A numerical modeling is performed to dimension the anaerobic digester and the biogas production deriving, as well as to dimension the energy unit and determine its techno-energy performance when it is fed by the previous biogas.
An application of the algorithm is made to a mid-size livestock farm, in order to valorize the biomass waste produced in situ.

ID #113

Recent Developments Towards Industry 4.0 Oriented Predictive Maintenance in Induction Motors

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Abstract

Predictive maintenance (PdM) for smart manufacturing and Industry 4.0 has been associated with manufacturing intelligence supported by Artificial Intelligence (AI). Therefore, PdM also relies on the smart manufacturing technologies including cyber-physical system (CPS) and big data analytics. The multi-agent system (MAS) technology and deep learning (DL) have shown the capacity to provide efficient tools for the implementation of PdM in a CPS enabled smart industrial production system gaining feedback from big data analytics. Induction motors (IM) constitute the main power source in the industrial production environment and therefore their maintenance and early fault detection and diagnosis (FD/D) is a critical process. Neural network (NN) based FD/D of IM has been widely used in order to identify different fault types. DL methods have recently emerged for FD/D of IM and can efficiently analyze massive data coming from different machine sensors. The MAS has recently been used in combination with artificial NNs as a decision support tool for FD/D of IM. This paper aims to provide a review of recent trends in PdM of IM focusing on MAS and DL based FD/D methods that have emerged in the last 5 years due to their potential to be implemented in a smart manufacturing system. A discussion of the presented methods is given in order to present the recent developments and trends and provide future directions for research.

ID #114

Microwave photonics approach as a novel smart fabrication technique of a radio communication jammers

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Abstract

A novel technique to fabricate a responsive radio communication jammer, the purpose of which is to suppress a radio signal with a detonation code as well as to interfere communication link due to Denial-of-Service effect is proposed and highlighted. The distinctive feature of our approach is to the process received radio signals, when instead of the operation of introducing noise interference into each radio channel exclusively used in existing multi-channel jammers, a common single-channel device with optoelectronic processor is exploited, which generates many replicas of received radio signal that critically degrade its signal-to-interference ratio so that the remote-controlled detonators of the explosive installed at the objects cannot be triggered. The results of our investigations to computer-aided design a response time performance of the proposed jammer using a co-simulation of specialized optoelectronic computer tool VPI Photonics Design Suite and a versatile Matlab software. The layout and results of proof-of-concept experiment that validate the simulation are presented and discussed.

ID #116

Smart operators: How Industry 4.0 is affecting the worker's performance in manufacturing contexts

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Abstract

The fourth industrial revolution is affecting the workforce at strategical, tactical, and operational levels and it is leading to the development of new careers with precise and specific skills and competence. The implementation of enabling technologies in the industrial context involves new types of interactions between operators and machines, interactions that transform the industrial workforce and have significant implications for the nature of the work. The incoming generation of Smart Operators 4.0 is characterised by intelligent and qualified operators who perform the work with the support of machines, interact with collaborative robots and advanced systems, use technologies such as wearable devices and augmented and virtual reality. The correct interaction between the workforce and the various enabling technologies of the 4.0 paradigm represents a crucial aspect of the success of the smart factory. However, this interaction is affected by the variability of human behaviour and its reliability, which can strongly influence the quality, safety, and productivity standards. For this reason, this paper aims to provide a clear and complete analysis of the different types of smart operators and the impact of 4.0 enabling technologies on the performance of operators, evaluating the stakeholders involved, the type of interaction, the changes required for operators in terms of added and removed work, and the new performance achieved by workers.

ID #118

Procedure model for the development and launch of intelligent assistance systems

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Abstract

The paper analyses the current state of knowledge on approaches for the practical implementation of machine learning based assistance systems for production planning and control.
A concept of a procedure model for application-oriented projects in the field of industrial series production is proposed. It focusses on order sequencing and machine allocation in a real time production environment. As part of an application-oriented research project, a use case is referenced. In this paper, a first conceptual approach is presented, using the example of an industrial production of printed circuit boards.
In the following steps, practical suitability is checked on the basis of the practical reference, conclusions are drawn and the methodology will be developed further. The aim is a generally valid procedure model for industrial series production.

ID #119

Open-source discrete-event simulation software for applications in production and logistics: An alternative to commercial tools?

