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Application of Neural Network in Shop Floor Quality Control in a Make to Order Business

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Abstract

A make to order business has to produce the products that are customized to the customer's current need. The customization can be realized by assembling different standard parts with various 'configurations'. The oil field service industry is a typical example where most products produced are cylindrical assemblies made up of standard parts customized in their size, material specifications, coating specifications, and threading suited for the particular load rating and environment. As business cycles go up and down, hiring and firing of personnel is the routine of the day. Thus, it is very hard to keep experienced inspectors due to high turnover of the staff on shop floor and thus intensive endeavor to train the inspectors for the same recurrent problems of the same standard parts is required. This paper proposes a neural network model to help the industrial practitioners address such a concern. The neural network is trained with ample 'judgment calls' from the manufacturing experts so that it can properly generate the decision to 'scrap', 'rework' or 'use as is' for the inspected parts. The real quality data from an oil field service industry is used to validate the effectiveness of the proposed tool.

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1. Introduction

Globalization has made operation in different economies an essential strategy for many industrial practitioners. This high level of competition amongst manufacturers has led to rapid development in the different manufacturing paradigms such as computer integrated manufacturing[1], flexible manufacturing[2], agile manufacturing[3], and intelligent manufacturing[4]. Such development has in turn generated a need for intelligent sensing and decision making systems capable of automatically performing many tasks traditionally executed by human beings[3].

Specifically, in such a business environment, a make-to-order manufacturing industry has to operate under additional constraints in comparison to standard mass manufacturing enterprises. The traditional manufacturing buzzwords like lean, six sigma, and kaizen may not be directly used on the actual shop floor due to the presence of a high degree of customization offered in their product portfolio. Most of the lessons learned and experience obtained may be limited to a small part of experienced manufacturing personnel and cannot be translated into effective process standards and widespread to the entire team on the shop floor due to high turnover of plant staff, which is used as a major labor strategy to deal with a highly cyclic and volatile business environment (e.g., oil industry).

In addition, manufacturing companies tend to benefit from the cost advantages available in developing economies. They try to achieve the same production quality considering the fact that different levels of skill and education do exist amongst manufacturing personnel in different countries. Thus, a burgeoning demand for “smart systems” consisting of advanced machine learning tools that are capable of retaining experience and automating low end repetitive work has been generated. The advantage of such "smart systems" is that they can utilize the reliability and speed of computers, while offering the flexibility and cognitive abilities of human beings[5], so that some repetitive and labour-intensive tasks (e.g., quality inspection) originally executed by human beings on shop floor can be implemented by such “smart systems”. The training cost for the new employed employees can be reduced and the reliability of the results of such tasks can be improved.

In this paper, we explore the feasibility of the utilization of neural network (NN) approach, a typical machine learning tool, for the application of quality inspection in oil industry. The rapid growth in automated manufacturing has made full-fledged human like intelligent machines possible[5]. This has provided a solid basis and environment where advanced “smart systems” can be implemented. The replacement of manual inspection procedures through the introduction of automated techniques offers a number of significant commercial and social advantages, including elimination of human error and/or subjective judgment, improved operational efficiency, creation of timely statistical product data, improved safety, better working conditions, and reduced labour costs[6].

NN is an adaptive learning mechanism which is able to learn and expand its experience continuously. It is an effective tool to allow the machine to do the repetitive tasks. In addition, the speed and accuracy provided by today’s computing power can enable manufacturing units to achieve needed cost edge in today’s market. NN is unique in comparison to traditional approaches regarding its ability to learn and make associations between new patterns and cluster data. It can recall the information once the network is presented with similar input[5]. The back propagation algorithm in NN is able to provide better results with sparser data compared with statistical approaches[7]. Several advantages such as processing speed, adapting ability, and robustness of the NN application in manufacturing applications have been enumerated in the literature[8]. The NN applications in manufacturing areas such as design, scheduling, process planning, and control have also been discussed[8], e.g., manufacturing stock price prediction[9], crude oil price forecasting[10], etc.

Regarding the application in quality control, several research has also been reported[11, 12, 6 and 13]. For example, NN application in textile seam (one type of defect) identification has been carried out by means of a self-organising map algorithm[11]. It employed image acquisition, feature extraction, and classification for locating the defect (seam). Another example is that the detection of causes of casting defects has been carried out through NN[12] using simple multilayer feed forward networks.

In this study, NN is applied to shop floor quality inspection in a make-to-order manufacturing enterprise in the oil field service industry using real data from our industrial collaborator. The decisions regarding ‘Scrap’, ‘Rework’, and ‘Use as is’ will be generated using NN approach. The results in terms of accuracy percentage using different NN algorithms will be obtained and compared to the manual inspection. The best algorithm will be recommended. The rest of the paper is organized as follows. Section 2 discusses the research methodology. It lists the data source, the