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Editorial

Editorial for the Special Issue on Intelligent Manufacturing

Peigen Li [a], Vladimir Marik [b], Liang Gao [a], Weiming Shen [c]

[a] The State Key Laboratory of Digital Manufacturing Equipment and Technology, School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, China
[b] Czech Institute of Informatics, Robotics and Cybernetics, Czech Technical University in Prague, Prague 16000, Czech Republic
[c] National Research Council, Ottawa, ON K1A 0R6, Canada


Peigen Li


Vladimir Marik


Liang Gao


Weiming Shen

Intelligent manufacturing is represented by a deep integration of advanced information and communication technologies and advanced manufacturing technologies. It runs through the whole life-cycle of product design, manufacturing, services, and recycling. The intelligent product is the center of intelligent manufacturing, while the intelligent production is the main activity and an intelligent service-centered industrial mode is the theme. With intelligent manufacturing, manufacturing systems become increasingly agile, with higher quality and efficiency, personalized customization, and environmental sustainability. Intelligent manufacturing technology is becoming a major trend in the development of the manufacturing industry around the world.

This special issue of *Engineering* is a collection of recent achievements in intelligent manufacturing research that hold potential to significantly promote the development of this area. It contains ten papers—including two opinion papers and eight research papers—contributed by influential experts from China, the United States, the United Kingdom, Sweden, Japan, Singapore, and Australia. These articles illustrate the state of the art of intelligent manufacturing in the following areas:

(1) Key technologies of intelligent manufacturing.

The first set of key technologies presented in this special issue comprises big data and artificial intelligence (AI) technologies, which include machine learning, deep learning, reinforcement learning, crowd intelligence, and cross-media intelligence. These technologies have developed significantly in recent years, promoting the accelerated development of intelligent manufacturing. The second key technology is design for intelligent manufacturing (DFIM), which should be considered to be the design of intelligent products and services in the context of intelligent manufacturing, and specifically in regards to emerging new-generation intelligent manufacturing systems. The third set of key technologies includes digital twins (DTs) and cyber–physical systems (CPSs), which are two of the most important technologies for an important prerequisite of intelligent manufacturing: achieving cyber–physical interaction and integration in manufacturing. The human–cyber–physical system (HCPS), which is an extension of CPS, is also a key technology of intelligent manufacturing. In the aspect of technology, HCPS can both reveal the technological principles and form the technological architecture for intelligent manufacturing.

(2) Typical applications of intelligent manufacturing technologies.

Intelligent manufacturing technologies exist in all aspects of manufacturing. The typical applications of intelligent manufacturing technologies provided in this special issue can act as useful demonstrations and promotions for new technologies. The biologically inspired design (BID) framework illuminates the promising direction of leveraging biological inspiration for smart product design. This research strategy and framework can be adapted to benefit other facets of product smartness such as adaptability, location-awareness, and network-awareness. The machine tool which evolves three stages (i.e. numerical control machine tool (NCMT), smart machine tool (SMT), and intelligent machine tool (IMT)) plays more and more important role in intelligent manufacturing. A deep belief network (DBN)-based online monitoring system for laser welding status provides a good way to apply vision-based online monitoring systems to other manufacturing processes. A data-driven anomaly diagnosis system for computer

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numerical control (CNC) machining processes can enable CNC to be used to improve product quality and production efficiency. This method can also be used in other processes, such as testing and assembly. One of the papers in this issue proposes a fog-computing-based industrial big data integration and sharing (IBDIS) approach named "Fog-IBDIS" in order to manage and provide data for big data analysis in manufacturing systems. Although very impressive applications of big data have been achieved in other fields, the question of how to use big data well in manufacturing remains a challenge. Combining IBDIS with fog-computing technology is an excellent attempt that may promote the application of big data in future manufacturing systems. Another paper in this special issue analyses the pathways for Chinese firms to transit across three technological paradigms of intelligent manufacturing—in parallel rather than in series—and provides a strategic "roadmap" as an explanatory guide to manufacturing firms, policy makers, and investors. This work provides very good upgrade intelligent manufacturing pathway for Chinese firms.

We have been deeply inspired by the impressive work presented in this special issue, and are grateful to all the authors for their contributions. However, the research results presented in this issue indicate that the research and applications of intelligent manufacturing technologies are just beginning. There is still a long way to go before some intelligent manufacturing technologies can be deployed in practice. An increasing number of AI-related and big-data-driven solutions will emerge in all aspects of manufacturing, including product design, production, service, and recycling, and will revolutionize the traditional manufacturing mode.