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Quality Control Using Agent Based Framework

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INTRODUCTION

Quality control (QC) is a process employed to ensure a certain level of quality in a product or service. One of the techniques in QC is to predict the product quality based on the product features. To date, However, traditional QC techniques have faced some drawbacks such as being heavily dependent on the collection and analysis of data and frequently associated with dealing with uncertainty processing. In order to improve the effectiveness during a QC process, an agent-based hybrid approach incorporated with data mining techniques such as Rough Set Theory (RST), Fuzzy Set Theory (FST) and Genetic Algorithm (GA) is proposed in this book article. Under the agent-based framework, each agent is able to perform one or more functionality during the entire QC process. Based on empirical case study, the proposed solution approach provides a great promise in QC processes.

BACKGROUND

To date, quality has given attention to a manufacturing strategic plan to increase efficiency of the company through improving resource utilization and satisfying the needs of customers in terms of price and reliability, with result in achieving manufacturing success in a highly competitive manufacturing market (Bothe 1997; Relyea 2011).

In recent literature, it indicates that quality is the only strategic component that influences manufacturing performance (Amoako-Gyampah and Acquaah 2008). To ensure the quality in a machining process, it is important to response the dynamic environment quickly. Some machining processes, operated by human resource, contain high uncertainty and may be difficult in automation implementation. Therefore, it is crucial to discover the significant features for the production process to facilitate quality analysis and control.

According to literatures, decision rules are appreciated to support for the QC procedures while diverse variations occur in the machining process (Xu *et al.* 2011). Moreover, the QC issues are normally associated with different data formats/structures and observed in the manufacturing process. In other words, the QC related operations and entities are therefore distributed in a heterogeneous environment. Consequently, an effective prediction model utilized significant features for part quality is demanded in contemporary manufacturing.

The literatures of agent technology applied in QC area are numerous. For example, Ouyang *et al.* (2009), Sepúlveda *et al.* (2007), Chakravorty (2009) that describe QC models composed of software components that represent the types of agents. However, few previous literatures focus on "efficient quality improvement" and "data integration." The aforementioned studies did not provide a whole picture of agent-based QC crossing all functions and propose a global architecture for agents, specifically focusing on efficient quality improvement. Furthermore, they do not consider the

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heterogeneity problems while the agent technology is applied. The objective of this book article is to develop an agent-based system to enhance the efficient quality improvement and solve the heterogeneity related problems. The agents in the system autonomously plan and pursue their actions and sub-goals, to cooperate, coordinate, and negotiate with others, and to respond flexibly and intelligently to dynamic and unpredictable situations in a virtual way.

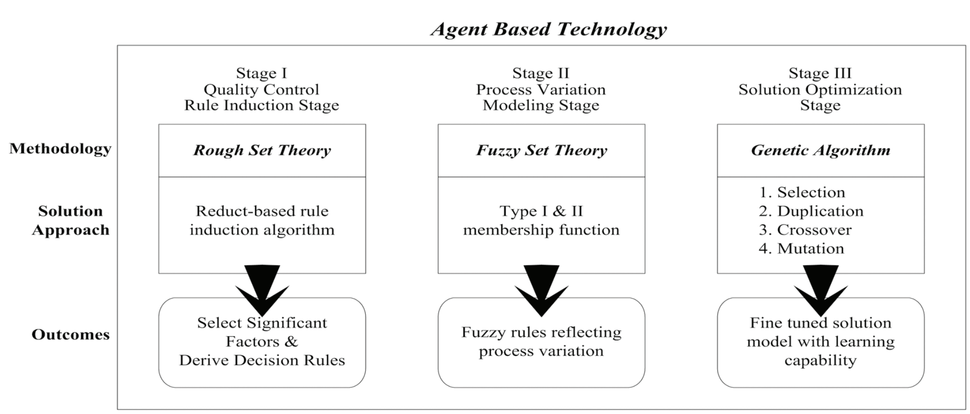
In this article, the agent based framework is proposed to augment effective part quality control. Under the agent technology based framework, three main stages are identified and constructed for the QC prediction system (Figure 1).

Stage 1: The feature & rule induction stage: A Rough Set (RS) based rule induction approach to select significant features and derive decision rules is used at this stage. Basically, features characterize each object in the database, and the approach discovers the dependencies between features and objects. By employing the concept of reduct in RST, the most significant set of features can be identified. For instance, the RS approach is able to identify "defective" and "significant factor" simultaneously, which is unique and useful in solving quality control problems. Compared with the conventional statistical tools that use a population based approach, the RS based approach uses an individual, object-model based approach that makes a very good tool for analyzing quality control problems (Derrac *et al.* 2013). In addition, the statistical method can't handle linguistic variables and uncertain or incomplete information. Rough set-based rule induction is able to generate decision rules from a database and has mechanisms to handle noise and uncertainty in data. Through using these meaningful decision rules, the technique facilitates managerial decision-making successfully (Huang *et al.* 2013).

Stage 2: The quality prediction stage: After significant features are identified at stage 1, a Fuzzy Set (FS) approach is used due to the following reasons: First, the FS method enables fast and easy synthesis and modification of the control rule base; second, the FS method can be integrated into the quality controller to compensate for process variations. The FS application includes Type 1 and Type 2 FS. Different types of FS express different strengths to handle heterogeneous factors as well as variables in the process. By support from the type-1 fuzzy sets which were introduced by Zadeh (1965), it is able to deal with the "crisp" type of the membership function. Type-2 fuzzy sets were also introduced by Zadeh (1983), whereas it is suitable to handle "uncertain" type of membership and the variable is highly correlated to time (e.g., tool wear during the machining process). The Type 2 FS has not been widely used to solve machining process problems thus making this study unique.

Stage 3: optimization stage: At this stage, Genetic Algorithms (GA) is used to train membership function at Stage II in order to implement fuzzy solution optimization. The combination of the unique strength at each stage is anticipated to provide better solutions for product quality analysis. Based on the aforementioned descriptions, the main research contribution in this book article is to develop a novel approach to effectively determine key quality factors and decision rules coping with manufacturing process variation as well as a fine tuned perdition model with learning capacity.

Figure 1. The framework of the proposed hybrid data mining approach



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