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Simulation for a Sustainable Future

Abstracts of the 11th EUROSIM Congress
on Modelling and Simulation
July 3 – 5, 2023, Amsterdam, The Netherlands

Editors
Miguel Mujica Mota, Alejandro Murrieta Mendoza, Paolo Scala

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Preface

This volume contains the abstracts version of papers presented at EUROSIM2023: 11th EUROSIM Congress in Amsterdam, The Netherlands held on July 3-5, 2023. Each submission was reviewed by at least by 3 Scientific committee members.

The EUROSIM Congress 2023, the 11th EUROSIM Congress, has been organized by DBSS, the Dutch Benelux Simulation Society, in Amsterdam, July 3-5, 2023. EUROSIM - www.eurosim2023.eu - the Federation of European Simulation Societies, provides a European forum for regional and national simulation societies to promote the advancement of modeling and simulation in industry, research, and development. Under the EUROSIM umbrella, EUROSIM Member Societies and co-operating societies and groups organize conferences, produce publications on modeling and simulation, work in standardizing or technical committees among other activities.

Simulation Notes Europe (SNE) is the official membership journal of EUROSIM.

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July the 3rd , 2023

Amsterdam, The Netherlands
Dr. Miguel Mujica Mota
Dr. Alejandro Murrieta Mendoza
Dr. Paolo Scala

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Emission-based Production and Inventory Control System: A stability-based analysis for system cost and service level

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Abstract. A discrete-time stability analysis is performed on an Emission-based Production and Inventory Control System (*EPICS*) to identify stability boundaries for control parameters. An initial simulation-based analysis is performed to determine short-term system performance on sustainability dimensions: service level (social measure) and system cost (economic measure) for stability boundaries of Production Inventory (*PI*) control parameters and Emission-control parameters. Negative Item Fill Rate (*IFR*) as an undesired state from order cancellation/return due to high Emission-control weightage results in high system costs. Further, as variability in the system increases, system performance for both cost and service level under higher Emission weightage is unaffected but for higher *PI* weightage system performance is significantly impacted.

Keywords: *EPICS, APIOBPCS, Perceived Emission Rate, Emission Permit, Average System Cost, Carbon Cost*

Architecture based on Cloud Services to boost cultural and heritage tourism in the department of Cesar, Colombia.

Paola Patricia, Ariza-Colpas[1,3], Marlon Alberto, Piñeres-Melo [2,3], Roberto-Cesar, Morales-Ortega[1,6] , Andres Felipe, Rodriguez-Bonilla[3] ,Shariq, But-Aziz[4], Leidys del Carmen Contreras Chinchilla[5], Maribel Romero Mestre[5] and Ronald Alexander Vacca Ascanio[5] and José Caicedo-Ortiz[1,3].

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Abstract. Cultural and heritage tourism is an important source of income for many regions around the world, including Colombia. However, it often faces a series of challenges that hinder its development and success. In the Cesar department of Colombia, the lack of updated information and effective management of tourism infrastructure have limited the potential of cultural and heritage tourism in the region. Tourists often do not have access to detailed information about places of interest, such as the history behind them and available activities. This makes travel planning difficult and reduces the quality of the tourist experience. To address these issues, the implementation of a cloud-based service architecture has been proposed to boost cultural and heritage tourism in the Cesar department. This architecture focuses on enhancing the tourist experience by providing updated and personalized information about tourist sites, allowing tour reservations, and facilitating the management of tourism infrastructure. The application called Enamorate del Cesar allows centralized and real-time management of tourist sites, which improves the quality of the tourist experience and reduces waiting times. Additionally, the architecture provides access to detailed and personalized information about tourist sites, which facilitates travel planning and improves tourist satisfaction.

Keywords: Tangible and intangible heritage, cultural heritage, economic reactivation, cultural tourism, experiential experiences, history, augmented reality.

Resilience Analysis of Large-scale Food Flow Networks with an Optimization-based N-1 Contingency Approach ⋆

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Abstract: Food supply systems are national critical infrastructures embedded in changing and uncertain environments. Hence, testing and evaluating them in their ability to meet food supply is key to reduce vulnerability to shortages. This paper presents an optimization approach to assess the resilience of nationwide food supply systems using the N-1 contingency criteria, which investigates whether the isolation of one region from the transport network destabilizes the food supply. To this end, we build a multi-regional multi-commodity large-scale model for food flow networks. Then, we implement a constraint optimization problem to find the management of food flows along the supply chain stages that minimize shortage, costs and penalties induced by the disruption for both the isolated and connected system. Lastly, resilience is quantified with established metrics. A numerical case study illustrates the proposed method, revealing which regions are critical to maintain the stability of the national food supply.

Keywords: Supply chain, food security, vulnerability, linear programming, resilience metrics

A survey-based system dynamics analysis of commercializing biomass supply chains in Iran

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Abstract. Iran has a wide capacity to utilize biomass for a wide range of applications. The current biomass supply chain in Iran is still in its early stages. This paper develops a framework to evaluate the potential of commercializing biomass supply chains in Iran. Accordingly, a thematic analysis approach has been implemented to examine the challenges and opportunities of biomass supply chains in Iran. Subsequently, a 5-point Likert Spectrum questionnaire form has been created to collect the responses from academic researchers and biomass-related practitioners. The responses have been analyzed using SPSS. Subsequently, a System Dynamics model is developed to examine the relationships between the most important codes. The findings reflect the most important challenges and opportunities of commercializing biomass supply chains in Iran and their dynamic relationships. This study was an attempt to enrich the current studies related to the biomass supply chain in Iran.

Keywords: Biomass, Commercializing, Thematic Analysis, System Dynamics.

"Would you like a bag?": An ABMS experiment to support investigations of social norms in plastic waste prevention

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Abstract.

Plastics assume a central role in hyper-consumer society and have been so essential to this process that some academics propose naming this period the Plasticene Era to emphasise their significance in altering the natural environment and social dynamics. Although treatment technologies exist, more is needed to deal with the rising demand for this material. Thus, it is essential to comprehend the mechanisms underpinning consumer behaviour in formulating policies centred on long-lasting behavioural change based on collective behaviours. The primary purpose of this study is to investigate the impact of social norms on plastic waste prevention behaviour using agent-based modelling and simulation (ABMS). ABMS is a promising tool for investigating mechanisms and testing interventions in large populations. The experimental methodology comprises three stages: (1) mapping the environmental motivation and difficulty of pro-environmental actions of an actual sample to support the implementation of the agents' decision-making; (2) conducting computational experiments to analyse how social norms may influence plastic waste prevention behaviour; and, (3) discussing the effects of these interventions on future plastic-related waste prevention policies. Testing and observing the behaviour dynamics in a virtual environment can be great allies for better planning pilot programmes, increasing the likelihood of achieving more satisfactory results and being less susceptible to adverse consequences, such as rebound effects.

Keywords: ABMS, waste prevention, single-use plastic, behavioural experiment

Modeling Dynamics of the Biogas Process Under Uncertainty: A Fuzzy Set Theory Approach

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Abstract. Global concern about climate change has led to a growing interest in exploring renewable energy sources, such as the biological conversion of biomass to methane in anaerobic environments. Anaerobic digestion model no. 1 (ADM1) is the most widely used platform for biogas process modelling. To describe the biochemical processes involved in anaerobic digestion, ADM1 employs a set of 35 differential equations. These equations can be solved simultaneously by knowing the appropriate initial values for the concentration variables. Biogas production has significant uncertainties in nature, as with many real-life applications, resulting in challenges in modelling and simulation. For instance, ADM1 is constructed on an ensemble of anaerobic biochemical reactions. Due to the possible variations and fluctuations in independent variables and parameters, the reaction rates cannot be calculated with absolute certainty. There are different approaches to classifying uncertainties in a system. The present paper proposes a mathematical framework to model biogas production's uncertainties. Among different approaches and tools describing the system's ambiguity, a possibilistic approach using fuzzy set theory has been employed. Based on the results, it is evident that the fuzzy model is able to capture and reflect the defined system uncertainties quite effectively. Using this mathematical tool, designers and decision-makers can gain a deeper understanding of the system.

Keywords: uncertainty modelling, anaerobic digestion, ADM1, fuzzy set theory

Validation of Data-Driven Reliability Models in Manufacturing - Work in Progress

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Abstract. Reliability modeling enables deriving reliability measurements and illustrating relevant fault-dependencies in manufacturing systems. Data-driven reliability modeling uses data generated in systems to either automate or at least support extraction of reliability models. To use these extracted models for decision support, we need to ensure models' validity. In this extended abstract, we discuss our initial approach for validating data-driven reliability models. The challenge with validating data-driven models lies in the fact that these models are continuously generated and updated, implying that we need a new or updated validation approach to enable an ongoing validation of these models. The upside is that the systems of interest generate large amounts of data, which can significantly support the quantitative validation processes. Additionally, we briefly address the implications that could result from our proposed approach.

Keywords: Data-Driven Reliability Assessment · Validation · Manufacturing Systems.

Surrogate Assisted Simulation-based Grey Wolf Optimization for energy-efficient Supply Chain Configuration

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Abstract. Due to the criticality of the increasing energy demand with a simultaneous decreasing availability of fossil energy sources and the current energy crisis, companies have to push the exploitation of energy saving potentials in their enterprises and especially in their supply chains. This paper introduces a simulation-based optimization approach based on the natural behavior of grey wolves and uses a surrogate model trained on an event-discrete simulation model of a real supply chain. The results are very promising as it outperforms classical genetic algorithms for similar use cases.

Keywords: Supply Chains, Sustainability, Meta-Heuristics, Simulation-based Optimization, Neural Networks, Surrogate Assisted Grey Wolf Optimization

Statistical Analysis of Aeronautical Parts Operating in Hazardous Conditions to Propose an Inventory Management. Case: Gulf of Mexico.

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Abstract. Maintenance is crucial in all industries, but its study becomes more relevant in areas where environmental characteristics play a role in the wear and tear of the equipment. In the case of hydrocarbon exploitation, the companies provide taxi services for their employees. The aircraft used are designed to operate in normal conditions. However, they are not exempt from operating in more demanding conditions, such as high concentrations of saltpeter and humidity in the environment, which is reflected in the wear of aircraft components. Therefore, the variations disrupt the current helicopter's maintenance plan by decreasing the expected lifespan of certain components. Hence, the importance of analyzing the lifespan in said conditions is to propose a maintenance and replenishment plan that helps reduce the associated no-service time and its associated cost.

As offshore oil extraction technology develops, the need to have a fast and efficient means of transportation independently on the hydrometeorological conditions in the drilling area became evident. In such a way that the arrival and departure of the facilities were safe, rotary wing aviation has become the perfect ally to transport personnel and cargo to the offshore platforms, and fight against spills or accidents. In Mexico's case, its economy is largely sustained by the exploitation of hydrocarbons and in the south of the country, the Cantarell exploitation site located in the Sonda de Campeche area is considered one of the 100 most important oil fields in the world contributing to 45% of Mexico's production. Being in this way the site with the largest number of air transport operations via helicopter in the country and one of the most important in the world. These transportation services are provided by a private company, with 10 aircraft available that fly an average of 5 hours per day, with this operation rhythm it has been found that it is common having aircraft out of service due to components that aren't reaching the expected lifetime and the main reason is the temperature and the saltpeter that characterizes the area, which has affected the supply chain strategy.

In the present work, a statistical analysis was performed to determine critical components and redesign the supply strategy to prevent aircraft out of service. The methodology used consists in defining the study object, which is the Main Rotor Blade (MRB) because of the replenishment costs and transportation and installation time, data collection of the flight hours until failure was recollected to develop the statistical analysis. The main faults were determined and through the goodness of fit tests, the probabilistic behavior model of the component lifespan was determined from the data of 200 MRB. As a result, the real failure rate, given by $\lambda=1/MTBF$, is $\lambda=1/2288=0.00043$ which is 77.12% less (2288 hours) than the expected lifetime estimated by the manufacturer (10,000 hours). Knowing this information and with the cumulative distribution function of the component the replenishment decisions are taken with a solid mathematical base, and we are able to determine when to start the replenishment process of a MRB. As future work, the use of this information as a basis, for a simulation development that considers the whole replenishment system to identify in which ways it is possible to optimize the replenishment strategy is proposed.

