Engineering 22 (2023) 1–2

Contents lists available at ScienceDirect

Engineering

journal homepage: www.elsevier.com/locate/eng

Editorial

Editorial for the Special Issue on Intelligent Manufacturing

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Intelligent manufacturing is a type of manufacturing that adopts computer-integrated manufacturing, high-level adaptability and rapid design personalization, system reconfiguration, the digitalization of manufacturing processes and resources, and flexible and organized technical labor training. This Special Issue focuses on the application of advanced information and communication technologies—such as artificial intelligence (AI), advanced topology optimization methods, edge computing, cloud computing, 5G networks, the Industrial Internet, and the Internet of Things—to address problems that arise during the design, materials and manufacturing, logistics, and services associated with intelligent manufacturing. In this issue, we present eight articles contributed by scholars and experts from countries around the world, including China, Sweden, the United Kingdom, and New Zealand. The published works examine intelligent manufacturing, with a particular focus on the phases of engineering design and materials and manufacturing.

1. Engineering design

Within this issue, Wang et al. propose a novel human-aided design (HAD) paradigm that could be revolutionary, as it carries potential advantages over computer-aided design (CAD). In the paradigm they propose, the entire product design can be completed by deploying isogeometric topology optimization. The proposed paradigm is tested on design domains with regular, irregular, and multiscale structures. Issues relating to accuracy, such as the number of integration points and the automatic generation of a junction surface, still need to be addressed problems such as heat conduction, fluid–structure interaction, and electromagnetism.

The key issue of obtaining the optimal engineering design for any complex functional part may be addressed by the development and application of topology optimization methods. Hong et al. propose a new reliability-based topology optimization method for the optimal design of a large-tonnage hydraulic press with respect to layout and size, while considering stochastic uncertainties. The proposed method is based on the reliability-and-optimization decoupled model and the teaching–learning-based optimization algorithm. Their method yields a simple and fast solution based on just a few parameters.

2. Materials and manufacturing

The materials procured from other industries or fabricated within the same industry are an important manufacturing resource, as they impact the quality of manufactured functional parts. The properties of a material have a great influence on the quality (strength, dimensional accuracy, fatigue life, etc.) of manufactured parts—especially large parts with a complex shape. In their perspective article, Zhao et al. propose a non-destructive method based on deformation forces for effectively inferring the unbalanced residual stress generated by material removal operations. The proposed method is found to have reliable accuracy and flexibility when tested on large aviation structural parts. The findings can be further extended to other complex parts and materials used in the aerospace, nuclear, and ship-building industries. Wang et al. propose a digital twin (DT) visual model that includes an extreme learning machine (ELM) for simulating the coupling

https://doi.org/10.1016/j.eng.2022.11.001

fields and predicting the quality of the composite material. The proposed method is tested on data generated from a curing process. The method is found to perform well on one type of composite material and can be tested further on other types of composite materials.

Cloud manufacturing (CMfg) is an intelligent manufacturing paradigm that virtualizes manufacturing resources and encapsulates these resources in a shared cloud, which delivers services to consumers. The cloud framework has powerful storage, networking, and computing resource abilities that make use of advanced information and communication technologies to predict, optimize, analyze, interpret, forecast, and so forth a large variety of big data (e.g., zettabytes). Optimal resource scheduling is important in CMfg in order to increase efficiency and reduce consumption while delivering high-quality services to customers. However, it has two limitations: ① Industrial robots, machine tools, and conveyers are statically configured, making reconfiguration and optimization very difficult for large-variety and small-volume manufacturing; and ② the generation of big data from different production machines results in a data-traffic and network-congestion problem. To address these limitations and achieve higher manufacturing efficiency, Yang et al. propose a software-defined networking manufacturing model for software-defined CMfg. The main idea is to transfer control/logic from the hardware (industrial robots, tools, etc.) to the software so that it can be easily reconfigured and operations can be evolved. An approach integrating a genetic algorithm, Dijkstra's shortest-path algorithm, and a queuing algorithm is proposed to solve the data-traffic control problem.

To achieve the massive personalization and customization of products for customer needs, the entire manufacturing system, including CMfg, can be operated at the highest level of smartness—for example, by using the "Self-X" manufacturing network, which is "self-aware, self-comparing, self-predicting, and self-optimizing." Li et al. propose an industrial knowledge graph and graph embedding approach for achieving cognitive intelligence in manufacturing systems. The proposed approach addresses the limitations of the organization of massive manufacturing resources and aims to develop trust between machines and humans-in-the-loop.

An industrial Internet platform is one of the main platforms used to promote the Made in China (MIC) 2025 and Industry 4.0 vision of the modernization and digitalization of the manufacturing industry. This technology enables large manufacturing resources to be virtualized, unified, and utilized effectively by being encapsulated as high-quality manufacturing services and collaboration solutions that can be delivered to customers. Pang et al. propose a dual-dimensional service collaboration methodology that considers both function and amount in order to simultaneously meet the functional demands of customer requirements and the task amount. A dual-dimensional manufacturing service collaboration optimization model is formulated, and a multi-objective memetic algorithm with multiple local search operators is applied to solve this problem.

Estimating the key performance indicators (KPIs)—such as product quality, energy consumption, production efficiency, and pollutant emissions—of complex industrial processes is an important issue, as the data collected from industries (especially discrete industries) is highly nonlinear, insufficient, and uncertain. Existing sensors and offline laboratory analysis methods are unsuitable for improving industrial production on a real-time basis. Sun et al. propose a causal-effect-based feature-selection method for developing soft sensors for the KPIs of industrial processes. They employ an AdaBoost ensemble decision tree method for soft sensor modeling, which requires almost no fine-tuning of parameters. The proposed method considers the casual effect between each feature and the KPIs and automatically selects a subset of features.

The published articles in this Special Issue briefly illustrate available solutions for addressing key issues in the field of intelligent manufacturing. However, strong coordination and further interdisciplinary efforts are still needed, particularly from experts in different communities (AI, manufacturing, materials, mathematics, communication, electronics, psychology, etc.), to develop holistic solutions and promote the advancement of intelligent manufacturing.