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Editorial

# Special Issue on Scheduling Theory and Algorithms for Sustainable Manufacturing

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The following Special Issue was initiated at the 10th IFAC triennial conference MIM 2022 (<https://hub.imt-atlantique.fr/mim2022/> accessed on 24 December 2024) on Manufacturing Modelling, Management and Control, held in Nantes, France. The authors of the most outstanding papers on the topics of decision aid, combinatorial optimization, and scheduling from the corresponding sessions of the conference were invited to submit extended versions to the present Special Issue. A special focus was placed on how the scheduling theory and algorithms can help to solve complex combinatorial optimization problems in manufacturing from sustainability and related perspectives.

Following their presentation at the conference and selection by the session chairs and members of the program committee, as mentioned above, a select group of authors were invited to submit an extended and improved version of their work to this Special Issue. However, the Special Issue was also open to papers that were not presented at the conference if they fell within the scope of the issue and were in relation or complementary to the papers selected at the conference.

The motivation of this Special Issue was to present state-of-the art mathematical models and algorithms providing efficient solutions for practical planning and scheduling issues in digital, sustainable, and human-centric manufacturing and logistics [1]. At present, the production and logistics systems for goods and services are faced with both production cost optimization and scarcity of resources, including energy [2]; such systems are becoming increasingly digitalized [3]. Scheduling and algorithms play a central role and offer the possibility to reduce production waste, manage efficiently, and limit the consumption of material resources and energy [4].

An increasing number of scholars are focussing their efforts on applying sustainability criteria when solving planning and scheduling problems in modern digital production environments [5,6]. Artificial intelligence techniques are often used, taking into account a large amount of available data and the complexity of the problem that needs to be solved. To address this issue, multi-objective optimization approaches have been developed.

The majority of studies on the planning and scheduling of production systems and their logistics from sustainability perspectives focus on economic issues and the minimization of electricity consumption and/or carbon emissions. These factors represent the economic and environmental parts of sustainability. Some researchers also integrate social responsibility issues into their work [6].

Various models and algorithms have been developed for planning and scheduling sustainable production systems, with various parameters, objective functions, constraints, model types, and optimization methods employed. Energy consumption and greenhouse



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gas emissions are the most studied factors of sustainability in the current planning and scheduling approaches [7].

The objective of this Special Issue was to complement the existing literature with the most recent research findings and to extend the scope of possible applications and techniques used in the planning and scheduling of production systems and logistics in the digital and AI era.

After a rigorous peer review process in accordance with the high standards of the journal, the following two reviews and nine research papers were selected for publication in this Special Issue:

“A Review on Reinforcement Learning in Production Scheduling: An Inferential Perspective” by Vladimir Modrak, Ranjitharamasamy Sudhakarapandian, Arunmozhi Balamurugan, and Zuzana Soltysova presents a systematic review of production scheduling based on reinforcement learning techniques covering the period between 1996 and 2024. This review provides new insights into the use of reinforcement learning in production scheduling and outlines future challenges to be addressed by practitioners and members of the academic community.

In the review “Unlocking the Potential of Remanufacturing Through Machine Learning and Data-Driven Models—A Survey” by Yong Han Kim, Wei Ye, Ritvik Kumar, Finn Bail, Julia Dvorak, Yanchao Tan, Marvin Carl May, Qing Chang, Ragu Athinarayanan, Gisela Lanza, John W. Sutherland, Xingyu Li and Chandra Nath, the authors examine the integration of artificial intelligence and data-driven and machine learning technologies into remanufacturing processes to improve both operational efficiency and sustainability. A comprehensive review of existing knowledge and algorithms is presented and the possibilities to use these techniques in the circular economy are discussed.

“Reducing Nervousness in Master Production Planning: A Systematic Approach Incorporating Product-Driven Strategies”, presented by Patricio Sáez, Carlos Herrera, and Victor Parada, addresses the widely recognized issue of nervousness in master production schedules. Taking into account variations in demand, production schedules change and create instability in the system. The findings presented in this article suggest a product-driven system to complement master production scheduling techniques with intelligent agents to reduce nervousness without significantly increasing production costs.

Manli Dai and Zhongyi Jiang, in their article “Multiprocessor Fair Scheduling Based on an Improved Slime Mold Algorithm”, propose an improvement to the “Slime Mold Algorithm” optimization method along three axes: the definition of a better initial population (based on reverse learning of Bernoulli mapping), an improved mutation strategy, and an optimized boundary-check mechanism. This enhancement allows for faster convergence of the algorithm. Experiments on test functions are conducted to demonstrate the performance and robustness of the approach, which is then applied to the multiprocessor fair scheduling problem to reduce the average execution time on each processor.