An Agent-Based Model for exploring behaviour change policies for improving waste separation at SMEs

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Abstract. Waste separation at companies is considered a priority to achieve a circular and sustainable society. This research explores behaviour change policies for separating the organic fraction of municipal solid waste (OFMSW) at Small and Medium Enterprises (SMEs), particularly in cities. At SMEs, co-workers are responsible for waste disposal. Therefore, their behavioural intention towards pro-environmental action plays a major role. In this study, we have used agent-based modelling and simulation to explore the waste behaviour of the actors in the system. The models were co-created in participatory workshops, surveys and interviews with stakeholders, domain experts and relevant actors. Additionally, we co-created and tested practical social and technical interventions with the model. We used the collaborative modelling method Lange reported to conceptualise, implement, test and validate the models. Five policies that affect waste separation behaviour were included in the model. The model and simulation results were cross-validated with the help of a literature study. The results were validated through experts and historical data to sketch a generalisable idea of networks with similar characteristics. These results indicate that combinations of behaviour profiles and certain policy interventions correlate with waste separation rates. In addition, individual waste separation policies are often limitedly capable of changing the behaviour in the system. The study also shows that the intention of co-workers concerning environmental behaviour can significantly impact waste separation rates. Future work will include the role of households, policies supporting separating multiple waste types, and the effect of waste separation on various R-strategies.

Keywords: Circular Economy, Waste management, Behaviour Change Policies, Value-Believe-Norm Theory, Agent-Based Modelling.

Evaluation of Government Incentive Policy on Industrial Waste Utilization by Agent-based Simulation of Industrial Symbiosis Network

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Abstract. With the increasing concern about the limitation of available resources, industry symbiosis (IS) has emerged as one of the mechanisms to achieve sustainable industrial ecology. However, the economic benefit is always the factory's primary consideration, few factories will consider implementing IS unless they see certain economic benefits. Governmental policies are the main factors to facilitate and stimulate IS development. Unfortunately, how governmental policy actions influence the development of IS is not completely clear. This article investigates the government subsidy policy and proposes an agent-based simulation study to investigate the relationship between this kind of policy and the industry symbiosis practice from the government's perspective. We found the expected results, which is that the subsidy policy can positively influence the emergence of the IS relationships which will eventually reduce the waste disposal to the landfill, beneficial to the environment. Moreover, from the simulation experiments, we also find that when incentives reach a certain level, they no longer work. Even if the value of the subsidy is increased, the amount of waste utilization will not increase anymore. We think that our research can serve as a reference for the policymakers who are interested in creating incentive policies to stimulate the IS practice and achieve more sustainable industrial development.

Keywords: agent-based simulation, industrial symbiosis, government incentive policy.

Simulation model to the online course advising

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Abstract. The processes involved in online teaching have been inherited from traditional face-to-face courses, in almost every case we transfer the face-to-face to the virtual without making an analysis about how the things work in virtuality. In this paper we propose a simulation model for the course taught process, and from the model we will review a point that we assume to be definitive: the quantity of hours that an advisor dedicates to grading a course. Even the size of the student's group assigned to an advisor is defined by administrative policy but not necessarily by the needs of the training program, which one can be different according to the project's aim. In this paper we are going to model the course online process to the case of study, with this model will identify if the workload advisor is optimal or not.

Keywords: simulation, optimization, teaching analytics, e-learning analytics.

Exploring the Use of Urban Consolidation Centers for Efficient Last-Mile Delivery Using Agent Based Modelling and Simulation

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Abstract. With the rise of e-commerce and door-to-door sales, last-mile deliveries are gaining more and more importance. As a result, last-mile distribution has become one of the most sensitive logistics processes due to its uniqueness, difficulties in meeting schedules, and high costs. Therefore, this work explores the use of urban consolidation centers to ease these last-mile difficulties. Experiments are based in different hub-based fleets (traditional internal combustion vehicles or electric cargo bikes), demand patterns, and delivery frequency strategies by means of a biased randomization vehicle routing optimization heuristic. Results quantify the effect of having an urban consolidation center and highlight the use of electric cargo bikes for the last-mile distribution.

Keywords: Last-Mile Distribution · Logistics · Simulation · Optimization · Heuristics.

An AI-Enabled Simulation: Applying Neural Network in a Flexible Flow Shop Problem

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Abstract. Simulation modeling is integral to the successful implementation of Digital Twin. As Digital Twin models become increasingly sophisticated, it is crucial to enhance the capabilities of simulation modeling by incorporating AI-enabled techniques. By leveraging the power of AI, such as deep learning and artificial neural networks, simulation modeling can be enhanced to provide more accurate and efficient predictions. This paper applies a neural network model within a simulation environment to facilitate decision-making in an assembly line setting. After training, the intelligent data-driven neural network model selects the server in real-time for each job. The Simio Neural Network tool is utilized to collect data, train the neural network model, and conduct experiments. According to the experimental results, the trained neural network model outperforms the baseline model solution.

Keywords: TwinAI · AI-enabled Digital Twin · Simio Neural Networks

Application of augmented reality in the Plaza Simón Bolivar in Manaure, department of Cesar Colombia, as a strengthening of tourism and culture.

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Abstract. Currently, one of the sectors most affected by the pandemic effect is the tourism sector, especially cultural tourism. The municipality of Manaure, located in the department of Cesar in the northeast of Colombia, has been characterized for having a high potential of the historical and cultural heritage of the department. However, there is a strong weakness concerning the dissemination, use, and appropriation of technology to support the processes of attracting and retaining local and foreign tourists. That is why the application "Enamorate del Cesar" has been developed as an application that combines the inclusion of augmented reality, applying the concept of time capsules and gamification to strengthen cultural tourism in both locals and foreigners. In the specific case of this department, the popular Plaza de Simón Bolívar in the municipality of Manaure has been taken as the epicenter for the use of new technologies applied to the tourism sector. To measure the impact of this application, which is the first one developed for the department of Cesar in Colombia, validation instruments have been designed to validate the use of the application with the community, which has resulted in progress in the processes of appropriation and improvement of the visibility of the cultural heritage. The objective of this article is to show the characteristics of the application and the impact it has generated in the processes of social appropriation of knowledge and post-pandemic economic dynamization.

Optimizing Portfolio Selection Strategy for Purchasing and Supply in Healthcare Considering Circular Economy Principles - Case: Isolation Gowns ⋆

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Abstract: The Procurement and Supply of hospital isolation gowns (IGs) pose significant challenges, including the potential for sudden increases in demand, the necessity of maintaining high-quality gowns, and the complexity of the supply process. One potential solution to these challenges is the investment in reusable IGs, which may seem financially infeasible due to their initial purchasing price. However, it can provide long-term financial and environmental benefits. In this research, a Simulation Optimization (SO) framework is utilized to model and analyze various product portfolio selection strategies, considering both financial and environmental perspectives, and to determine the optimal strategy for meeting both financial and environmental objectives. The proposed strategy is implemented to the problem based on obtained Life Cycle Assessment and market data.

Keywords: Purchasing and Supply Management (PSM), Healthcare, Isolation Gown, Simulation, Optimization, Circular Economy (CE).

Design of robust business processes using multimodel approach

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Abstract. Nowadays, for companies, enterprises or firms to remain competitive and efficient, the business processes used in their activities must be reliable resistant to risk. The problem of creating such businessprocesses remains relevant. Software system is proposed, which involves the use of methodsand tools of DSM (Domain Specific Modeling), ontological approach, methods of simulation modeling, mathematical schemes (mass service theory, Petri nets) to build a reliable business process. In addition, an ontological approach is proposed for the verification and validation of simulation models derived from thetransformations. As an example, the business process of passenger identification is considered. To conduct a simulation experiment the system of simulation modeling ANYLOGIC is used, to perform model transformations - the software tool METALANGUAGE. The validation of simulation models is proposed by determining their semantic proximity and the ontologicalapproach is used for this purpose.

Keywords: Multimodel approach, Reliable business process, Business process risks, Simulation, Domain-based modeling, Queuing systems, Petri nets, Ontologies, Verification, Validation.

Permutation Entropy as a Conceptual Model to Analyse Brain Activity in Sleep

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Abstract. Sleep stage classification is a widely discussed topic, due to its importance in the diagnosis of sleep disorders, e.g. insomnia. Analysis of the brain activity during sleep is necessary to gain further insight into the processing that occurs in our brains. We want to use permutation entropy as a model for this analysis. Therefore, the signal processing in terms of electroencephalography is described. This results in a time discrete signal, that can be further processed by applying the method of permutation entropy, which is a modification of the Shannon entropy as a measure of information processing. The method is applied to 18 data sets, nine electroencephalography measurements of patients suffering from insomnia and nine of people without a sleep disorder. A strong correlation between the permutation entropy value and the sleep stages was found during the simulation runs. The results are analysed and presented using boxplot diagrams of the permutation entropy over the sleep stages. Furthermore, it is investigated that there is a steady decrease in the value when the patient is in a deeper sleep. This suggests that the method is a good parameter for sleep stage classification. Finally, we propose an extension of the conceptual model to other pathological conditions and also to the analysis of brain activity during surgery.

Keywords: permutation entropy · sleep stage classification · EEG monitoring.

Simulation-Optimization of Job Shop Scheduling using Reinforcement Learning

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1 Abstract

Dispatching rules fundamentally dictate the performance of a job-shop problem. Heuristic approaches to solving Job Shop Scheduling(JSS) assumes JSS as a static environment and fails to incorporate the dynamic changes taking place in real-time. Such changes caused by in-coming jobs often alters the characteristics of an entire job queue, making static solution approaches unable to meet the real life requirements. In this study, we structured the JSS problem as a sequential decision-making process wherein a Reinforcement Learning (RL) agent outputs the policy of dispatching rule by adapting to the dynamic nature of incoming jobs. We modeled and tested an on-line dispatching rule framework that contains a Job shop simulator and a Deep Q-Learning Network(DQN) RL agent. A single machine environment was simulated to investigate the application of DQN for a multi-objective job shop scheduling problem. Three practical objectives including, total tardiness, total make-span, and percentage of jobs completed in time were evaluated. The experimental analysis indicates that the dispatching rule produced by RL agent achieves considerable gains when benchmarked with traditional heuristic approaches. The findings from this research are expected to be the basis for further investigations into applying reinforcement learning to more complex job shop environments in the future.

The use of simulation throughout the lifecycle of advanced software algorithms – a case study

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Abstract. Software development is a complex process. It is often faced with various challenges such as complexity, integration, scalability, reliability, and security. To address these issues, a stepwise approach is developed making use of dynamic simulation models in the development lifecycle from initial prototyping, implementation, testing, to operation. Such stepwise approach from rapid prototyping to testing control algorithms in a simulation environment to testing the entire system against a virtual environment ("digital twin") enables control over the development and insight in the expected behaviors as early in the process as possible. This paper, using a real case study in a container terminal, demonstrates the benefits of enabling such control and insight by using simulation being the essential key to a successful development and implementation of software. However, it should be acknowledged that such approach making use of simulation is still not a solution to everything. Drawbacks and limitations of its use in both prototyping and testing phases have been also observed from our experience. Examples of such drawbacks and limitation include the representation of simulation conditions vs. reality, happy-day operation vs. exception handling, unpredictable use cases, etc. This paper also presents these findings from our real case study experience and the lessons learnt that could be possibly utilized to mitigate and overcome (part of) these issues.

Keywords: Software, Simulation, Emulation, Digital twin

Supervised machine learning for input modelling of an agent-based simulation model for autonomous on-demand shuttle services

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Abstract. The quality of simulation-based experimentation is directly related to the estimation of its key input parameters. Yet, especially when it comes to innovative transportation concepts that are characterized by a multiplicity of influencing factors, such as autonomous on-demand transport systems, reliable and realistic input parameters are difficult to obtain. In order to tackle this challenge, we propose an automated machine learning integration to estimate contextualized parameters for an agent-based simulation model. To demonstrate the effectiveness of the proposed approach, a test scenario is conducted on the estimation of mobility patterns for an agent-based simulation model of autonomous on-demand shuttle operations. Here, the results of several simulation experiments prove the viability of the proposed input modelling approach, showing that an automated machine learning integration can generate more accurate estimations of input parameters in innovative, highly uncertain systems in an efficient manner.

Keywords: Automated Machine Learning, Computer Simulation, Agent-based Modelling, Autonomous On-demand Transport, Supervised Learning

WATER MANAGEMENT IMPROVEMENTS TYHORUGH THROUGH STRATEGIC ENGINEERING COMBINING SIMULATION & GENETIC ALGORITHMS

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Abstract. Water distribution networks are a vital part of critical infrastructure that provides communities with fresh water. However, these networks often experience water losses resulting from issues such as leaks, breaks, and other network defects. These losses, commonly known as non-revenue water (NRW), have a considerable impact on water availability and affordability for consumers.

To address this problem, this study proposes a Strategic Engineering approach that incorporates modeling and simulation, artificial intelligence (AI), and data analytics. This approach utilizes data obtained from the field in a closed-loop system to identify and address water spills in simulated water distribution networks. Specifically, a Genetic Algorithm engine is devoted to identify the most promising hypotheses matching real measures to detect water losses and evaluate most promising fixings while the simulation is used to calculate the expected measurements corresponding to adopted hypotheses on losses network.

The final goal of this research is to provide an innovative solution for water management to be applied in real-world water distribution networks to enhance their efficiency and reduce water waste. By leveraging cutting-edge AI and data analytics techniques, this study aims to contribute to sustainable water resource management and promote a more sustainable future.

