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Editorial

Algorithms and Methods for Designing and Scheduling Smart Manufacturing Systems

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1. Introduction

This Special Issue is a collection of some of the latest advancements in designing and scheduling smart manufacturing systems. The smart manufacturing concept is undoubtedly considered a paradigm shift in manufacturing technology. This conception is part of the Industry 4.0 strategy, or equivalent national policies, and brings new challenges and opportunities for the companies that are facing tough global competition. Industry 4.0 should not only be perceived as one of many possible strategies for manufacturing companies, but also as an important practice within organizations. The main focus of Industry 4.0 implementation is to combine production, information technology, and the internet [1]. Therefore, an introduction of smart manufacturing systems is primarily associated with the adaptation of the Internet of Things, cyber physical systems, artificial intelligence, advanced robotics, cloud technology, and so forth. In particular, web technologies act as enablers of smart manufacturing that can promote a disruptive innovation in small and medium enterprises. However, some recent studies (see, e.g., [2–4]) have shown that pre-existing managerial methods and philosophies such as lean manufacturing, reconfigurable manufacturing systems, or cellular manufacturing systems are of utter importance for the concept of smart manufacturing. In this context, manufacturing system design and scheduling methods also play a vital role in the era of the fourth industrial revolution. It is particularly evident from the link between Industry 4.0 and lean manufacturing that both domains are strongly interrelated [5]. Thus, we hope that this Special Issue may be helpful in solving the particular problems which are related to smart manufacturing systems and advanced manufacturing technologies.

2. Description of the Papers

The presented Special Issue consists of ten research papers presenting the latest works in the field. The papers include various topics, which can be divided into three categories—(i) designing and scheduling manufacturing systems (seven articles), (ii) machining process optimization (two articles), (iii) digital insurance platforms (one article). Most of the mentioned research problems are solved in these articles by using genetic algorithms, the harmony search algorithm, the hybrid bat algorithm, the combined whale optimization algorithm, and other optimization and decision-making methods.

The above-mentioned groups of articles are briefly described in this order in the rest of this editorial paper.

The paper written by J.S. Park, H.Y. Ng, T.J. Chua, Y.T. Ng, and J.W. Kim [6] presents a novel genetic algorithm approach that utilizes a multiple chromosome scheme to solve the flexible job-shop scheduling problem which involves two kinds of decisions—machine selection and operation sequencing. This novel genetic algorithm approach enables the application of an identical crossover strategy in the categorical and sequential parts. The authors used this unified approach for the extension of the existing candidate order-based genetic algorithm to the unified candidate order-based genetic algorithm to solve flexible job-shop scheduling problems.

The other paper titled "Calibration of GA parameters for layout design optimization problems using design of experiments" [7] focuses on finding out how the solutions of the cell formation problem are influenced by a set of probability parameters of genetic operators, namely crossover and mutation, including balanced weight factors. In view of this, the presented work attempts to employ the Taguchi approach to find an optimal combination of parameters that impact the efficiency of the genetic algorithm and to explore whether the optimal combination of the genetic operators for the given type of machine-cell formation problems can be influenced by the magnitude of the noise factors.

The next paper [8] introduces a robust cluster algorithm based on the concept of group technology. The paper is written by L.M. Li and its originality lies in its use of the algorithm to balance an assembly line by matching operators to workstations so that the line's workstations achieve the same targeted output rates. It enables managers to solve the problem of worker absences by assigning more than one operator with the required skillset to each workstation and rearranging them as needed. This algorithm has been applied to cellular manufacturing system problems. Four examples were presented to implement and validate this algorithm, where training time was reduced by matching operators' training and skills according to the workstations' skill requirements.

The paper written by L. Nagarajan, S.K. Mahalingam, S. Salunkhe, E.A. Nasr, J.P. Davim, and H. Hussein [9] proposes a novel methodology for simultaneous minimization of manufacturing objectives in tolerance allocation of complex assembly tasks. The methodology consists of a two-step process. For this purpose, a heuristic approach was applied to determine the best machine for each process. Subsequently, it applies a combined whale optimization algorithm with a univariate search method to allocate optimum tolerances with the best process selection for each sub-stage/operation. The proposed methodology was validated by solving two typical tolerance allocation problems of complex assemblies: a wheel mounting assembly and a knuckle joint assembly. Authors also compared their approach with existing ones. The comparison results showed that the proposed approach considerably reduces tolerance cost and machining time.

