Chapter 12
Optimizing Manufacturing Processes With Neural Network–Based Quality Control

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ABSTRACT

This chapter discusses how progress made in the area of neural networks has helped to revolutionize the issue of quality assurance in manufacturing systems. It starts by reviewing some of the past approaches to quality control with a view of showing how they fail to meet today's manufacturing demands. The availability of neural networks (deep learning and reinforcement learning) is put forward as a realistic solution to increasing the efficiency of defect detection and improving the process. The chapter also gives an outline of neural network systems with the emphasis of data acquisition, data preprocessing, and choice of the neural network architecture of the implementation tools and platforms, such as TensorFlow and PyTorch. Quantitative findings derived from the case analysis show better enhancement in the defects rate and quality scores when using neural networks instead of traditional techniques.

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INTRODUCTION

Quality control (QC) is broadly defined as the activities employed to guarantee that goods within a manufacturing line conform to the necessary standard and quality. They subsume a set of planned and coordinated activities that help avoid the generation of defects and guarantee the fulfillment of quality standards in the manufacturing process. No doubt, qualification control is vital since it reflects the customers' response, business image, and organizational effectiveness (Agme, N., K. Prasad, S. R. Kawale, and S. Mallikarjun 2024). The typical methods of QC basically entail hand-checking and statistical sampling procedures which may not respond to the rapid changes inherent in today's production processes. But as industries become more complex, purely mechanical ways of production can prove to be cumbersome and expensive (Anandaram, H., and M. R. G. 2022). This has to do with the need to achieve increased efficiency in the current environment as manufacturers seek to increase the production rate while maintaining satisfactory quality. Process control refers to the enhancement of specific sequences in the production line, minimization of excesses and adoptions of efficiency to enhance high production in goods and low incidences of defects (Arvind, N. N. 2022). Optimization, therefore, goes beyond issues of cost reductions as it creates an opportunity for improvements in quality, shortens time to market, and shows the ability to respond to shifts in market conditions. In this regard, quality assurance is no longer viewed as fire fighting activity, but as a strategic activity whose aim is to achieve incremental improvement and to make decisions backed up with strong qualitative and quantitative evidence (Ashreetha, B., M. B. Kumar, and K. Karthikeya 2024).

The novelty in the domain of quality control could be attributed with Neural Networks which falls under Artificial Intelligence or machine learning. These models are intended to identify different structures within the structures of huge sets of data to help manufacturers use a lot of information that is produced during manufacturing. Such systems can take data from sensors, production tools (Aswath, G. A. S. 2021), and quality and perform forecasts and conclusions based on this data for the purpose of decision making. Indeed one significant strength of artificial neural networks is that they can process large volumes of data and learn from them and change when new data is fed to them and therefore are very useful in manufacturing environments where conditions and requirements at times can change frequently.