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Abstract

Discrete-event simulation is an established method to support decision making for planning tasks in production and logistics. However, there are still many enterprises, especially smaller companies that do not use discrete-event simulation because of the high costs associated with buying and maintaining commercial simulation tools. The question is whether or not free discrete-event simulation software is an alternative to commercial tools for solving typical planning tasks in production and logistics. The paper analyzes the modeling process with the three free and open-source discrete-event simulation tools Salabim, JaamSim and CloudSim and compares them with the two standard commercial simulation packages Arena and Plant Simulation. JaamSim provides everything which is necessary to model typical planning tasks in production and logistics and proves as a real alternative to commercial discrete-event simulation tools.

ID #120

Dynamic online optimization in the context of smart manufacturing: an overview

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Abstract

Solving manufacturing optimization problems in the context of intelligent production involves the consideration of continuously changing events of the respective enterprise environment in real time. Smart solution methods are needed which are able to cope with such necessary reactions to uncertainty and dynamics. In general, this field of research belongs to the topic of dynamic optimization. However, investigating the relevant literature reveals the broad range of this research area. In addition to real time, i.e. online optimization it contains a large number of other (dynamic) sectors. After differentiating dynamic online optimization from other research domains of dynamic optimization, the aim of this work is (1) to show in which streams and problem fields it has already been investigated, and (2) which different approaches to categorize online optimization problems are known so far. As a result, an overview of the state of the art concerning the occurence and existing categorizations of online optimization problems in the context of smart manufacturing is given, demonstrating ambiguities in the language used and in the categorization efforts for this optimization problem and therefore motivating further research efforts on a comprehensive integration of the findings of different streams in this area.

ID #122

Developing an Artificial Intelligence Framework to Assess Shipbuilding and Repair Sub-Tier Supply Chains Risk

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Abstract

The defense shipbuilding and repair industry is a labor-intensive sector that can be characterized by low-product volumes and high investments in which a large number of shared resources, technology, suppliers, and processes asynchronously converge into large construction projects. It is mainly organized by the execution of a complex combination of sequential and overlapping stages. While entities engaged in this large-scale endeavor are often knowledgeable about their first-tier suppliers, they usually do not have insight into the lower tiers suppliers. A sizable part of any supply chain disruption is attributable to instabilities in sub-tier suppliers. This research note conceptually delineates a framework that considers the elicitation of the existing associations between suppliers and sub-tier suppliers. This framework, Shipbuilding Risk Supply Chain (Ship-RISC), offers a simulation framework to leverage real-time and data using an Industry 4.0 approach to generate descriptive and prescriptive analytics based on the execution of simulation models that support risk management assessment and decision-making.

ID #123

Explainability of AI-predictions based on psychological profiling

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Abstract

Using a local surrogate approach from explainable AI, a new prediction method for the performance of start-up companies based on psychological profiles is proposed. The method assumes the existence of an interpreted 'base model', the predictions of which are enhanced by an AI-model delivering corrections that improve the overall accuracy. The surrogate (proxi) models the difference between the original (labeled) data and the data with labels replaced by the AI-corrections. As this corresponds to comparing the AI-correction applied before the base model is used with the original utilisation of the base model, the approach is called Before and After prediction Parameter Comparison (BAPC). The change of the base model under application of the AI-correction yields an interpretation of it by means of 'effective' parameter changes. This is useful for the interpretation of 'subjective' psychological profiles (such as 'risk-affinity', 'open-mindedness', etc.) in terms of effective changes of 'objective' monetary firm data (such as 'revenue', 'price of product', or 'cost of development').

ID #124

The Sustainable Role of Human Factor in I4.0 scenarios

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Abstract

The ageing of working population is the byproduct of the global recognized trend of the general population ageing. The decline of elder human operators' capabilities is a main subject concerning industrial engineering and management in the ongoing 4th Industrial revolution and the introduced new technologies. In this paper, the concept of human factor sustainability inside manufacturing line is explored. It is discussing the theoretical fundamentals of a complexity based states loop to be tested inside 4.0 frame. This is pointing on advanced ICT technologies for ageing workforce management in manufacturing lines. The paper starts with a systematic literature review on the ageing workforce inside industries highlights the human capabilities deterioration, knowledge and experience management of ageing workers. The review is used as the key trace of the modified human factor sustainability concept including Physical, Behavioural, Mental and Psychosocial dimensions. Those are related with the age factor while discussing about traits and entropy based information probability. Furthermore, the proposed formula of Human Factor (HF) probability with a context based application is discussed. Finally, some conclusion remarks will be given, and the future agenda will be proposed based on the collaborative work scenarios.

