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A hybrid OLAP-association rule mining based quality management system for extracting defect patterns in the garment industry

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ABSTRACT

In today's garment industry, garment defects have to be minimized so as to fulfill the expectations of demanding customers who seek products of high quality but low cost. However, without any data mining tools to manage massive data related to quality, it is difficult to investigate the hidden patterns among defects which are important information for improving the quality of garments. This paper presents a hybrid OLAP-association rule mining based quality management system (HQMS) to extract defect patterns in the garment industry. The mined results indicate the relationship between defects which serves as a reference for defect prediction, root cause identification and the formulation of proactive measures for quality improvement. Because real-time access to desirable information is crucial for survival under the severe competition, the system is equipped with Online Analytical Processing (OLAP) features so that manufacturers are able to explore the required data in a timely manner. The integration of OLAP and association rule mining allows data mining to be applied on a multidimensional basis. A pilot run of the HQMS is undertaken in a garment manufacturing company to demonstrate how OLAP and association rule mining are effective in discovering patterns among product defects. The results indicate that the HQMS contributes significantly to the formulation of quality improvement in the industry.

1. Introduction

Nowadays, customers are seeking products of high quality and low cost. Manufacturers are urged to achieve better quality in their products so as to stay competitive in the industry. Unfortunately, variance in product quality is unavoidable as it can be induced by many factors during production. One of these critical factors is the workmanship which commonly exists in labor-intensive industries where many production processes are performed manually. In the garment industry, human factors such as different levels of skill, years of experience and human errors may result in garment defects in some circumstances. In order to produce high-quality and low-cost products, it is important to achieve quality improvement while at the same time to identify any product defects at an early stage. Unfortunately, it is challenging to maintain the quality of garments which are processed manually. It is thus necessary to inspect products carefully so as to ensure they are of good quality. Traditionally, garment defects are identified by human inspectors who treat each defect individually without being aware of the relationship between different defects, thus making causal analysis and defect prediction difficult.

Fig. 1 depicts the existing problems in handling quality problems in the garment industry. There are various departments responsible for different tasks along the production workflow from product design to final product inspection. Hence, it is difficult for manufacturers to identify the department to which a particular garment defect should be attributed, and the root causes of the defects. This shows that there is a lack of information to tackle product quality problems. Manufacturers do not have timely information to analyze defect causes and individual departments fail to be aware of any possible defects that they might be causing. In addition, owing to the complexity of garment manufacturing processes, there are numerous defects which can be found on a single garment. Without any tools to manage massive relevant data and identify the hidden pattern among defects, manufacturers are unable to discover any correlations between defects, or the reasons for different defects. This indicates the lack of a mechanism for investigating defect patterns which could be useful in defect prediction and defect diagnosis. The problems outlined above will certainly lead to bad consequences for the garment industry, such as failure in achieving quality improvement, low customer satisfaction, high rework cost and long production cycle times. With the aim of tackling these problems, this paper presents an intelligent system, namely hybrid OLAP-association rule mining based quality management system (HQMS), to extract garment defect patterns in