Keywords: Simulation, Artificial Intelligence, Water Distribution Network, Leakage Detection

A Causal STAM Model to Increase Airspace Network Capacity

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Abstract. ATM digitalization paves the way for new efficient solutions that overcomes present inefficiencies caused by spatial fragmented airspace. Lack of airspace capacity is an important factor that impacts on a sustainable and efficient air transport system with aggravated indicators in future growing demand scenarios. Despite research on new ATM digitalized services to improve airspace capacity, the mitigation of latent capacity by enhancing synergies among adjacent sectors has not been addressed yet. In this paper, spatio-temporal sector interdependencies are analyzed to quantify the topological interdependencies and evaluate the increment of capacity that can be achieved in those sectors that cannot fit the dynamic demand requirements. A sector network model has been implemented formalizing the ATC sectors as network nodes, and traffic flows at different levels of granularity as time-stamp perishable edges. The dynamic evolution of the occupancy in adjacent sectors together with the inverse correlation between saturated sectors, paves de way for a Short Term ATM Mechanism to improve the capacity invulnerability at sector level while at the same time provides a mechanism to improve the airspace capacity at network level.

Keywords: Demand-Capacity Balance, sector occupancy, early handover, STAM.

A Monte Carlo Simulation Methodology for Uncertainty Analysis in Product Recall Management

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Abstract. Product recall campaigns are performed when defective or unsafe products are in the market or another supply chain stage. Product recall manage-ment is an uncertain issue for estimating the operations or processes that cause product failure. It is necessary to use quality engineering techniques and tools for analyzing uncertainty in product recall management. Therefore, we propose a Monte Carlo Simulation for Uncertainty Analysis in Product Recall (MCS-UAPR) methodology to improve decision-making in product recall management. It was applied in a company in the automotive sector and made it possible to identify the operations with the highest impact on the total unit recall cost.

Keywords: Automotive industry, Product recall management, Monte Carlo Sim-ulation applications, Quality costs, Quality engineering.

Applying Simulation System to Compare the Use of Electric and Diesel Truck Fleets

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Abstract. Computer simulation is one of the methods for investigation of processes in transport systems. Due to the emergence of electric vehicles, new tasks related to the charging stations placement can be solved with its help. This task became especially relevant when electric goods vehicles appeared on the transportation market. The paper devoted on the development and application of a simulation model to analyse the process of regional transportation, which is carried out using electric and diesel trucks of similar carrying capacity. The model was created using the TraPodSim simulation system, recently developed by the authors of this paper. The core of the TraPodSim system is a universal multi-agent model implemented using the AnyLogic package. The model presented in the paper uses the real geography of the transport network and the real technical parameters of electric and diesel trucks.

Keywords: Cargo Transportation, Electric Trucks, Multi-agent Simulation, Indicators.

Contributions of Process Mining and Simulation to the Process Management Lifecycle using the Example of Healthcare Case Studies

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Abstract. Process mining and simulation show considerable benefits taken for themselves. Process mining aims at building a process model to describe the behavior contained in event logs of information systems and is concerned with the past and the present, whereas simulation is concerned with future scenarios. A synergetic effect can be derived from combining these two approaches to conduct qualified Process Management. This paper contains a structuring analysis of relevant literature on process mining and simulation. As a large number of studies found was from the healthcare domain the focus was set on healthcare applications. The results are mapped to the (Business) Process Management Lifecycle by discovering patterns in the topic categories addressed by the different studies. The main takeaway is the comparison of application fields of process mining and simulation between healthcare and non-healthcare studies. These results can be used to develop case study designs dealing with core issues in healthcare management systems and processes to obtain more transparency and a more reliable basis for decision-making.

Keywords: Workflows, Healthcare, Process Models, Conformance

Simulation applied to a consulting team assignment problem

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Abstract. There are intermediary entities that improve the administration of human resources, adapting agents' profiles with companies' requests. This paper presents a university social service program that requires student teams to give consultancies to companies' groups but has a desertion problem derived from an assignment with long distances and incompatibility between schedules and requirements. We use process-oriented simulation to analyze some proposed methodologies and variants of the classic assignment problem as possible solutions while uncovering the need for a flexible method that enables continuous modification and maintains easy user data management. We define our human resources case with multiple attributes (distance, requirements, and schedules) as a multi-criteria assignment model with quadratic (QAP) and qualified semi-assignment characteristics. To solve it, we use a tessellation to facilitate the inclusion and reduction of distances between agents and tasks while evaluating the qualified association of the requirement and schedules as categorical variables. We integrate a modular method based on hexagonal tessellation, reducing the dedicated time from 5 days to 90 minutes and a total distance of 585 km between students and companies while improving the schedules and requirements compatibility, solving the real problem in its context. We hope this will contribute to other assignment problems with a similar structure or goals.

Keywords: Assignment Problem, Hexagonal Tessellation, Multi-criteria assignment.

Network Effects from Local Performance Improvements in Europe's Air Transport System

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Abstract. The European aviation system is a key enabler in guaranteeing economic welfare and is mandatory to ensure reliable mobility between large cities and metropolises. In 2014, aviation supported 8.8 million jobs in the European Union and contributed over €621 billion to European Union Gross Domestic Product, say 4.7%. A predicted traffic increase of 1.9% per year to reach 16.2 million flights by 2040, in combination with particularly saturated infrastructures, causes a significant challenge to maintain the system's functionality. This paper gives insights into the propagation of local performance improvements in the aviation network. Using a scenario with increased throughput at London Heathrow airport, changes in utilization and delay figures for the EUROCONTROL member state airspace are simulated using a macroscopic airport-airspace simulation model considering the 212 busiest European airports. The actual European airspace layout and equal-sized hexagon airspace portions are considered in this framework. Using a stochastic route generation model, flight trajectories are calculated, and a simulation of the air transportation network based on a flight plan containing over 35,000 flights is performed. The results indicate a significant impact on punctuality and throughput figures on a large part of the airspace in combination with a measurable traffic shift. A decrease in inbound delay can be observed for 2,252 flights (6.4% of the network traffic volume). 39% of them are taking off or landing at London Heathrow airport and benefit directly from the increase in performance. The remaining 61% can be assigned to propagation effects since these affect only flights indirectly impacted by the performance improvement.

Keywords: Air Traffic Network · Airspace Capacity Management · Airport Performance · Propagation Effects.

Towards Sustainable Manufacturing: Digital Twins for Enhanced Energy Efficiency

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The rapid growth in industrialization and the increasing demand for energy have brought about a critical need for energy efficiency in various industries. Adopting intelligent manufacturing techniques is imperative to optimize energy consumption and reduce environmental impacts caused by traditional manufacturing processes. Enhancing energy efficiency in manufacturing involves real-time monitoring, improved control mechanisms, modeling tools, and energy-efficient equipment. Two key fronts can be addressed to enhance energy efficiency in the industry: utilizing renewable energy sources for production and reducing energy consumption in manufacturing systems. Digital twins, serving as virtual replicas of assets or processes, offer a promising solution by enabling efficient monitoring and optimization in both areas. This comprehensive approach ensures enhanced energy efficiency in industrial settings.

Digital twins should enable real-time monitoring, data analysis, and simulation of manufacturing processes, providing valuable insights into energy consumption patterns and identifying areas for improvement. By integrating the principles of Industry 4.0 and Internet of Things (IoT) technologies, digital twins facilitate the implementation of advanced energy management strategies and enable proactive decision-making. This research explores the importance of energy efficiency in the manufacturing sector and highlights the potential benefits of employing digital twins in achieving energy optimization and also highlights the primary challenges associated with employing digital twins for energy-efficient manufacturing.

As a result, we propose a conceptual framework to address the challenges and complexities associated with implementing digital twins for energy efficiency in manufacturing. The framework includes the definition of objectives and metrics, data collection and integration from various sources, data validation, knowledge extraction, and model development and validation. Our framework utilizes well-established Key Performance Indicators (KPIs) for energy-related performance evaluation in manufacturing, offers visualization and simulation capabilities, and enables real-time feedback and control for optimizing energy usage and improving overall efficiency. Lastly, performance evaluation and reporting in digital twins for energy efficiency is proposed as a process that evaluates and measures the performance of digital twins in relation to energy efficiency, and then reports to stakeholders, providing valuable insights into energy efficiency performance and guiding decision-making for further enhancements.

Enhanced Hydrogen production from gasification of wood pellets in a fluidized bed reactor with air-steam as oxidizing medium

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Abstract. Syngas from the gasification of wastes and biomass can be utilized for a wide range of applications like power generation, producing biofuels, biomethane, and chemicals depending on the quality of the mixture gases. The product gas quality and yield significantly depend on the oxidizing medium.

This work aims to obtain the optimal parameters at which Hydrogen-rich syngas can be produced from an auto-thermal gasification of wood pellets using air steam as the gasifying medium in a bubbling fluidized bed gasifier. A three-dimensional Computational Particle Fluid Dynamics model of the gasifier was developed in Barracuda VR by considering the heat transfer model, chemical kinetics rate, and particle size distribution. To check the CPFD model robustness, the CPFD results were validated with the experimental data obtained from a 20kW gasifier. The reactor was simulated in two steps: (I) thermal flow simulations at different equivalence ratios and (II) thermal flow simulations at different steam-to-air ratios. The results depicted that at an equivalence ratio of 0.25 (with air as the gasifying medium), better-quality syngas with higher bed temperature and lower unconverted carbon in the bed was observed. The Hydrogen fraction in product gas was enhanced from 11 (vol.%) to > 21-26 (vol.%) with the addition of (1-5) wt.% steam to the inlet fluidizing gas. Above the steam-to-air ratio of 0.05, unreacted steam in the product gas increased. The unconverted carbon in the bed increased significantly with a decrease in reactor temperature by 300°C at the steam-to-air ratio of 0.2. The optimal equivalence ratio at which the reactor sustained auto-thermal operation with enhanced gas quality and lower unconverted carbon in the bed was 0.25, with an optimal steam-to-air ratio of 0.05.

Keywords: Gasification, Fluidized bed, Hydrogen, steam-to-air ratio, CPFD

Deep Neural Input-Filtered Gaussian Process Model

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Abstract. This paper presents a new model for addressing the error-in-variables problem in Gaussian process autoregressive models by combining a Gaussian process with a deep neural network. The Gaussian process autoregressive model is a simple and effective method for modeling dynamical systems due to its nonlinear, nonparametric, and Bayesian nature. The analytic solution for the marginal log-likelihood is obtained by considering the training input-output relationship to be static, with dynamics modeled through the inclusion of lagged observations in the input regressor. The limitation of this autoregressive method is that both the outputs and inputs are affected by noise. The simulation is obtained iteratively by propagating the Gaussian distribution through a nonlinear function. This results in a costly estimation of the simulated response with Monte Carlo integration. We propose an alternative approach in which a pre-filtering step is performed using a deep neural network to approximate the intractable recurrent filtering of the latent states. The proposed model improves the autoregressive approach while reducing the computational time of the simulation. The proposed model is validated on two case studies: a synthetic example and a real-world problem.

Keywords: Gaussian process models · Deep neural networks · Error-in-variables · Dynamical systems · Simulation.

Simulation-based Allocation and Routing Optimization: A Case Study of Single Versus Team Driving

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Abstract. Planning vehicle routes in supply chain management is a challenging problem since all demands need to be met at the minimum cost with various limitations on available resources. This study tries to find the optimal routes for multi-type vehicles based on information provided by a real-world supply chain dataset, which includes the delivery information of eleven vehicles with both single-type and team-type drivers. To achieve this, this paper also simulates routes and re-allocates delivery locations to different vehicles by the particle swarm optimization (PSO) algorithm and optimizes the routes within the newly allocated delivery locations. Experimental results show that this simulation-based approach improves the routes in terms of overall cost and distance for the deliveries in comparison with the original routes that have been operated. This study also evaluates the necessity of having additional drivers in a cost-effective manner. The optimal newly-assigned routes could help minimize the logistical costs of the company and efficiently manage its supply delivery network.

Keywords: Vehicle routing · supply chain management · particle swarm optimization · simulation-based allocation · meta-heuristics.

truck shuttle simulation between production plant and logistics centre: data acquisition and preparation

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Abstract. The present text reports on data acquisition and preparation in a simulation for evaluating a planned truck shuttle operation from a production facility to a logistics centre. Special aspects include the development of time intervals for the provision of finished goods that must be transported to the logistics centre by truck. Furthermore, the text describes how the travel time between the production facility and the logistics centre can be determined using various approaches. Finally, the results demonstrate the impacts that a more detailed consideration of the aforementioned aspects can have, particularly with regard to dynamic truck allocation and production planning.