ID #125

Statistical Process Control of assembly lines in a manufacturing plant: Process Capability assessment

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Abstract

Among the main strategies adopted by companies for enhancing their competitive advantage as well as for improving the internal efficiency is the quality management. Several tools can be involved when dealing with this issue; one of these is the Statistical Process Control, which includes the employment of statistical methods and metrics to monitor and control a process' quality. In this paper, indeed, two statistical metrics are involved for assessing the process capability of a filler machine produced by an Italian company operating in the food context. Specifically, two processes are inspected: the slewing ring-pinion backlash and the handling clamps height check, both showing excellent performances after having carried out the control and provided appropriate adjustments. Results are also compared with those obtained from the Six Sigma theory, another tool involved for quality controls which is in line with principles of lean manufacturing. Moreover, for the second process, a software was implemented for speeding up operations and achieving benefits in terms of time. The reliability of these analysis is confirmed by the application of the ANOVA Gage R&R tool, which allowed to assess the precision of the measurement system involved.

ID #126

Economic evaluation of automated guided vehicles usage in a food company

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Abstract

Nowadays, companies are more and more attracted and interested by the possibility of automating processes which can be easily carried out by devices or machines instead of employees, allowing saving in costs, higher productivity and flexibility. Among the most spread ways of automating processes, more precisely in this specific case the flow of materials, the Automated Guided Vehicles (AGVs) stand out. But the main question that everyone asks is the following: is it convenient or not? In this paper, the answer is provided for a company operating in the food context, which intends to automate the transport of raw ingredients from the kitchens where they are produced and prepared to the filling lines; to this end, an economic feasibility study is carried out, taking into account three different levels of automation for three different lines. Results from all the three scenarios demonstrate the convenience in terms of achievable revenues, saved hours and manpower, and will support the management in their operational decisions.

ID #127

Fuzzy Cognitive Map-Based Knowledge Representation of Hazardous Industrial Operations

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Abstract

Hazardous industrial operations are highly stochastic, still human-dependent, and risky. However, operators who work in such a tremendously dangerous environment must understand the complex interrelation between several factors contributing to safe and effective operations. Therefore, being able to predict the effects of their actions on provoking or mitigating possible accidents is crucial. This study aims to utilize fuzzy cognitive maps (FCM) to model the expert's reasoning about occupational health and safety (OHS) in confined space. This knowledge is therefore used by operators to build their mental models during hazardous operations. The developed FCM displays all the possible incidents of a confined space and links these incidents with all their causing and preventing factors. This approach facilitates training (especially the development of simulation-based training solutions leveraging on serious games and Virtual Reality) and allows operators to act proactively during the operation.

ID #128

Human factors, ergonomics and Industry 4.0 in the Oil&Gas industry: a bibliometric analysis

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Abstract

Over the last few years, the Human Factors and Ergonomics (HF/E) discipline has significantly benefited from new human-centric engineered digital solutions of the 4.0 industrial age. Technologies are creating new socio-technical interactions between human and machine that minimize the risk of design-induced human errors and have largely contributed to remarkable improvements in terms of process safety, productivity, quality, and workers' well-being. However, despite the Oil&Gas (O&G) sector is one of the most hazardous environments where human error can have severe consequences, Industry 4.0 aspects are still scarcely integrated with HF/E. This paper calls for a holistic understanding of the changing role and responsibilities of workers in the O&G industry and aims at investigating to what extent, what type of, and how academic publications in the O&G field integrate HF/E and Industry 4.0 in their research. Bibliometric analysis has been conducted to provide useful insights to researchers and practitioners and to assess the status quo. Our findings show that academic publications have mainly focused on simulation-based training to increase process safety whereas revealed the lack of specific studies on the application of cognitive solutions, such as Augmented Reality-enabled tools or Intelligent Fault Detection and Alarm Management solutions.