Chapter 21
Intelligent Manufacturing Systems Driven by Artificial Intelligence in Industry 4.0

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ABSTRACT

Intelligent manufacturing plays an important role in Industry 4.0. Key technologies such as artificial intelligence (AI), big data analytics (BDA), the internet of things (IoT), cyber-physical systems (CPSs), and cloud computing enable intelligent manufacturing systems (IMS). Artificial intelligence (AI) plays an essential role in IMS by providing typical features such as learning, reasoning, acting, modeling, intelligent interconnecting, and intelligent decision making. Artificial intelligence's impact on manufacturing is involved in Industry 4.0 through big data analytics, predictive maintenance, data-driven system modeling, control and optimization, human-robot collaboration, and smart machine communication. The recent advances in machine and deep learning algorithms combined with powerful computational hardware have opened new possibilities for technological progress in manufacturing, which led to improving and optimizing any business model.

INTRODUCTION

Intelligent manufacturing (also known as Smart manufacturing) is the new manufacturing paradigm where manufacturing machines are fully connected through wireless networks, monitored by sensors, and controlled by advanced computational intelligence with the purpose of optimizing production, improving product quality and sustainability while reducing costs *(Wang, Ma, Zhang, Gao & Wu, 2018).* Key technologies such as Artificial Intelligence (AI), Big Data Analytics (BDA), the Internet of Things

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(IoT), Cyber-Physical Systems (CPSs) and Cloud Computing *(Lu, 2017)*, enable Intelligent Manufacturing Systems (IMS). With implementation of these technologies in manufacturing, data from different product stages is collected and processed. AI plays an essential role in IMS by providing typical features such as learning, reasoning, acting, intelligent interconnecting and intelligent decision-making. In that way, data-driven intelligence with advanced analytics transforms the complex nonlinear relationships among data into actionable and insightful information for intelligent manufacturing.

Cyber-Physical Systems (CPS) are an integrative research field aimed toward a new generation of engineered systems *(Song, Chen, Sastry & Tas, 2009)*. Cyber-Physical Systems integrate computing and communication capabilities by monitoring and controlling the physical systems via embedded hardware and computers *(Sang, Suh, Tanik, Carbone & Eroglu, 2014; Penas, Plateaux, Patalano & Hammadi, 2017)*. Today, CPS can be found in diverse industries as manufacturing, automotive, energy, healthcare, infrastructure, consumer electronics and communications. Building effective CPSs of the future require multi-disciplinary skills. In particular, the confluence of real-time computing, embedded systems, wireless sensor networks, control theory, signal processing and knowledge creation using artificial intelligence are required to create these new systems *(Bosankic, Banjanovic-Mehmedovic & Mehmedovic, 2015)*.

Industrial embedded systems are used across a wide range of industry to perform specific tasks such as controlling processes, driving motors, controlling product line speeds, networking equipment, etc. *(Mokey, 2018)*. The primary use of embedded system in industrial automation applications is machine control and monitoring. For machine control, the embedded automation system helps to reduce maintenance costs, optimize a machine's performance capabilities and improve overall product quality. Industrial embedded systems supervise a system's condition in real-time during machine monitoring and send performance data to a centralized server or cloud-based gateway using Internet of Thing (IoT) resources. This data is analyzed using artificial intelligence techniques and provide actionable information through a dashboard. This is a proactive way to prevent production losses using embedded systems (microcontrollers and FPGA logic). With reducing factory equipment, maintenance costs are expected by up to 40%, reducing equipment downtime by up to 50% and reducing capital equipment investment costs 5% *(Ezell, 2016)*.

Cloud-based IT-platform serves as a technical backbone for the connection and communication in Industry 4.0 applications *(Vaidya, Ambad & Bhosle, 2018)*. Increased data sharing across the sites and companies, i.e., "Digital production" concept make the connections of different devices to the same cloud to share information to one another. Within IoT-enabled manufacturing environments, the smart manufacturing objects (SMOs) (machine, robots) are able to sense, interconnect, and interact with each other from the entire plant to automatically and adaptively carry out manufacturing logics directly or indirectly to the web. Machine intelligence plays an important role in supporting human-machine collaboration, machine-to-machine connections and cooperation, too.

This chapter presents a review of application of artificial intelligence algorithms in the intelligent manufacturing systems (IMS), the most important advanced methods of deep learning neural network and overview of their application in IMS, as well as the importance of artificial intelligence application in Industry 4.0.