Keywords: Data acquisition and preparation, Truck Shuttle Simulation, automatic loading systems

On the Relationship between Model Complexity and Decision Support in Agent-based Modeling and Simulation*

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Abstract. Agent-based models are often used to explore the potential consequences of different assumptions or scenarios and support decision-making in complex systems. One challenge in employing agent-based models for decision-making is identifying the appropriate level of detail and granularity of the models in relation to the decision-relevant questions. On the one hand, more detailed and granular models may provide more accurate and nuanced insights, but they may also be more challenging to interpret and may require more time and resources to run and analyze. On the other hand, simpler and more aggregated models may be easier to interpret and may be more efficient to run, but they may also sacrifice some accuracy and nuance in the process. In this paper, we explore the trade-offs between detailed and aggregated models and discuss the factors that influence the appropriate level of detail and granularity.

Keywords: Agent-based modeling and simulation · Model complexity · Decision making.

Inventory control in MSMEs using Monte Carlo Simulation

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Abstract. In this article, the optimal inventory levels for a beer retailer are determined by using the Economic Order Quantity (EOQ) model with the help of @Risk tools to generate a Monte Carlo simulation. In this sense, the product catalog was classified according to the ABC system for its analysis, the products with the highest rotation were selected, limiting them to the seven most sold beers; the estimated demand was determined through probabilistic models and the total inventory costs in order to establish the optimal level of orders, the safety inventory and the reorder points. For each product selected, a test was carried out with three inventory policies in order to choose the most efficient one according to its total costs and service level.
This model has the particularity of being able to be applied in companies that identify difficulties in inventory management and thus identify areas for improvement.

Keywords: Economic Quantity Order Model (EOQ), ABC System, Reorder Point, Demand, Costs, Monte Carlo Simulation Model.

Simulation analysis of flow patterns inside a cyclone bag separator at increasing clogging levels

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Abstract. Milling plants often employ pneumatic conveying systems that use air to transport grains and flour within the plant. Before the particulate-laden air can be released into the atmosphere, however, it must be purified to meet strict environmental regulations. Cyclones and bag filters are commonly adopted for this purpose.

In this study, CFD simulation was used to reproduce the functioning of a cy-clone separator equipped with a fabric bag filter. The digital model was used to simulate different clogging conditions of the fabric bags and evaluate their impact on the system functioning in terms of flow rate distribution and pressure drop. Based on the results of the simulations, additional sensor locations could be de-fined where the calculated velocities exhibited a clear trend as the clogging levels increased. In future research activities, additional sensors will be installed on the plant at the identified locations to validate the results obtained.

The results of the simulations performed allowed for gathering important in-sights for the optimization of the maintenance of the device. Indeed, in future research activities, the digital model developed aims to be implemented for pre-dictive maintenance purposes and the generation of a Digital Twin of the pilot plant.

Keywords: cyclone separator, fabric bag filter, CFD simulation, predictive maintenance

A new Simheuristics procedure for stochastic combinatorial optimization (extended abstract)

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Abstract. Ignoring uncertainty in combinatorial optimization leads to suboptimal decisions in practice. Nevertheless, the focus is often on deterministic combinatorial optimization problems, mainly because they are already challenging enough without stochasticity. To make it easier to address stochasticity in combinatorial optimization, Simheuristics have been developed that allow solving stochastic combinatorial optimization problems. We propose a new Simheuristic procedure that dynamically changes the optimization focus between a deterministic and stochastic perspective based upon a statistical model. By doing so, an adequate trade-off is made between exploration and exploitation of the solution space during the optimization. We numerically show that the new Simheuristic procedure solves real-life stochastic scheduling problems more efficiently than standard Simheuristics strategies.

Keywords: Simulation optimization · Simheuristics · Stochastic combinatorial optimization problems · Stochastic scheduling problems.

Enhancing Smart Manufacturing Systems: A Digital Twin Approach employing Simulation, Flexible Robots and Additive Manufacturing Technologies

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Abstract. A new generation of manufacturing systems is emerging through the adoption of new policies to overcome future crises highlighted by constant social, environmental, and economic concerns. The rise of so-called smart manufacturing is noticeable. However, new risks to humankind are being introduced, and, more than ever, science and technology are required to guarantee the future sustainability and resilience of our manufacturing systems. This research presents a Digital Twin approach resorting to simulation models with embedded intelligence to transform efficient manufacturing systems and react to complex and unpredictable circumstances. The methodology covers production scheduling incorporating flexible robots, internal logistics supervision contemplating planning and control of mobile robots, and capacity management. The method demonstrates the potential of integrating Additive Manufacturing technologies to quickly react to production needs. The developed strategy was enforced and assessed in an industrial experiment, exhibiting its robustness and promising application. The attained results were very encouraging, highlighting its potential extension to more complex industrial systems.

Keywords: Digital Twin, Smart Manufacturing, Discrete Event Simulation, Real-Time Decision-Making, Addictive Manufacturing

Modeling Social behavior on energy consumption – An agent-based with multivariate regression approach

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Abstract. On this project we developed a simulation model that functions as a support tool to understand the behavioral strategies that influence energy efficiency in buildings. With the model we intend to understand the relationship between activities, influence and energy consumption based on intervention factors that can be economic, social, or environmental. A survey was conducted with staff members and students at a university building to understand the demographics and the characteristics of individuals that would lead to changes in energy conservation behaviors.

What is novel about this approach is the fact that a multi-variate regression model was developed in Python to predict the behavior of any individual, based on all their specific characteristics, and this regression model was used in an agent-based simulation that would recalculate the predictor on energy consumption behaviors (stairs and lights utilization) based on changes in the ideas about climate change, diet and energy saving intentions a person might have, through social pressure, rewards, leadership influence, and peers behaviors.

The results show an important effect not only in the reduction of energy consumption, but also improving health through frequent stairs utilization.

Keywords: Social Behavior, Agent-Based Modeling, multi-variate regression

Augmented reality applied to the "Balneario Paso de la Danta" in Manaure Cesar, an interactive experience of ICT and cultural heritage.

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Abstract. This scientific article focuses on showcasing the technological novelty and the post-pandemic economic impact of implementing augmented reality at Paseo de la Danta, a tourist resort located in the Cesar department. The research was conducted through a case study, analyzing the use of augmented reality in tourism promotion and its effect on generating income at the resort. The results show that the implementation of this technology has allowed for an improvement in the tourist experience, increasing the influx of visitors and, consequently, the economic income generated. Furthermore, in the context of the pandemic, augmented reality becomes a safe alternative for tourism promotion and entertainment, allowing for the economic reactivation of the sector during crisis. In conclusion, this study highlights the importance of technology and innovation in the economic and tourism development of a region, and the need to continue exploring new tools to improve the competitiveness of tourism destinations.

Keywords: Augmented Reality, Digital Media, Balneario Paso de la Danta, cultural heritage.

Optimal Active Generator Torque Control Strategies for Tower Lateral Load Reduction in the IEA 15 MW Wind Turbine

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Abstract: The extension of wind turbines' lifetime by reducing fatigue loads is a topic of interest. The contribution of this work is focused on designing a controller that mitigates lateral tower vibrations in the full load region. The proposed strategy is based on Active Generator Torque Control (AGTC), which produces an extra component of the generator torque added to the rated torque. In addition, the AGTC control is combined with a Collective Pitch Control (CPC) scheme based on the NREL's Reference OpenSource Controller (ROSCO), whose main purpose is to reject wind speed perturbation maintaining the wind turbine speed at its nominal value. Some variants of this scheme are proposed including an optional filter and a derivative gain in the AGTC. The controller parameter tuning is formulated as an optimization problem that minimizes the Fatigue Damage Equivalent Load (DEL) index for tower lateral loads. The resolution is carried out through genetic algorithms, and the design is applied to the IEA 15 MW RWT wind turbine model developed by NREL using the OpenFAST software. The ROSCO controller is used as the baseline scheme, comparing its performance with the proposed AGTC+CPC schemes. According to the simulation results, all the proposed AGTC strategies reduce the DEL index more than 30% with respect to the baseline controller. This reduction can be increased up to 42% at the expense of higher oscillations in the generated power and torque signal.

Keywords: lateral tower vibration control; vibration load mitigation; IEA 15 MW wind turbine

Towards a hospital-wide simulation framework

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Abstract. In a hospital, there are many dependencies between different resources, processes and departments. When changes are made to one resource or in one department, it is often very difficult to estimate the consequences for the rest of the hospital and it is unclear how far they actually stretch. While there is a tendency towards more integrated planning in hospitals, analysing the effects and benefits, especially for the whole hospital, is often still not possible. The aim of our research project is to design and build a simulation for a complete hospital including all departments, processes, resources and care provision that allows for a hospital-wide analysis. In order to achieve that, we first derive a conceptual model as a basis for the implementation. By using a container-based approach, we allow the integration of various simulation models for different departments and their interactions. A simulation-wide event calendar and clock align the events and makes sure that the interaction between the individual sub-models is well-coordinated and stable.

Keywords: Hospital · Simulation Framework · Integrated Planning.

Simulating patient outmigration based on regional-level healthcare quality: an agent-based modeling approach

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Abstract. Health system is a complex adaptive system characterized by nonlinearity and emergent behavior. We focused on the regional-level *outmigration* of the South Korean health system, in which patients living in provincial areas travel to Seoul in the hopes of receiving better treatment. Agent-based modeling (ABM) was used to examine the mechanism of such phenomenon. We constructed a simulation model reflecting the dynamic interaction between individuals and the environment. We performed a stepwise approach of first understanding the mechanism with a simple model, and then performing hypothetical policy experiments by changing quality-related parameters. Simulations showed that outmigration is alleviated with increased feeling of reassurance towards the regional health system, decreased quality gap between provincial and capital hospitals, and the construction of new provincial hospitals. Such results have policy implications in ongoing debates on how to strengthen regional health systems in South Korea.
Keywords: Agent-based modeling, Health system, Healthcare quality

Sustainable Simulation-based Digital Twin: an Application Portfolio Management tool to Minimize Digital Waste and Maximize Useful Life

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Abstract. The use of software in industry has become increasingly relevant, although its impact from an environmental perspective is often underestimated because of its intangible nature. Therefore, the need to make technology more sustainable is becoming urgent. This paper investigates this question from a sustainable digital twin technology perspective and points out the importance of analyzing every source of digital waste of a simulation-based digital twin (SBDT). To this end, we adopt Application Portfolio Management (APM) principles, including control charts and TIME analysis, to ensure that the digital twin is always aligned with the real system. We discuss the importance of tracking over time the performance of each Digital Twin component that estimates the Remaining Useful Life in terms of value through an APM dashboard. A proof of concept of a Digital Twin Portfolio Management tool dashboard is developed for monitoring the value as well as the cost-benefit of every component of a SBDT of a smart brewing system.

Keywords: Simulation-based Digital twin, Application Portfolio Management, Sustainable Technology, Lean Digital Waste, Accreditation.

Learning Explanatory Coherence Models from Agent-Based Simulation Experiments

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Abstract. In Agent-based models of complex adaptive systems, macro-level behavior is not engineered but results from local interactions among agents. Due to the consequences of complex, distributed interactions among decentralized agents, the causal chain of cross-cutting processes that give rise to behavioral regularities is difficult to explain. To provide a context for the explainability of agent-based models, a systematic review of philosophical and cognitive models of causal explanation is provided. For illustration purposes, the theory of explanatory coherence is used as a computational framework for learning explanatory cognitive maps of increasingly refined and broadened model features. The framework offers a perspective that signifies strategies for learning coherence-driven explanatory models with implications for simulation model development environments.

Keywords: Modeling methodology · Explainable model · Agent-based simulation · Cognitive coherence · Causal explanation.

A multivariate approach to improve the estimation of seismic risk of concrete bridges

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Abstract. To improve the estimation of seismic risk in construction, it is necessary to reflect on the drawbacks offered by conventional analysis. Some examples in this regard are seen in cases of evaluating the seismic response of some prototype structures, such as tall buildings and bridges, where it is not guaranteed that the response is solely governed by the fundamental mode of vibration of the structure, and the interaction of ground motion in all three orthogonal directions. In these cases, a multivariate probabilistic study is justified with the consideration of a parameter vector. The objective of this work was to develop a multivariate formulation, using copula theory, to model the patterns of statistical dependence between the set of intensity measures of seismic motion and their relationship with the dynamic response of the bridge structure (bridge structural modeling). It is concluded, among other things, that the application of the multivariate formulation for the case of estimating the probability of exceeding a certain percentage of damage in some bridges resulted in a lower and more rational probability compared to the univariate approach.

Keywords: Bridge modeling, Copulas, Ground motion records, Seismic risk, Statistical dependence.

