Artificial Intelligence, Big Data, and Machine Learning in Industry 4.0

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INTRODUCTION

The globalization and the rapid technological advancements have brought about numerous changes to various sectors. The industrial sector is no exception to this phenomenon. The global market has become fiercely competitive and the requirements more demanding. Consequently, it is vital to utilize innovative technologies and reap their benefits in order to address and satisfy the new and forthcoming needs and create new values. As a result, the emergence of the fourth industrial revolution (Industry 4.0) was inevitable.

By enabling physical assets to be integrated into intertwined digital and physical processes, Industry 4.0 enhances traditional industries by transforming them into intelligent ones (Xu et al., 2018). Industry 4.0 offers new organization levels and has the potential to change and add value throughout the entire value chain by enabling the creation of autonomous, automated, intelligent and digitalized processes (Lasi et al., 2014). Nonetheless, as Industry 4.0 is still at its infancy, several challenges remain to be met in order for it to be fully adopted and successfully implemented. Several technologies, such as Artificial Intelligence (AI), Machine Learning (ML), Big Data (BD), Internet of Things (IoT) etc., help towards the realization of Industry 4.0 and its development. These technologies can be used in combination while simultaneously helping each other advance.

This chapter aims at providing an overview regarding the vital role that the state-of-the-art technologies of AI, ML and BD offer to the realization and adoption of Industry 4.0, the numerous merits they can yield as well as the multitude of contemporary solutions, applications and services they can provide. Consequently, this chapter presents the concept of Industry 4.0 as well as those of AI, ML, BD and Big Data Analytics (BDA) technologies. In addition, it discusses the potentials that these technologies could offer and the merits they could yield when applied within the context of Industry 4.0. Finally, it presents the summary of the main findings, open research issues and challenges, drawn conclusions and provides directions for future research.

BACKGROUND

The plethora of smart devices and the everyday life digitalization have led to a rapid increase of a wide variety of data sources, digital content as well as data structures and types (Gahi et al., 2016). Consequently, an exponentially increasing volume of heterogeneous data, which is called BD, is created and is differentiated from traditional data based on its volume, variety, veracity, velocity and value (McAfee et al., 2012).

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BD can be processed using advanced analytical tools, called Big Data Analytics (BDA), which utilize analytic and parallel techniques in order to retrieve, process, examine, analyze and manage vast amounts of diverse digital data, information and statistics (Parwez et al., 2017). The BD era offers uncountable potentials for innovation in addition to numerous other advantages, all the more so as BDA offer prescriptive and predictive insight and enable intelligence gleaning, retrieval of crucial data and enhanced decision-making (LaValle et al., 2011). Therefore, there is no doubt that both BD and BDA are essential parts for the implementation of Industry 4.0.

The exponential increase of digital data has given rise not only to new requirements and challenges but also to new opportunities and potentials. ML is a novel scientific field which capitalizes on this vast amount of data as well as the increase in computational power in order to offer improved services and new solutions (Jordan & Mitchell, 2015). Intelligent and highly flexible models that learn through examples, meaning that they simulate the human way of learning, are being developed through ML (Mohri et al., 2018). Hence, ML can be used in various domains, such as computer vision, object recognition, natural language processing, intelligent decision-making systems, recommender systems etc. It is worth noting that as the volume of input and processed data increases so does its efficiency.

Moreover, Deep Learning (DL) constitutes a specialized form of ML. The term "deep" refers to the multitude of layers through which the data is transformed. DL uses multi-layer neural networks and advanced supervised and unsupervised learning methods (Deng & Yu, 2014). Moreover, it allows "*computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction*" (LeCun et al., 2015, p. 436). Therefore, it utilizes nested hierarchies to represent concepts with each individual one being defined as a result of other simpler and more abstract representations.

ML models identify and utilize the optimal combinations of complex input data in an autonomous and automatic manner (Goodfellow et al., 2016). Consequently, they are able to create autonomous human-like decision-making systems that are able to increase the overall process effectiveness without requiring any form of human intervention or action. As the amount of data increases, the algorithms and architectures used become more advanced and systems acquire more compute power, the merits that can be yielded through ML as well as its innovative applications will increase (LeCun et al., 2015). Therefore, it can be claimed that ML plays a vital role in the realization of Industry 4.0.

AI can capitalize on both BD and the advancement of ML to further support and enhance the development of Industry 4.0. AI can be regarded as the capability of digital computers or computer-controlled robots of autonomously performing tasks which are usually associated with intelligent beings (Russell & Norvig, 2002). Furthermore, the term commonly describes systems that have been developed to have human characteristics, intelligent behavior, cognitive functions and the ability to perceive their surrounding environment (Nilsson, 2014). Through its numerous applications, AI can materialize the vision of Intelligent Manufacturing (IM) to further increase overall productivity (Li et al., 2017). Moreover, AI can significantly affect not only the way humans use and interact with computers and machines, but also impact Machine-to-Machine (M2M) communication (Lee et al., 2018). AI is also able to provide sophisticated, intelligent and autonomous decision-making systems and provide several merits and innovative applications and solutions when used in conjunction with ML (Duan et al., 2019). Therefore, AI also plays a significant role in fulfilling the vision of Industry 4.0.

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