In the article “Mitigating Co-Activity Conflicts and Resource Overallocation in Construction Projects: A Modular Heuristic Scheduling Approach with Primavera P6 EPPM Integration” by Khwansiri Ninpan, Shuzhang Huang, Francesco Vitillo, Mohamad Ali Assaad, Lies Benmiloud Bechet and Robert Plana, a heuristic approach for managing complex construction projects is presented, integrating Primavera P6 EPPM and Synchro 4D. The approach enables proactive conflict detection and the resolution of spatial conflicts during concurrent tasks, in addition to resource verification prior to task initiation, thereby ensuring the generation of feasible and conflict-free construction schedules. This approach integrates seamlessly with existing industry tools.

In the article “Towards Sustainable Inventory Management: A Many-Objective Approach to Stock Optimization in Multi-Storage Supply Chains” by João A. M. Santos, Miguel

S. E. Martins, Rui M. Pinto, and Susana M. Vieira, the authors consider the issue of sustainable supply chain management consisting of the optimization of inventory levels in storage facilities, minimizing holding costs, energy consumption, and shortage risk concurrently and thus integrating sustainability considerations into inventory management.

The next article, “Multi-Criteria Decision Support System for Automatically Selecting Photovoltaic Sets to Maximise Micro Solar Generation”, by Guilherme Zanlorenzi, Anderson Luis Szejka, and Osiris Canciglieri Junior takes into account technological advancements that have made solar energy more accessible. The authors propose a multi-criteria decision support system to select the most suitable photovoltaic systems for microgrids, using the AHP and TOPSIS methods. When tested in real-world conditions, the system provided solutions with efficient yields and high internal rates of return. The authors of this article establish a methodological framework and a practical decision tool to enhance the feasibility of solar projects and improve their accessibility.

Vladimir Kats and Eugene Levner, in their article “Maximizing the Average Environmental Benefit of a Fleet of Drones under a Periodic Schedule of Tasks”, present a new, environmentally oriented problem aimed at determining the optimal number of vehicles that maximizes the average profit of a fleet of drones. The authors model the problem as an infinite periodic graph and reduce it to a special type of parametric assignment problem. They develop a method that allows the problem to be solved to optimality for larger fleets of drones than any previously known exact algorithm.

In the article “The Parallel Machine Scheduling Problem with Different Speeds and Release Times in the Ore Hauling Operation” by Luis Tarazona-Torres, Ciro Amaya, Alvaro Paipilla, Camilo Gomez, and David Alvarez-Martinez, the authors present an approach to determine the minimum amount of hauling equipment required to meet an ore transport target. The authors model the problem as a parallel machine scheduling problem with different speeds and release times, with the objective of minimizing both the completion time and the costs associated with the equipment used. The approach helps decision-makers ensure that loading and hauling equipment are utilized to their fullest potential while adhering to budgetary constraints and operational schedules.

Yumin He, Alexandre Dolgui, and Milton Smith in their article “An Algorithm for Part Input Sequencing of Flexible Manufacturing Systems with Machine Disruption” explore the management of disruptions in flexible manufacturing systems (FMSs), with a particular emphasis on part input sequencing. Disruptions, such as machine breakdowns, are unpredictable and can significantly impact supply chains and production processes. An efficient algorithm is proposed to make part input sequencing in an FMS under machine failure conditions and is subsequently tested through simulations. Lastly, managerial implications and further research directions are provided.

In the paper “Minimum-Energy Scheduling of Flexible Job-Shop Through Optimization and Comprehensive Heuristic” by Oludolapo Akanni Olanrewaju, Fabio Luiz Peres Krykhtine, and Felix Mora-Camino, the authors consider a flexible job-shop scheduling problem in high energy-consuming flexible production plants. The primary objective of the study is to generate energy-efficient schedules with acceptable production delays for each job. The authors develop an ad hoc heuristic as the computational complexity of the problem increases with the requirement to generate efficient schedules in a dynamic environment.

It is our hope that this carefully curated selection of papers will be of interest to readers of the journal *Algorithms* and useful for all members of our community.

**Conflicts of Interest:** The guest editors declare no conflict of interest.

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