Analysis of Covid-19 Transmission Using Complex Networks

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Abstract. The global public health crisis caused by the SARS-CoV-2-19 (COVID-19) pandemic has highlighted the need for research into contagion complexity. This challenge necessitates the development and testing of various approaches to manage rapidly changing information with high impact. In this paper, we employ time series analysis and complex networks analysis to compare the evolution, spread, and containment of COVID-19 pandemics in eleven countries and globally. Our analysis enables us to observe the dynamics of spread and the impact of different strategies employed by each country in increasing and decreasing cases through complex network techniques. Additionally, we explore the transformation of data behavior over time as our understanding of the virus improves. Our findings provide important insights into the limitations of using statistical models and suggest that simulation of new cases of COVID-19 data can be modeled using complex networks. The complex network model provides a general description of contagion dynamics in the 11 countries and worldwide situation. This paper contributes by highlighting the limitations of using statistical models to infer and study early time series data and proposing the use of a complex network approach to study contagion dynamics.

Keywords: COVID-19, Visibility algorithm, Time series, Complex networks.

Investigation of syngas production potential from gasification of coffee wastes using a computational particle fluid dynamic simulation

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Abstract.
Thermal degradation of wastes for energy extraction is a viable option that can substitute for green energy demand. In general, thermo-chemical conversion methods are incineration, pyrolysis, combustion, and gasification. Among the thermochemical conversion processes, the gasifi-cation of solid wastes gives better gaseous products. The main combustible gas components from the gasification process are methane, hydrogen, and carbon monoxide which can be utilized for producing biofuels and chemicals or power generation.

In this work, syngas extraction potential from coffee wastes was studied using a Computational Particle Fluid Dynamic (CPFD) Simulation. A CPFD model was developed for a 20kW fluidized bed gasifier using numerical codes available in the commercial software Barracuda. The CPFD model robustness was validated by comparing the experimental data obtained from the gasification of coffee grounds. The gasification experiments were carried out in a bubbling fluidized bed gasifier where sand particles were used as the bed material and air as the fluidizing gas. The coffee ground pellets used in this work were prepared using a lab-scale pelletizing press machine. The CPFD model was used to predict the influence of different parameters (temperature, equivalence ratio, particle size) on the product gas compositions. The gas concentration of CH_4, CO, and H_2 decreased when ER changes from 0.15 to 0.3. As the temperature increases, for ER 0.15, the concentration of H_2 increases from 10% to 13% and CO_2 from 20% to 22%. In contrast, the concentration of CH_4 and carbon CO decreases.

Keywords: Waste, Gasification, CPFD, Simulation

Uncertainty Processing based on Nonlinear Scaling for the TCP-100 Solar Thermal Power Plant ⋆

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Abstract. This paper presents a plan based on Nonlinear Scaling for the processing of uncertainties in parabolic trough collector solar plants. The new TCP-100 research facility at Plataforma Solar de Almería (CIEMAT) is presented as the test rig where the experiments will be done. This new research facility replaced the 32 years old ACUREX facility with which so many advances in Automatic Control were reached by the research community. The method based on Nonlinear Scaling is presented, and a proposal for the experiments to perform discussed. Data-based analysis methodologies, which have been earlier applied for the Acurex collector field, are used for developing monotonously increasing scaling functions, which consist of two second order polynomials. The monotonous increase is ensured by limiting constraints. The data-based computation of the scaling functions is done by using equal-sized sub-blocks, i.e. the norm for several samples can be obtained as the norm for the norms of individual samples. Uncertainty processing combines fuzzy numbers and rule-based fuzzy set systems with nonlinear scaling functions. Fuzzy scaling functions are introduced if there are slightly different situations included in the analysis. The set of membership functions depends strongly on the shape of the scaling functions. The parameters are fuzzy in Level-2 fuzzy numbers and these additional parameters are not used in fitting. They are essential in keeping the response fuzzy as well. The preliminary simulation experiments in a limited set of subsystems will be extended before going to the test campaigns with the new facility.

Keywords: dynamic modelling, first principles, uncertainty processing, nonlinear scaling, fuzzy systems, solar PTC plants

Simulation of pointing error of a heliostat

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Abstract. Enhancing energy efficiency in buildings often relies on increasing levels of natural sunlight. Consequently, this study introduces a device designed to redirect solar radiation in a specific direction during daylight hours. The focus of this document is on simulating the pointing error of this solar tracker to assess its feasibility for construction and installation.
The prototype construction involved utilizing 3D printing and machining techniques for parts subjected to higher mechanical stresses. The pointing error simulation was performed using the Matlab environment, yielding a prototype model with an acceptable pointing error suitable for urban applications. Additionally, the model proved to be user-friendly and easy to handle and install.

Keywords: Heliostat; Matlab; simulation; natural lighting

Simulation-Optimisation-based decision support system for managing airport security resources

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Abstract. Airport access mode disruptions have a significant impact on passenger arrival flow. Such events can lead to a wave of late outbound passengers, that can congest airport facilities such as check-in counters or security systems. In this context, efficient handling of airport resources is crucial to ensure passengers' reliable door-to-door journeys and maintain a high airport Level-of Service. Through a simulation-optimisation-based decision support system, we investigate the relevance of a dynamic opening of fast security line facilities for delayed passengers. An optimisation model solved through simulated annealing is proposed to improve security resource handling at a tactical level. Airport's Level of Service is evaluated before and after optimisation through a microscopic passenger flow simulation model. The methodology is tested on a study case based on one of the terminal buildings of Mexico-City airport. Results indicate that using dedicated security lines for passengers in a hurry due to disruptions reduces the number of stranded passengers at the end of the day; out of the three scenarios evaluated the one that uses a dynamic management of resources provides the best results; however this task should be governed by a DSS that adapts to the particular case under study.

Keywords: Airport · Optimisation · Simulation · Disruption Management

The experience of implementation of augmented reality in the "Parque Adalinda Sierra", municipality of La Paz, Cesar, Colombia.

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Abstract. The implementation of augmented reality in the Parque Adalinda Sierra, located in the municipality of La Paz, Cesar, Colombia, has been an innovative project that has transformed the way visitors experience the park. Augmented reality is a technology that combines virtual elements with the real environment, allowing for interactive and enriching experiences for users. In Parque Adalinda Sierra, the implementation of this technology has been used to improve environmental education and the dissemination of the indigenous culture of the region. Through augmented reality, visitors can scan QR codes at different points in the park to access detailed information about the animal and plant species that inhabit the park, as well as about the culture and history of the indigenous peoples of the region. Additionally, augmented reality has been used to create interactive games for children and adults, in which participants can learn in a fun and practical way about the flora and fauna of the park. These games also promote environmental awareness and nature conservation. The implementation of augmented reality in Parque Adalinda Sierra has had a significant impact on tourism in the region, as it has attracted a greater number of visitors and improved their experience in the park. It has also improved environmental education and fostered respect for the nature and indigenous culture of the region. This implementation of augmented reality in Parque Adalinda Sierra has been an innovative and successful project that has improved environmental education, the dissemination of indigenous culture, and the visitor experience in the park. This

Use of simulation to determine the production capacity of plastics line in MSMEs

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Abstract. Currently, Industry 5.0 gave an unexpected turn to Production, since the new concept of "Technology as an aid and not as a threat" makes labor necessary for production to be efficient through current technologies, which makes an important resilience in production lines.

This document gives us a visibility of how to optimize production lines by means of simulation for future decision making in a MSMEs. In this case the main objective is to reduce line production capacity but maintaining process output. The simulation is about reduce from three to two machines process and supply the current demand.

The analysis based on structural, operational, and numerical data is the fundamental basis for the simulation analysis. We followed the Harrell-Ghosh-Bowden simulation procedure, which allows analyze, compile, and propose the solution of an event in a practical and straightforward way. In this paper we evaluate the decision scenarios proposed by the stakeholders in a production line of MSMEs, and we suggest the scenario with the best results using simulation tools to improve the operation.

The simulation process let improve the production line without affect the real operation process and it could apply on this small business case.

Keywords: discrete event simulation, line production, capacity, MSMEs

Backward-Oriented Decision and Planning Approaches in Production Scenarios: A Systematic Literature Review and Potential Solution Approach

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Abstract. Manufacturing processes are increasingly driven by new product needs, innovations, and cost efficiency. Planning Staff and decision makers face the challenge of achieving fixed production programs and subsequently individual orders in a certain quantity and within a certain period at a guaranteed completion date. A systematic approach to scheduling and tracking resource requirements is necessary to ensure efficient flow of manufactured products. Forward- and backward-oriented planning strategies are most used by manufacturers to meet their demands for existing orders. The current application of such approaches is very time and resource intensive due to the complexity and dimension of the decision and planning problems to be considered; it is difficult to react to short-term changes within the production program. To address this gap, this paper provides a systematic literature review of backward decision and planning approaches in production scenarios and presents a potential overarching solution approach of a simulation- and machine learning-based decision support combination for operational production planning.

Keywords: scheduling, backward scheduling, backward simulation, production scenarios, semiconductor manufacturing, data farming, machine learning.

A simulation framework to support maintenance management in the design of biomass supply chains

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Abstract. To design and deploy their supply chains (SC), companies must naturally take into account several strategic and tactical aspects. This work aims to provide a simulation-based framework to enhance this design process in the case of a biomass SC in Portugal. Biomass is, in fact, a quite valuable natural by-product that can be used for heating, for energy production, and even for the development of biomaterials. In real environments, there is a significant variability in the availability of forest residues, in the biomass demand, and in the operations productivity, particularly in the forest-to-bioenergy supply chain. This research proposes a simulation framework, developed in the FlexSim software, to support decision-making by combining plans generated by a resource allocation model with the simulation of multiple disruptions. Different scenarios have been designed to address uncertainty in the production capacity and in the performance of alternative maintenance policies for "chippers", a piece of critical and sensitive equipment in the process. The obtained preliminary results provide interesting management insights for the case study, with suggestions to improve the chain's effectiveness and robustness. A natural extension of this approach will be to use models combining simulation and optimisation with real-time replanning, as a way to configure and design more resilient supply chains. Further extensions of the approach to other sectors also seem rather promising.

Keywords: Discrete Event Simulation; Supply Chain Design and Management; Equipment Deterioration; Preventive Maintenance; Biomass Supply Chain.

Optimizing Electric Arc Furnace Operations through an Intuitive User Interface on Siemens MindSphere: A Decision Support System

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Abstract. This paper presents a novel decision support system specifically designed for electric arc furnace operators to improve the efficiency and effectiveness of their decision-making process. The system uses advanced mechanistic and data-driven models trained on historical data to simulate planned batches based on real-time data, providing operators with valuable information to help them make decisions about furnace settings. One of the main objectives of the system was to develop and implement a user-friendly graphical interface that uses the Siemens MindSphere cloud service for interactive management with the operator support system. With this interface, operators can easily analyze past batches and compare them with simulated batches, using different input data and melting parameter settings. By analyzing the simulation results and different melting scenarios, operators can identify optimal settings, resulting in improved process optimization and lower operating costs. Our decision support system is a powerful digital twin that enables electric arc furnace operators to make efficient and informed decisions, ultimately leading to more sustainable and cost-effective operations.

Keywords: user interface, decision support system, MindSphere, electric arc furnace, furnace settings, cloud service, process optimization, digital twin

Modeling of Logistics Networks with Labeled Property Graphs for Simulation in Digital Twins

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Abstract. Digital twins have gained increasing attention in research and practice. This includes the use in logistics networks, which are the parts of supply chains focusing on implementing flows of goods. Digital twins are the digital representation of physical objects and feature a wide array of data. The tasks of digital twins in the domain of logistics include simulation, optimization, and monitoring. To fulfill these tasks, data models are required as a base. Using a common data model for all tasks is a promising approach, but there is a lack of modeling rules and guidelines on how to create appropriate models. In this paper, a modeling framework is proposed and discussed to fill this gap for logistics networks. It is based on labeled property graphs, which are a special graph structure. Also, the proposed modeling framework is applied exemplarily on a real-world use case scenario in the domain of city logistics.

Keywords: Logistics Networks · Simulation · Digital Twins · Modeling · Labeled Property Graphs

Pilot Simulation for Public Passenger Transport Energy Consumption

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Abstract. The knowledge of the variables that impact energy consumption allows a better understanding of how to mitigate energy consumption and emissions production for public passenger transport.
The current operation of public passenger transport in a large city with unregulated types of public passenger transport like developing countries case, causes an increase in energy consumption and emissions generation. Therefore, this paper aims to propose a simulation that estimates energy consumption. Different spacing stops length configurations are used to compare the energy consumption estimates to acknowledge the impact. The performed simulation is an initial approach to how improvement measures impact energy consumption in public passenger transport, taking as a first measure stops establishment. The results indicate that stop spacings impact energy consumption, when there are non-established stops, meaning that the users take the buses where they want the consumption increases. However, after 500 meters of spacing, energy consumption does not vary significantly, therefore establishing stops considering a demand coverage approach is suitable.

Keywords: Public Passenger Transport, Energy Consumption, Simulation Spacing, Stops.