The next paper which is authored by S.K Mahalingam, L. Nagarajan, S. Salunkhe, E.A. Nasr, J.P. Davim, and H. Hussein aims to acquire the maximum number of non-linear assemblies with closer assembly tolerance specifications by mating the different bins' components [10]. Their proposed approach is based on using the combination of the univariate search method and the harmony search algorithm. The efficacy of the proposed method is demonstrated by showing 24.9% of cost savings while making overrunning clutch assembly in comparison with the existing method. Based on the obtained results in this work, the contribution of the proposed novel methodology is legitimate in solving selective assembly problems.

The originality of the following paper written by Zheng J. and Wang Y. [11] lies in an application of the hybrid bat optimization algorithm, which is based on the variable neighborhood structure, and two learning strategies to solve a three-stage distributed assembly permutation flow shop scheduling problem (DAPFSP) with the aim to minimize the makespan. The proposed algorithm is firstly designed to increase the population diversity by classifying the populations which solves the difficult trade-off between convergence and diversity of the bat algorithm. Secondly, a selection mechanism is used to update the bat's velocity and location, solving the difficulty of the algorithm trade-off of exploration and mining capacity. For this purpose, the Gaussian learning strategy and elite learning strategy assist the whole population in jumping out of the local optimal frontier. Based on the obtained simulation results, this algorithm can solve the DAPFSP problem well. In comparison with other metaheuristic algorithms, it provides better performance than the compared ones; thus, it is suitable to find the optimal solution(s).

The brief overview of the further paper titled "A multi-criteria assessment of manufacturing cell performance using the AHP method" [12] is as follows. It introduces the solution for how to find the optimal manufacturing cell design from alternative designs by using a multi-criteria evaluation. Alternative design solutions are mutually compared by using the selected performance criteria, namely operational complexity, production line balancing rate, and makespan. Then, multi-criteria decision analysis based on the analytic hierarchy process method is used to show that two more-cell solutions better satisfy the determined criteria of manufacturing cell design performance than three less-cell solutions. The main benefit of this approach lies in the exactly enumerated values of the selected criteria, according to which the points from the mentioned scale are assigned to the alternatives.

The first paper of the second group of articles is titled "Meta-heuristic technique-based parametric optimization for electrochemical machining of Monel 400 alloys to investigate the material removal rate and the sludge" [13]. The authors investigate in this work the predominant electrochemical machining process parameters, namely applied voltage, flow rate, and electrolyte concentration, and their effects on the performance measures, i.e., the material removal rate and the nickel presence. For this purpose, authors used a meta-heuristic algorithm named as the grey wolf optimizer for the multi-objective optimization of the process parameters for electrochemical machining. The obtained results were compared with the moth–flame optimization and particle swarm optimization algorithms. Based on the obtained results, it was observed that all the process variables significantly influenced the objectives. Then, it is confirmed that these metaheuristic algorithms—the moth–flame optimization algorithm and the grey wolf optimizer—are suitable for finding the optimum process parameters for machining Monel 400 alloys with electrochemical machining.

The second paper of this group is named "Optimization of process parameters for turning Hastelloy X under different machining environments using evolutionary algorithms: A comparative study" [14]. In their research, the authors investigated the machinability of turning Hastelloy X with a PVD Ti-Al-N coated insert tool in dry, wet, and cryogenic machining environments. The machinability indices, namely cutting force, surface roughness, and cutting temperature, are studied for the different set of input process parameters such as cutting speed, feed rate, and machining environment. They used the experiments conducted as per L27 orthogonal array. The authors proposed the moth–flame optimization to identify the optimal set of turning parameters through the multiple linear regression models, in view of minimizing the machinability indices. The effectiveness of the proposed algorithm is evaluated in comparison to the findings of genetic, Grass–Hooper, grey wolf, and particle swarm optimization algorithms. Based on the obtained results, this algorithm outperformed the others.

The last article in the given order is titled "Reflections on the customer decision-making process in the digital insurance platforms: An empirical study of the Baltic market" [15]. It aims to expand upon the existing scientific knowledge of end-user behavioral patterns and process frameworks in the Baltic insurance market, by including and examining a factor group of technological enablers. This paper is focused on research results in digitalization, personalization, and customization levels within the Baltic non-life insurance market in Estonia. There are also three major factor groups and process stages identified which influence insurance purchase decision-making in digital insurance platforms in the Baltic market.

3. Conclusions

It is believed that the collection of the ten papers in this Special Issue will be beneficial to readers who are interested in applying modern algorithms and methods for designing and scheduling smart manufacturing systems and related problems. Although this Special Issue has been closed, the current market challenges justify the need for an additional in-depth research in this domain.

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