Chapter 18
Literature Review on the Study of Non-Qualities of a Product Using Neural Networks

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ABSTRACT

The purpose of this study is to use the neural networks method in order to build a neural network system that studies and determines the cause of non-conformities. Companies are regularly confronted with quality problems stemming both from assembly mistakes and also during upstream stages in the process, like design, logistics, technical, and industrial support. These problems would sometimes reach the end customer inducing huge losses for the companies in term of costs and reputation. Therefore, an improvement of non-conformities detection systems as well as the identification of their causes is necessary, which is the purpose of this chapter. First, per the authors, this chapter discusses non-conformities in the industrial field and the management of quality problems. Then, the neural networks method is presented, as well as a review in its recent development and its applications. As a result, the steps to building the neural network system to study non-conformity causes are defined and described.

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INTRODUCTION

The industrial performances have been a major concern for companies since the beginning of the industrial era. However, its evaluation has evolved from a single productivity indicator to a global and multi-criteria evaluation policy. In recent years, there has been a growing consensus in the operation management field about the benefits of drawing insight from major theories in other fields such as economics, management (Buhman et al., 2005; Handfield, 2006; Sousa & Voss, 2008). Theories in system engineering also recommend thinking in terms of a total system, rather than just a specific discipline (Hasking 2006), especially the risk management field which requires an interdisciplinary approach for better understanding and management of the different industrial risks (Magne & Vasseur, 2006). Industrial risks are defined as risks that have to be considered by organizations that build, run, and control industrial facilities (Magne & Vasseur, 2006). Among these industrial risks, this paper focuses on the risk of non-conformities in product delivery reaching the customer. A product recall represents the worst non-conformity propagation case, in which a defect has reached the final customer. It questions the performance of the protection system of industrial companies set up to protect them against non-conformities.

These protection systems, or quality control systems, are often grounded on the experts' knowledge and risk analyses. There are many risk analysis techniques that exist (Tixier et al., 2002) and can be classified in two main categories: Tree analyses (failures, root causes, butterfly), which start from a feared event in order to find the causes and consequences, and Systematic analyses (FMEA, FMECA, HAZOP).

From these analyses, actions are undertaken, and layers of protection are set up. Layers of protection (Summers, 2003; Gowland, 2006; Duijm, 2009) illustrate the efforts to prevent failures' propagation and to stop them as close as possible from their origin in order to limit their impact at least in terms of costs. In the industrial quality field, these protection layers are, for example, control charts, preventive maintenances, acceptation tests, and inspections. However, the problem remains: how can we study the defects and non-conformities and determine their causes ?

One of the most interesting methods by which we can proceed with this study is Artificial Neural Networks. It's a calculation method that builds several processing units based on interconnected connections. It is a part of a computer system that mimics how the human brain analyzes and processes data. Self-driving vehicles, character recognition, image compression, stock market prediction, risk analysis systems, drone control, welding quality analysis, computer quality analysis, emergency room testing and oil and gas exploration are some of the applications of artificial neural networks.

Neural networks have been applied in many fields and have achieved breakthrough successes, such as those in image and data processing (Tong et al., 2023; Yang, 2023; Chamanbaz & Bouffanais, 2023). Although a deep structure helps a network extract more information than a shallow structure, most deep networks suffer from difficulties in training and theoretical analysis because a deep network involves a great number of parameters and complicated structures (Li et al., 2017). Fortunately, it has been observed that increasing the network width makes training easier (Rudin et al., 2022). It has been suggested in recent papers that if the width significantly exceeds the number of training samples, the training error can be reduced to 0 via gradient descent, and the generalization of the trained network remains good (Lin et al., 2021; Yang et al., 2022).

In this context, this paper focuses on the use of neural networks in the quality field, and more specifically to detect non-conformity causes. First of all, we will talk about non-conformities in the industry and the management of quality problems. Then we will present the neural networks method, as well