Combined Integration of Simulation and Machine Learning in a Design Methodology for Agile Production Networks

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Abstract. An agile production network enables companies to respond quickly and economically efficiently to expected and unexpected market changes. In this context, the complexity of designing agile production networks is a major challenge. This paper proposes the integration of simulation and machine learning (ML) in a mutual methodology to manage and understand the complexity in designing agile production networks. Accordingly, a brief introduction to the design of agile production networks and related works will be provided. Based on this, the authors explain the integration and functionalities of simulation and ML. The paper provides a basis for further developments and shows further potentials as part of a design methodology based on simulation and ML.

Keywords: agent-based modeling, reinforcement learning, complex networks.

Modelling passengers in air-rail multimodality

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Abstract. Air-rail mobility has the potential to play a significant role in addressing European mobility challenges such as emissions reduction and capacity shortages. Rail can complement the air network in different ways: enlarging airport catchment areas, supporting operations in case of disruption or replacing air links to obtain environmental benefits. There is, however, still a need to better understand the potential role of rail when substituting current air links both from a strategic and a tactical mobility perspective, particularly when passenger connections are considered. This was initially assessed, considering passengers' door-to-door itineraries, as part of the Modus project (H2020 - SESAR 2020) with an innovative approach towards data driven, integrated air-rail modelling. Further considerations, such as the evaluation of strategic and tactical multimodal solutions, will be explored in the MultiModX project (Horizon Europe - SESAR 3). This discussion paper presents the modelling challenges addressed in Modus and the approach defined for MultiModX to evaluate and model multimodal door-to-door solutions.

Keywords: Multimodal mobility · Integrated modelling · Air-rail networks · Passenger door-to-door transport.

A Methodology for Limit Cycle Detection in Simulation Models

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Abstract. The exploration of model behavior is often a necessary step to validate and generate information from them, and it permits modelers and users to identify critical parameters. This is even more crucial when simulation techniques, such as agent-based models, are employed. The paper contributes to the discipline by proposing a novel exploration methodology to detect parameter configurations that generate limit cycles. It differs from pre-existing methodologies since it automatically explores the parameter space with a strategy that, once detected, investigates all the neighboring space until the limit cycle region ends.

Keywords: Model exploration · Limit cycles · Simulation · Agent-based model.

Simulation-based learning in aviation management studies using SIMIO software

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Keywords: Aviation Studies, Simulation Based Learning, SIMIO, Aviation Management (AM), Action Research

1 Introduction

Aviation is a complex industry that encounters extraordinary situations, requires fast and efficient solutions to provide functionality, an acceptable level of service and safety. New innovative technologies in aviation are based on the extensive use of digital solutions, which in turn, require personnel with wide-scale digital skills. Today in aviation education are widely used various simulations, designed to mimic a real-world scenario. Simulation-based learning tools and strategies can be applied in designing structured learning experiences (Lateef, 2010), providing opportunities to practice skills and to implement different types of scaffolding to support effective learning (Chernikova et al., 2020). Although simulation-based learning techniques have been widely applied in the training of pilots, less attention has been paid to the use of simulations in air transportation management (AM) training.

SIMIO simulation software enables to visualize processes and provides a true object-based 3D modeling environment which allows the construction of a 3D model in a single step. It allows fast access to a massive library of freely available 3D symbols that can quickly and easily add realism to the models (Simio, 2021). This has led to the successful application of SIMIO in different disciplines, for example, in engineering, healthcare, aerospace, including in simulation based learning in aviation management (Dehghanimohammadabadi & Keyser, 2017; Duca & Attaianese, 2012).

During the current aviation studies, the students should acquire comprehensive knowledge and skills of how aviation's various components are interrelated and operating. However, there are lacking synthesized results on the role of different features of simulations and instructional support (scaffolding) with regard to effective support for learners (Chernikova et al, 2020). Previous studies about AM simulations have provided numerous possibilities for how to apply experimental controls and to test and validate new AM concepts (Blickensderfer & Liu 2005; Heesbeen, Hoekstra & Clari, 2003). AM simulations based on SIMIO software, allow to design of an authentic and expressive learning environment that simplifies the technical process and take into consideration the experience and previous knowledge of students.

Digital Twins for Operations and Supply Chain Management from Data Engineering Point of View ⋆

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Abstract:
Digital Twins (DTs) have emerged as a powerful technology that enables manufacturing companies to build virtual representations of physical systems or assets, allowing them to monitor, analyze, and optimize their Operations for Supply Chain Management (OSCM) systems. By leveraging the capabilities of data analytics, IoT sensors, and cloud computing, digital twins can help organizations gain insight into their manufacturing operations and supply chain networks, improve production efficiency, reduce downtime, and enhance overall customer satisfaction. Although the potential benefits of DTs are widely acknowledged, little attention has been paid to the examination of the Data Infrastructure (DI) of these tools, which is a critical aspect of their successful implementation. A systematic and comprehensive understanding of the data sources, data warehousing, data integration, and data analytics techniques used in OSCM-related DT applications is essential for realizing their full potential. Consequently, this article provides a high-level introduction to the main DI components of DT applied to OSCM.

Keywords: Digital Twin (DT), Data Infrastructure (DI), Operations, Supply Chain Management, Simulation, Web Application.

Medical Device Safety Notification Process Analysis Using Queuing Theory and Simulation

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Abstract. This paper presents the application of Queuing Theory and Simulation in a case study of a company dedicated to the manufacture of medical equipment for the health care sector, which has the need to execute the communication process to its customers with the intention of reducing the risk of incidents and thus improve the safety and performance of a medical device daily. The main objective is to demonstrate the benefits of analysis and the improvements that can be made in a system to increase its efficiency through these two tools. In addition, a system was selected in which data could be collected to perform the diagnosis, analysis and conclude with the proposal of actions to improve the service capacity of the system. Finally, simulations of different scenarios were carried out to confirm the operation of the system with the improvement proposals made.

Keywords: Queue, processes, mathematical and simulation model, medical device.

Error-Model Predictive Control of Wheeled Mobile Robots for Minimum-Time Trajectory Tracking *

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Abstract. In this paper, we propose an error-based four state kinematic model of a wheeled mobile robot with tricycle drive for trajectory tracking control. The trajectory tracking algorithm was developed for a discrete system and implemented using a model predictive control (MPC) approach. The objective function of the MPC is minimized with particle swarm optimization (PSO). The minimum-time trajectory used in the experiments satisfies velocity, acceleration, and jerk constraints, which we used to indirectly describe the dynamic properties of the wheeled mobile robot (WMR). Simulation results showed robust performance in the presence of various non-ideal conditions, such as measurement noise, delays, and constrained control velocities. Consequently, we were also able to apply the approaches from the simulations to a real robot platform to confirm the real-time applicability. Our proposed control algorithm and trajectory generation approach are well suited for automated guided vehicles (AGVs) used in logistics in industrial environments, where efficient operation depends on minimizing travel time.

Keywords: intelligent control · model predictive control · particle swarm optimization · trajectory-tracking · automated guided vehicles · jerk constraints

Identifying Flight Schedule Characteristics Increasing Pilots Absenteeism at an Airline Using a Data Mining and Simulation Approach

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Abstract. Sickness absenteeism among flight crews is a pervasive problem disruptive to operations and costly for the employer. According to literature, exposure to certain schedule attributes has been associated with adverse health issues. However, the relationship between schedule characteristics and sickness absenteeism remains unclear. Therefore, the aim of this study is to identify schedule characteristics increasing the odds of sickness absenteeism based on historical data. Here, data records for each flight crew member were obtained from a Dutch low-cost airline in the period between 1 January 2018 and 24 January 2020. Schedule characteristics with an adverse effect on both the circadian and/or social rhythm, as identified in literature, were extracted from the available data, and included in the model. Exploration on these potential harmful schedule attributes was done using two generalised additive models. After adjusting for the socio-demographic and work-related confounding variables, simulations revealed that employees exposed to night shifts, backward, and forward rotations over a thirty-day period were significantly more likely to report sick. Furthermore, employees who flew four sectors showed higher odds to call in sick compared to employees who flew two sectors. Based on the results, it is recommended to schedule either sufficient rest periods after exposure or limit the occurrence of the identified schedule attributes.

Keywords: Sickness, Absence, Flight Crew, Schedule, Model, Data.

Simulation, a tool to improve the medical equipment production line

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Abstract. Population growth affects human activities and increases the demand for healthcare goods and services. This results in companies seeking to serve customers better while maintaining quality, timeliness, and fair pricing. This paper presents a discrete event simulation exercise carried out by implementing a 6 steps methodology of our own to achieve greater efficiency in the production of orthopedic products and be able to meet sales commitments. For this, different preliminary activities were carried out, such as the identification of work areas, the process mapping, the recording of operational data linked to production and their analysis, the elaboration of an influence diagram and the development of the model for the simulation. Using simulation allowed us to identify factors of use in machinery and operators, bottlenecks, use of resources (raw material), among other aspects. Likewise, variations were made in the model to solve the problems encountered and prepare the final recommendations in order to achieve a better operation. The significance of implementing a related methodology and the advantages of using scientific knowledge to resolve issues are highlighted by this simulation exercise. The article's value is demonstrated using prescriptive simulation as an analytical tool for decision-making in small businesses.

Keywords: Simulation, orthopedic products, line production, bottlenecks.

SIMULATION OF DADAR STATION, MUMBAI

Analysis of Commuter Comfort in Interchange Stations

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Keywords: Commuter Comfort, Railway Simulation, Passenger Operations

EXTENDED ABSTRACT

The suburban railway system in Mumbai is a densely loaded and intensely utilized public transport system in India. The railway network has the highest density in the world and caters to 8.5 million commuters every day. The Dadar Station is the interchanging point for the Western and Central Lines of the Mumbai Suburban Railway. Being the junction for railway line interchange, the station experiences a surge of passengers, particularly during office hours. The trains often operate in overcapacity and long wait times lead to super dense railway platform leading to many accidents.

The comfort and safety of the passengers remain prime concern for the Ministry of Railways, India. The simulation research aims to provide insights on two performance metrics – capacity utilization of local trains and comfort level of passengers at the Dadar station. The results can provide literature for formulating safety policies (*extension of coaches in train and prevention of trespassing deaths at Dadar station*).

Anylogic Simulation Modeling Software is used to simulate the passenger movement during railway line interchange. The schematic diagram of Dadar Station is developed to capture eight railway line switches that passengers make between the Western and Central Lines. The passenger movement (boarding, un-boarding, and line interchanges) is simulated using the hourly arrival rates of passengers, arrival rates of the trains, and train capacity based on report by Ministry of Railways.

The simulation runs in Anylogic software generate the hourly queue data for all the boarding stations. The hourly arrival rates of trains and the queue length for particular hour indicates the capacity utilization of the local trains at Dadar Station. The simulation indicates overutilization of trains. The highest overcapacity was 21% (the train carrying 21% more load than safe), which indicated high discomfort level for passengers during the office hours (8:00 AM – 10:00 AM)[1].

[1] https://drive.google.com/drive/folders/1PlFP73l_DPl8U3hiZqubbre2ms5-wSRs

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Evolving Neuro-Fuzzy Design of Experiments: A Novel Approach of Nonlinear Process Identification*

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Abstract. This paper presents a novel model-oriented sequential online design of experiments for model identification. An evolving neuro-fuzzy model identification of nonlinear dynamical systems is combined with two approaches to experiment design. First, a sequential design based on the maximin space-filling criterion was used to select an input space with the least model coverage. Second, an optimal experiment design method was used to select the optimal input signal online near the operating point selected with the first step. The use of an evolving model allows online generation of a model-based optimal input signal for identification of nonlinear dynamical processes without the need for multiple iterations or an initial model. The method was validated on a multiple-input single-output theoretical model of a plate heat exchanger.

Keywords: Evolving neuro-fuzzy · Space-filling · Optimal design of experiments · Plate heat exchanger · Filtered recursive least squares

A method for efficient simulation of production lines through software-supported cooperation between production and simulation experts

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Abstract. Production simulations are associated with considerable effort, among other things due to the knowledge transfer between the domain expert and the simulation specialist. For small and medium-sized companies, this often represents an economic hurdle when using the simulation. This article presents a method for software-supported collaboration between the production expert and the simulation specialist, which leads to a significant reduction in effort. In this way, the advantages of the simulation can be used economically even with low optimization potential.

Keywords: production, DES, procedure model for a simulation study.

Exploring Plausible Futures for the Transition of Schiphol Airport to a Smart Autonomous Airside in 2050

Coco de Brouwer, Catya Zuniga and Wenjing Zhao

BrightSky, a Dutch aviation initiative, aims to enhance innovation and competitiveness through advancements in MRO, airport security, ground handling, and airport systems. The Smart Autonomous Airside work package focuses on transitioning to a fully autonomous airside by 2050, replacing vehicles with an interconnected fleet of emission-free vehicles and automating processes. Within this work package, multiple companies will collaborate, including Amsterdam University of Applied Sciences (AUAS), Royal Schiphol Group, KLM Ground Services, T-Hive, Vanderlande, and TNO.