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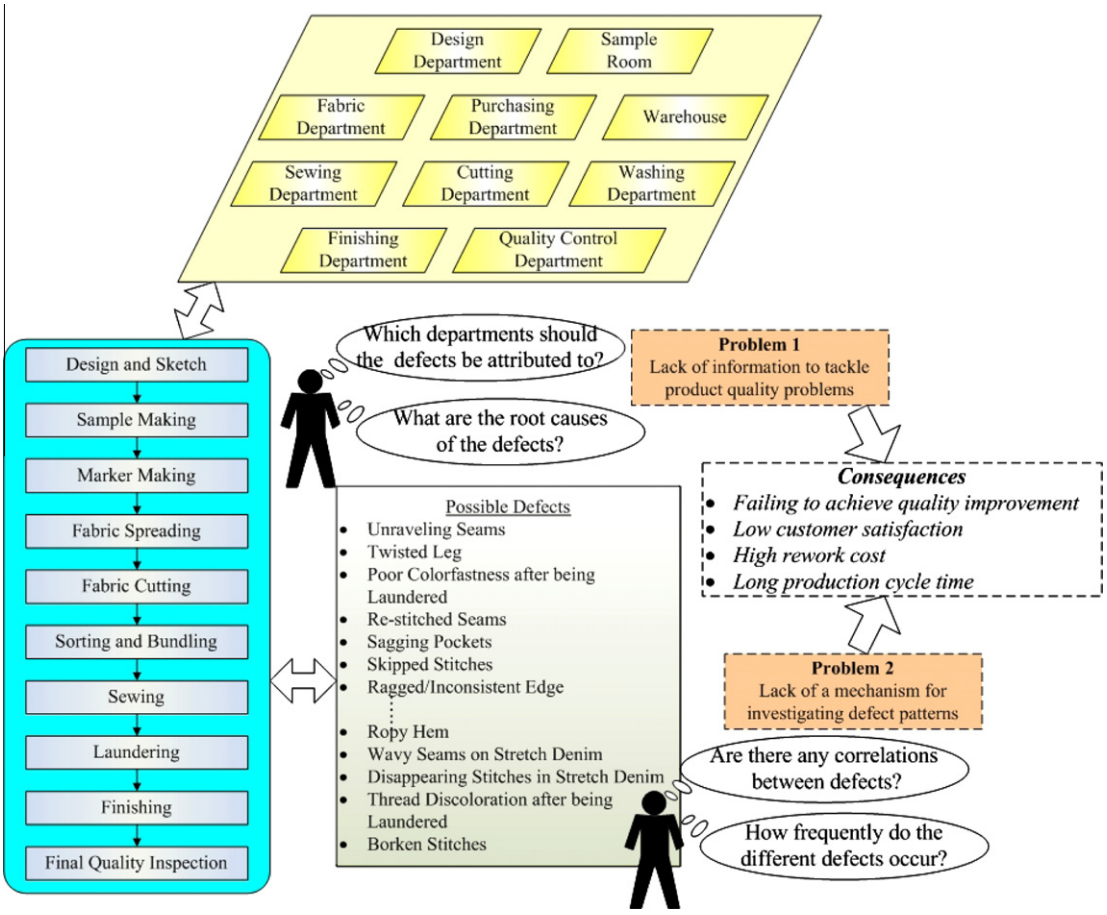

Fig. 1. Existing problems in handling quality problems in the garment industry.

the form of association rules so as to formulate useful quality improvement plans. To provide manufacturers with the ability to explore different kinds of desired data effectively and mine data at different levels, Online Analytical Processing (OLAP) is also applied in the system that is developed.

This paper is organized as follows: Section 2 is a literature review related to this study. In Section 3, the architecture of the HQMS is proposed. Section 4 contains a case study where a pilot run of the system is conducted in a case company. In Section 5, the discussion of the HQMS is presented. Finally, Section 6 is the conclusion.

2. Related studies

Owing to increased economic and environmental pressures in recent years, customers now have higher expectations of products. They are now seeking products which can fulfill environmental requirements, are of high quality but low in cost. These changes present a formidable challenge to product quality improvement. In order to respond to the market changes, manufacturing firms have shifted their attention to quality control and improvement of their products. In many manufacturing sectors, product defects can be eliminated with better machine and process settings. This arouses the interest of many researchers to solve product quality problems by dealing with operation parameters. Ferreiro, Sierra, Irigoien, and Gorritxategi (2011) developed a model for burr prediction during drilling processes by taking machine settings such as that of the drill bit and drilling velocity into account. Lau, Ho, Chu, Ho, and Lee (2009) proposed a methodology for quality management with knowledge discovery based on quantitative process values including the temperature setting of machines, the thickness of the product and the time spent in cleaning. Lou and Huang (2003) developed an intelligent decision support system for defect reduction in automotive coating by recommending changes in process parameters such as the booth air temperature, humidity and the viscosity of the paint. However, in labor-intensive industries, adjustment of machine and process parameters may not be fully applicable to the resolution of their product quality problems which could be caused by workmanship rather than by machines.

Because of the error-prone nature of labor-intensive manufacturing processes, inspection of semi-finished products and finished products is critical in labor-intensive industries. In particular, inspection of garment products usually solely relies on human effort (Yuen, Wong, Quan, Chan, & Fung, 2009), resulting in biased inspection results (Wong, Yuen, Fan, Chan, & Fung, 2009). With the aim of achieving better quality control and improvement of garment products, researchers have started investigating the possibilities of automatic detection of defects which exist in the textile and garment industry. Mak, Peng, and Yiu (2009) proposed a novel defect detection scheme to facilitate automated inspection of woven fabrics. Wong et al. (2009) combined wavelet transformation and a neural network to detect and classify stitching defects. In a similar vein, Yuen et al. (2009) presented a novel hybrid model combining genetic algorithms and neural networks to detect stitching defects. It is found that existing works related to fabric or garment defects focus mainly on automated inspection systems. Yet, little effort has been paid to garment defect diagnosis, such as