Chapter 11
Machine Learning and Artificial Intelligence (AI) in Manufacturing

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ABSTRACT

The integration of machine learning (ML) and artificial intelligence (AI) into manufacturing has transformed traditional processes, creating smarter, more efficient, and adaptable production systems in line with Industry 4.0 principles. Advanced AI applications can enhance automated quality control by detecting defects in real time, thus improving product reliability and reducing waste. Technologies like digital twins and generative design allow manufacturers to simulate, optimize, and innovate production processes before physical implementation, cutting down on development time and costs. In supply chain optimization, ML algorithms enhance inventory management, demand forecasting, and logistics efficiency. The benefits are substantial are challenges such as big data management, integration with legacy systems, workforce reskilling, and ethical concerns. Future trends include the emergence of autonomous manufacturing systems, sustainable AI applications, and improved interoperability through the Internet of Things (IoT) and edge computing in the manufacturing sector.

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INTRODUCTION TO MACHINE LEARNING AND AI IN MANUFACTURING

Manufacturing has long been a cornerstone of economic growth and technological advancement, driving industrial revolutions and shaping global economics. Over the years, this sector has evolved from manual production to mechanization, automation, and digitalization. The advent of Industry 4.0 marks the latest evolution, blending traditional manufacturing processes with cutting-edge technologies to create intelligent, interconnected systems. In developments in the manufacturing industry, sustainable development activities in the manufacturing industry are always integrated with Industry 4.0. (Hussain, Akhunzada, Iqbal, Bibi, & Gani, 2021; Patalas-Maliszewska & Łosyk, 2022).

The rise of machine learning (ML) and artificial intelligence (AI) has catalyzed a monumental shift in the manufacturing sector. These technologies are revolutionizing how manufacturers operate by unlocking data-driven insights and enabling unprecedented levels of efficiency, innovation, and adaptability. Industry 4.0, characterized by the convergence of digital, physical, and cyber systems, has been a pivotal force in this transformation. Key technologies such as big data analytics, Industrial Internet of Things (IIoT), and machine learning are increasingly adopted to enhance productivity, optimize processes, and improve decision-making capabilities (Antony et al., 2024; Nacchia, Fruggiero, Lambiase, & Bruton, 2021). Figure 1 shows the scope of machine learning in manufacturing.

Figure 1. Machine learning in manufacturing