This research aims to explore multiple plausible futures developing insight into a possible transition path from current operations to a new concept of operations for a fully autonomous airside in 2050. This transition path faces many challenges, from globalization to a different operational, management, and regulatory environment, due to the impact of new technologies on society and jobs, among others, and hence, must ensure that the opportunities that these trends present are foreseen. The transition needs to have strong cooperation between all actors envisaging a greener Smart autonomous airside, recognizing that the whole ecosystem must act together to identify the possible transition paths to 2050 together with the key indicators and milestones in 2024, 2030, and 2040. Scenario development is a valuable tool for generating qualitative depictions of potential futures, providing insights into uncertain futures and informing present-day choices. This research adopts the Horizons Foresight Method (HFM), derived from the generic approach proposed by Bishop et al. (2007), comprising seven phases and an additional validation phase. The process involves problem and assumption identification, scanning weak signals, system mapping, change driver identification, scenario construction, roadmap development, and research process validation. Back-casting is employed for roadmap creation by envisioning a desirable future and working backwards. The chosen drivers of change, autonomy and environment, have led to the development of two distinct scenarios.

Using HFM, diverse plausible scenarios based on the community perspective were identified. In the most desirable one, Schiphol's community has embarked on a transformative journey to become the most sustainable airport in the world, with a clear focus on achieving the commitment with the zero emissions in 2050. The stakeholders share a common goals and ambitions, they have a high level of collaboration promoting synergy and facilitating the rapid implementation of numerous innovation projects. The airside operations have undergone significant changes, combining autonomous technology on the equipment and alternative fuel sources of energy to optimize efficiency and environmental sustainability. The airport accommodates a solar and hydrogen farm to support clean operations on the airside such as the vehicles and equipment charging. Most of the transport operations on the airside are performed by autonomous electrical fleets of vehicles. The smart and autonomous technologies provide real-time insights into vehicle and its location streamlining the processes, improving safety and operational efficiency in Turnaround Aircraft Processes (TAP). All ground handling activities on the airside, including the transport of passenger and cargo are managed through a semi-centralized system allowing an integrated airport management, that has integrated both landside and airside operations management using advance support systems to assist the human operators. Although significant financial investments are required, but the well organizer and collaborative community has noticed that circular economy analysis and cost-emissions balances studies support long-term sustainability. Progressive regulations, collaboration, and digital infrastructure is present to contribute to maintain sustainable technological advances. To achieve this future, a detailed roadmap must be design identifying key milestones where still strategic actions might change, therefore, further research on the impact of the drivers will have on the future.

Nonlinear control of a helio-crane laboratory device

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Abstract. When designing control loops, we often encounter non-linear systems that have much more complex dynamics than linear systems. This means that with classical control algorithms we cannot guarantee that the control loop works sufficiently well over the entire operating range. Therefore, in this paper we focus on controlling a nonlinear dynamic system with more advanced nonlinear controllers. All experiments were performed on a helio-crane laboratory device. The device exhibits nonlinear operation and rather oscillatory behaviour and is therefore particularly well suited for testing developed nonlinear controllers. In this work we have developed and tested three controllers: PID controller with optimised parameters, fuzzy cloud-based predictive functional controller (FCPFC) and NARMA L2 controller. We first present the results for each controller, which we compare to determine the best type of controller for our nonlinear problem. The goal is not only to find the best controller in terms of efficiency, but we also consider the time required to develop the control solution. In this way, each of the controllers has its own advantages and disadvantages.

Keywords: Fuzzy predictive functional controller · Neural NARMA L2 controller · nonlinear control.

Process mining and agent-based simulation: A harmonious blend!

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Abstract. In this work, we explore the potential synergy between process mining and agent-based modeling and simulation (ABMS). ABMS is a powerful tool for analyzing complex socio-technical systems and has advanced data-driven capabilities. Process mining is an emerging discipline that combines data mining and process modeling to gain insights into process execution by analyzing event data. This includes process discovery, conformance checking, and process enhancement. Our research examines the role of process mining in the ABMS paradigm. We classify existing research, present related use cases, and suggest future research directions for utilizing process mining with ABMS. Our findings offer initial guidance for researchers and practitioners and highlight promising avenues for further investigation in this exciting area of research.

Keywords: Agent-based simulation · Agent-based modeling · Process mining.

Reward Calculation in Real-time Scheduling Based on Simulation and Q-learning

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Abstract. The precondition for reinforcement learning to solve real-time scheduling problems is that the defined reward function must guarantee that the objective of the scheduling is achieved while the cumulated reward is maximized in the algorithm. This requires that the reward function must directly derive from the objective. Since jobs are unknown in real-time scheduling, an overall objective is not able to know before the concerned time horizon ends. As a substitute, the whole horizon is divided into several small periods. A period-wide objective is calculated after each period. It is considered to be the collective reward of the decisions in the period. Then the collective reward is distributed to every decision in this period. The value function will be updated according to these individual rewards. Based on this idea, five methods are proposed to distribute the reward and evaluated by experiments in a single-machine model.

Keywords: Real-time Scheduling, Simulation, Q-learning, Collective Reward, Reward distribution

Evaluating logistical concepts with simulation: A case study of increasing freight train length at ports

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Abstract. The European freight rail network will have to handle increasing volumes largely due to a shift from road to rail to reach the sustainability goals defined in the European Green Deal. Efforts are being undertaken to define and evaluate measures that will allow an already busy network to handle more volumes. One of the promising measures is the usage of longer freight trains going up to 740 metres. Increased length of trains means more cargo per service, but also means new challenges. Although this measure seems straightforward, the devil sits in the details, most notably operational details. In this paper, we present our investigations into the operational details of freight trains handling at one of the important endpoints of the network, the Port of Rotterdam. In order to account for details, we have developed a micro-simulation that incorporates the operational processes of freight train handling. Using this model, we have compared scenarios using various compositions of trains, among which a scenario with a high level of long trains. In the experiments, we have considered each individual siding and shunting yard of the port to have insights into the operations. While longer trains can help in handling more volumes, it will also create more additional congestion at shunting yards that needs to be considered.

Keywords: discrete event simulation, rail freight, case study, logistical concepts

Impact of power and CO_2 emissions on parking sustainability: comparative analysis between automated and traditional systems

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Abstract. Advances in technology and automation are bringing forward vast opportunities for reduction in cost and increase in efficiency in many areas. For example, using autonomous parking systems that rely less on manpower are becoming more popular. However, where some problems are solved, others unfold. This study employs simulations to compare the power consumption and CO_2 emissions between an automated parking system and a traditional one, where both gasoline cars and electrical cars are considered. Results showed that with both types of cars the traditional model uses less energy than the automated model. A performed sensitivity analysis showed that for the automated parking to be more energy efficient, 26% less power should be used by the cars' elevators and 32% by the cars' platforms for the case of gasoline cars. These percentages increase to 43.7% and 55.9% respectively for the case of electrical cars. Different factors combinations for the reduction of CO_2 emission in the automated parking are also presented at the end of the study. The main contribution of the study is a better understanding of the needed efforts to reach an acceptable sustainability level for new automated parking systems.

Keywords: power consumption, C02 emission automated, parking system.

U-space strategic deconflicting service impact on Very Low Level airspace capacity

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Abstract. European airspace is about to change accommodating a new type of unmanned traffic that will impact the transport of people and goods. Unmanned Aerial Vehicle traffic will offer a new level of services, but it is not clear how safety and operators' time flexibility while planning a flight will impact capacity. This work characterizes how the airspace structure, strategic conflict resolution U-space service, and required time of actions between operators and future airspace managers will limit the capacity of the future Very Low Level airspace.

Keywords: U-space, capacity, UAV traffic simulator.

Closed-loop workload input-output control of production systems: A hybrid simulation study

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Abstract. Workload Control (WLC) is a method of adjusting the overall workload in the production system by controlling the input of production orders and the output of produced items. It contributes to the predictability of lead times and more accurate delivery date commitments in make-to-order manufacturing. Input control relates to order release and output control to capacity adjustment. Recently, a novel approach to simultaneous and integrated input-output control has been proposed: a dynamic closed-loop model where automatic feedback control is added and where order release and capacity decisions are based on the observed shop floor state. The control was applied to an abstracted continuous dynamic model of a shop with unidirectional flow and three control rules were tested in scenarios with unbalanced work in process (WIP) and demand fluctuations. In this paper, the approach was further investigated in a more realistic hybrid simulation setting, combining discrete-time controllers and a discrete-event model of a manufacturing shop. The results show that simultaneous input-output control is effective and enables the system to maintain WIP balance, absorb demand fluctuations and effectively reject disturbances, especially when global information is provided to the controller.

Keywords: Production · Workload control · Closed-loop control systems · Industry 4.0 · Simulation.

Automating Digital Twin Creation for Humancentric Manufacturing Systems

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In today's industrial landscape, manufacturing systems face challenges that have significant implications for productivity, efficiency, and overall performance. The growing complexity of these systems and the need for optimization, efficient resource allocation, and adaptability demand innovative approaches. One solution that has gained prominence are digital twins (DTs), which are virtual replicas of physical manufacturing systems that can address the challenges faced by modern manufacturing systems. DTs enable methods like predictive maintenance and simulation-based optimization. Consequently, companies have a strong motivation to develop DTs for their manufacturing systems.

Our research focuses on an especially challenging case, i.e., humancentric manufacturing systems. These involve the active human participation, often driven by intrinsic motivation rather than strictly adhering to predefined protocols. This poses additional challenges in automating the creation of their DTs. On one hand, human behaviors introduce specific uncertainties, which must be appropriately considered in the model; not only are production cycles never identical, but factors like motivation, well-being, and energy levels constantly fluctuate. On the other hand, the processes of collecting data become more complex as human workers require additional hardware, such as wearables, to effectively gather relevant data. Consequently, there currently may be a significant imbalance in the data, with sparse representation for the human-related steps and abundant data available for the machine-related ones. In addition, the collection of worker-related data may lead to privacy concerns that will need to be addressed as well.

Due to the aforementioned challenges, most DTs for humancentric manufacturing systems are currently created manually, which is a labor-intensive and time-consuming process. Moreover, the need to adapt production based on economic factors and derived goals leads to continuously adjusting the underlying models, significantly increasing maintenance costs. However, many companies possess large amounts of machine-related manufacturing data that can be leveraged to automate model extraction processes. Process mining is one such technique that automatically extracts underlying process flows in manufacturing systems from their event logs. Extracted process flows form the basis for the machine-related part of the DTs. To complete DTs, the human-related processes need to be integrated. This integration starts by defining the goals of the human-related portion of DTs and subsequently identifying or adjusting the relevant performance metrics. Our goal is to develop a general framework and methodology that links these performance metrics to data streams to enable data-driven DTs for humancentric manufacturing systems.

Estimating Wind and Emission Parameters in an atmospheric transport model*

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Abstract. The present study proposes a novel data assimilation (DA) approach for estimating emission and wind direction parameters in an advection-diffusion model. This experiment aims to improve the prediction of a chemical transport model over long distances by updating the emission operator in the model using DA techniques. As a first step, we want to test the technique in a small-scale scenario. A low-dimensional advection-diffusion model was utilized to evaluate the effectiveness of the proposed approach under various sampling observation numbers. This sequential DA techniques exploit the ensemble of multiple model realizations to reduce uncertainty in the state and parameter representation. The model's emission and wind parameters are perturbed as a source of uncertainty. The parameters are sequentially estimated with the adjoint-free Ensemble Kalman filter with an augmented state vector. An associated stream function with a divergence-free condition controls the wind fields, and the estimation of this stream function through the assimilation process allows corrections of the wind fields without violating physical laws. The technique's performance was compared against validation observations such as the Root-Mean Square (RMS), and it was found that the number of assimilated observations had a significant impact on the parameter estimations results. In conclusion, this study demonstrates the potential of the proposed DA approach for improving the prediction of transport in the advection-diffusion model through parameter estimation.

Keywords: Air Quality modeling · Parameter estimation problem · Chemical Transport Model · 2D advection-difussion model · Data Assimilation · divergence-free · LOTOS-EUROS · Ensemble Kalman filter information · atmospheric transport model

Online Appointment Scheduling of Patients in a Resource Constrained Facility

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Abstract. An online scheduling problem for a scanning facility in a hospital is described. The facility operates in a resource constrained and high-demand scenario in which machine idleness is undesirable. Other practical constraints dictate that several patients are scheduled in fixed time slots. The objective is to balance the competing goals of minimizing patient waiting time and negligible idle time of the machine. Based on the data available from the facility, patients are divided into three types, and two different policies are proposed for scheduling: one fills all slots one by one, while the other uses the best-fit variant of online bin-packing. To account for variability in the scan times, some slots are overbooked. The proposed appointment policies are simulated and compared. Simulations are based on data received from the MRI department of a cancer-care hospital. The second policy trades off between lesser waiting time for patients and machine idleness.

