Chapter 13
Computational Intelligence in Manufacturing Technologies

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ABSTRACT

This chapter delves into the fusion of machine learning and artificial intelligence, emphasizing both supervised and unsupervised learning methodologies, as well as their implementations in deep learning, AI-powered automation, and robotics. The text explores the correlation between cyber-physical systems (CPS) and the internet of things (IoT), showcasing their influence in the development of intelligent factories through the analysis of real-life examples. The chapter examines and evaluates the difficulties encountered in the implementation of these technologies, encompassing technological, organizational, and ethical obstacles. Ultimately, it anticipates upcoming developments, highlighting nascent technology, the partnership between humans and machines, and the necessity for flexible policies and regulations. This thorough investigation provides a strong argument for the essential requirement of computational intelligence in tackling current manufacturing difficulties and emphasizes its extensive capacity for innovation and enhancement in the sector.

DOI: 10.4018/979-8-3693-5762-0.ch013

INTRODUCTION

Industry 4.0 represents a significant shift in manufacturing, where modern technologies like artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), and cyber-physical systems (CPS) are integrated (Gröger et al., 2020). This chapter examines the crucial significance of computational intelligence in the field, investigating its definition, extent, and significant influence on contemporary manufacturing procedures (Ng and Law, 2020). Computational intelligence refers to a variety of technologies that allow robots to imitate human cognitive abilities. This, in turn, improves manufacturing operations by increasing efficiency, accuracy, and adaptability. By utilizing these technologies, manufacturers may attain unparalleled levels of automation, streamline production workflows, and sustain a competitive advantage in the global market.

The chapter's structure is intentionally designed to offer a thorough overview of computational intelligence applications in manufacturing. It covers everything from basic concepts to actual implementations and future trends (Mohamed and Hasan, 2020). After this introduction, the chapter is structured into multiple crucial sections. The initial portion delves into the fundamental elements of machine learning and AI, encompassing supervised and unsupervised learning, applications of deep learning, and automation powered by AI. The following sections explore data analytics and big data, emphasizing the significance of gathering data, predictive analytics, and making decisions in real-time. The following analysis focuses on the integration of CPS and IoT, specifically exploring the implementation of smart factory principles and various applications of IoT. The text discusses the practical uses of computational intelligence in quality control, production optimization, and supply chain management. It also analyzes the problems involved in implementing these applications. Lastly, the chapter ends with an examination of upcoming patterns, highlighting developing technology, cooperation between humans and machines, and the consequences for policies. This extensive investigation seeks to provide readers with a complete comprehension of how computational intelligence is transforming the industrial business.

Overview of Industry 4.0

Industry 4.0, or the 4th Industrial Revolution, signifies a fundamental change in manufacturing where digital technologies are seamlessly incorporated into physical production settings (Bhambri, 2024a). This revolution utilizes progress in automation; data interchange, and automated processes to establish smart factories that possess exceptional adaptability and efficiency. The fundamental elements of Industry 4.0 consist of the IoT, cyber-physical systems, analytics for big data, and cloud computing