Keywords: Healthcare · Patient scheduling · Discrete event simulation.

Technology-supported Teaching of Modeling and Simulation in Inverted Classroom Format

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Abstract.
Modeling and simulation is an interdisciplinary field requiring several competences. Due to this interdisciplinary nature and diverse set of skills that it imposes, teaching modeling and simulation in a university setting poses specific challenges. To confront this issue and contribute to the ongoing discussion on alternative methods of teaching, this paper proposes an inverted classroom approach, combined with a digital training system, as a means of teaching modeling and simulation. The proposed approach aims to address this challenge of teaching multiple aspects in the right quantity and pace for all participating students. The paper presents a teaching concept for a lecture and exercise on modeling and simulation and evaluates the effectiveness of different tools in various settings of the course from the lecturer's perspective. The importance of appropriate technology integration and an engaging learning environment as the means of supporting the students in independent studies is also discussed.

Keywords: Innovative Education, Inverted Classroom, Flipped Classroom, Individual Feedback, Automatic Assessment.

Identification of Hybrid Systems by Fuzzy C-regression Clustering*

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Abstract. This paper presents a method for the identification of a hybrid system. It is based on fuzzy C-regression clustering. A unique feature of this approach is that it uses hyperplanes as cluster prototypes in the input space while sharing the parameters of the antecedent and consequent parts. The number of design parameters of the proposed identification algorithm is small, making the technique easy to implement and tune. The proposed approach is illustrated by three simulated examples.

Keywords: Hybrid systems · Identification · Fuzzy C-regression clustering

Application of Digital Twin Simulation in Deploying AGV/ARV System to Hi-Tech Industry

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Abstract. The application of Automated Guided vehicles (AGVs) in manufacturing environments has become globally popular to enhance process automation. A current trend is that AGVs have become more prominent and the advancement in its technologies places the solution at top of the industry with its sustainability in many complex application environments. For every single portable stage, no matter what their application is, there is an extraordinary interest to model the system in a simulation environment. Various use of simulation tools analyses the routing, scheduling and allocation of models. The application of predictive simulations related to intra-logistics in assembly systems additionally projects a significant role, which pertains to the establishment of the operation of AGVs too. In this paper a non – human intervention approach is discussed wherein AGV/ARV (Automated Robotic vehicles) are used in Surface Mount Technology (SMT)line to replace the traditional operator-based material handling. It deploys optimized utilization with high performance of AGV/ARV with a new dispatching approach. The analysis for increased future production volume of the system is provided.

Keywords: Automated Guided vehicles (AGVs), ARV (Automated Robotic vehicles), dispatching, simulation

Analysing the sensitivity of pedestrian behaviour using a pedestrian simulation model

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Abstract. Simulation models capable of capturing the behaviour of pedestrians realistically can aid in controlling large crowds. Such pedestrian simulation models are increasingly being used as a tool to assess crowd management practices. This paper proposes to test commonly occurring situations using the proposed pedestrian simulation model when people are constrained by barricades/railings to ensure safe and smooth crowd flow. These situations include crowd control strategies like a stop-and-go release of people, changes in the geometry of the facility, and variations in pedestrian characteristics. It is observed that the number of lane changes is highest in scenarios where a slow-moving agent enters at regular intervals, when agents halt in between and when a stop-and-go control strategy is implemented. However, the queue length is more evenly distributed when agents wait for a longer time at the destination. It is possible that simple scenario analysis could be used to validate the performance of pedestrian simulation models. Analyzing pedestrian behaviour under different possible circumstances can provide useful insights and can help improve the pedestrian flow and thereby aid in crowd management.

Keywords: pedestrian simulation, crowd, lane changes, queue, unidirectional flow.

Simulation and optimization in cross-sectoral water: a review

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Abstract. Simulation and optimization models have been of pivotal importance in bringing solutions to major problems. However, their impact is determined by the accuracy and level of detail of the conceptual models describing the systems. In water management these tools have provided valuable solutions, nonetheless, throughout the years models have simplified critical aspects that curb efforts to deliver more effective results. That is the case of cross-sectoral relationships that are often misrepresented in the models despite their relevance with the aim to reduce complexity. Cross-sectoral perspectives have taken place in recent years due to the valuable insights they deliver by addressing those commonly unseen relationships. As a result, the objective of the present article is to introduce a brief review of the cross-sectoral studies that using simulation and optimization techniques have contributed to mitigate the effects of the current and future water crisis through a change of paradigm in models' constructions.

Keywords: Cross-sectoral optimization, water simulation, water optimization, sustainability.

A multi-paradigm simulation-based approach for resilient and sustainable supply chains in the process industry

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Abstract. Today's companies are part of complex and global value chains with increasingly demanding management challenges. This is particularly true for the process industry due to its economic relevance, global scale, and environmental and social impacts. Ensuring the resilience of the process industry supply-chains (SC) is a cornerstone for the well-being of a society that requires access to essential goods and services, even when facing unexpected disruptions or crises. In this context, and more than ever, companies must design and manage resilient and flexible SC configurations to guarantee sustainable growth and efficient operations. Adequately handling these problems has, therefore, become a significant priority and challenging task, requiring the use of sophisticated and often complex management approaches. The primary purpose of this work is, therefore, to develop innovative tools for more informed and effective decision-making, while achieving sound trade-offs between SC robustness and flexibility, operational efficiency, and environmental and social aspects. A multi-paradigm simulation-based decision-support platform is being developed for the design and assessment of effective SC design strategies, and for providing efficient operation plans capable to ensure sustainable growth and long-run business continuity, under high uncertainty scenarios.

Keywords: Supply Chain, Sustainability, Resilience, Process Industry, Simulation.

Data-based Model Identification of the Hypothalamus-Pituitary-Thyroid Complex

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Abstract. The thyroid gland, in conjunction with the pituitary and the hypothalamus, forms a regulated system due to their mutual influence through released hormones. The equilibrium point of this system, commonly referred to as the "set point", is individually determined. This means that determining the correct amount of medication to be administered to patients with hypothyroidism requires several treatment appointments creating an extended treatment process. Because the dynamics of the system have not yet been fully explored, mathematical models are needed to simulate the mutual influence of the respective hormones as well as their course over time. These models enable a deeper understanding of the functionality in the context of data measurements. Therefore, two existing time-dependent mathematical models are used and further analyzed to replicate this overall influence of disparate systems. Both are based on a system of two differential equations modelling the interacting hormones. The parameters of the two models are identified according to different calibration approaches by means of patient data collected in a retrospective study in collaboration with the Medical University of Vienna. The hormonal course in the time domain as well as equilibrium curves including the set-point are then simulated and analyzed with respect to the normalized mean squared error. These calibrated systems allow a more profound insight into the functionality of the formed complex.

Keywords: simulation of HPT complex · thyroid set-point · system calibration.

Digital Twin Development with Agent-based Model to Support Aircraft Ground Operations in Total Airport Management*

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Abstract. Inside the complex air traffic network, delay occurring at the aircraft stand and related ground processes has the potential to propagate and so increase. This "butterfly effect" typically has a significant negative impact on the downstream flights and airports. Efficient aircraft ground operations can help stabilize the in- and outbound aircraft operations and, in some cases, reduce knock-on effects. Reliably forecasting possible bottlenecks at a dedicated airport and its management is key to optimally using resources and applying appropriate strategies. In this research, we implement the digital twin of a selected airport section, Pier H of Amsterdam Schiphol airport, to simulate the aircraft ground operations throughout the course of a single day using an agent-based model. The agents' behavior representing various ground handling operators is considered for an optimized collaborative decision making process in total airport management. The findings and lessons offer the possibilities for predictable airport ground operations, both in terms of strategic and tactical planning as well as operations.

Keywords: Aircraft ground operations · Total airport management · Agent-based model · Digital twin.

Integration of Reinforcement Learning and Discrete Event Simulation Using the Concept of Experimental Frame

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Abstract: Reinforcement Learning (RL) is an optimization method from the field of Machine Learning. It is characterized by two interacting entities referred to as the agent and the environment. The agent influences the environment through actions and the environment responds with state information and reward values. The goal of RL is to learn how an agent should act to achieve a maximum cumulative reward in the long-term. A Discrete Event Simulation Model (DESM) maps the temporal behavior of a dynamic system. The execution of a DESM is done via a simulator. The concept of an Experimental Frame (EF) defines the general structure used to separate the DESM into the dynamic system, called the Model Under Study (MUS), and its application context. This supports the diverse use of a MUS in different experimental contexts. This paper explores the generalized integration of discrete event simulation and RL using the concept of EF. The introduced approach is illustrated by a case study that has been implemented using MATLAB/Simulink and the SimEvents blockset.

Keywords: Discrete Event Systems, Discrete Event Simulation, Experimental Frame, Reinforcement Learning, Simulation Based Experiments, MATLAB/Simulink, SimEvents blockset.

Evaluating The Optimal Facility Location For Additive Manufacturing Service Bureau

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Abstract: Additive manufacturing (AM) is becoming a promising technology in the spare parts supply chain due to its numerous benefits like lead time, cost etc. There are several types of research ongoing in the integration of additive manufacturing and spare parts supply chain. However, these literature studies are more aligned towards AM technology selection, part identification, economic benefits analysis, the decision of 3D print or supply through conventional manufacturing, development of centralized or decentralized supply chain etc. The subsequent step is to determine the optimal AM facility location by fulfilling the customer orders, which is an essential and foremost significant area of research to fully utilize the benefits of AM in terms of the loss of opportunity cost. Nonetheless, the body of literature resides limited to exploring new avenues in the direction of additive manufacturing facility location for AM service bureau. Thus, the authors have developed an optimal facility location by integrating and examining an agent-based discrete event simulation-based model and scenario analysis considering four facilities and four spares. The results investigate the order fulfilment of AM spare parts supply from primary locations, which is almost equal distance from all four locations. This study calculated the shortfall at each location and its economic implications for each plant. This model reveals that Thane is the most compatible location to install AM facility to mitigate the order fulfilment losses (loss of opportunity cost).

Keywords: spare parts, supply chain, additive manufacturing, discrete event simulation, scenario analysis, facility location.

Irrigation Efficiency using a Systems Dynamics Model: A Case Study of a Pepper Crop in La Merced - Peru

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Abstract. This paper presents a system dynamics simulation model for an irrigation system applied to bell pepper crops, integrating various components of a cropping system, including water usage and plant growth. The study focuses on Latin American regions with limited irrigation facilities, highlighting the importance of simulation techniques to analyze different levels of analysis for irrigation components, including water wastage. The increasing global population, food security, and water management concerns require innovative approaches to overcome difficulties and paradigms in crop irrigation. The simulation model proposed in this study provides insights into the irrigation system's behavior and explores various scenarios to optimize crop yield while minimizing water wastage. Results obtained through simulation demonstrate the dynamics between irrigation time and water discarded in a crop, considering the complex behavior of living systems. The paper's contribution highlights the value of simulation models as a powerful tool for analyzing and improving crop irrigation systems, ultimately contributing to sustainable agriculture and water management practices.

Keywords: Irrigation Model, Pepper Crop, System Dynamic, Waste Management.

The Impact of Adding Interaction-Driven Evolutionary Behavior to the Schelling's Model

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Abstract. Schelling's model is thoroughly researched because it highlights a crucial human phenomenon known as segregation. The term "segregation" is used to describe the practice of dividing up the human population into several groups. The policies of governments, environmental concerns, economic concerns, familial dynamics, and so on, all have a role in shaping the ways in which people are separated from one another. All of these factors contribute to segregation by influencing people's preferences in different ways. The studies have evaluated each factor separately and demonstrated how each variable influences segregation dynamics. In this study, we investigate the effect of agents' evolutionary (dynamic) behavior on segregation dynamics. Behavioral patterns of agents are made interaction-dependent, and the results of this interaction-driven evolutionary model are compared to those of the original model. The results demonstrate that evolutionary behavior leads to a higher number of subgroups when the model converges than the number of subgroups in the original model. Furthermore, because the evolutionary model is more complex than the original model, it converges later and produces results that are more variable than those of the original model.

Keywords: Segregation · Evolutionary · Agent Based Simulation.

Discrete-Event Modeling of Human Behavior for Spread of Diseases on University Campuses

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Abstract. The COVID-19 pandemic has highlighted the importance of defining sound policies to make attending workplaces safe. Sometimes, deciding on different policies is challenging as this highly depends on the behavior of the individuals. We introduce a Discrete Event based method to study such policies, including human behavior along with information about the workplace layout and building characteristics such as ventilation rate or room capacity. We exemplify how to use this method using the case study of Carleton's University Campus. We introduce a case study focusing on the effect of the ventilation policy on the number of disease cases on campus.

Keywords: DEVS, disease spread, human behavior.

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