Intelligent Quality Management using Knowledge Discovery in Databases

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***Abstract*—The application of data mining and knowledge discovery technologies in total quality management (TQM) expert system will certainly become one of the focuses of the quality engineering research field. This paper proposes an intelligent TQM expert system with knowledge discovery in databases. The intelligent quality management system is equipped with the "data mining" feature to provide quality knowledge with the ability to understand the relationships between the enterprise management processes. The realization scheme of knowledge discovery model in large-scale quality database is also given. The proposed system can solve the "knowledge bottleneck problem" in conventional quality system and improve the cooperative ability for monitoring the process effective, efficient and adaptable.**

Keywords-knowledge discovery; data mining; total quality management; quality control; expert system

I. INTRODUCTION

In today's competitive industrial environment, insisting on quality is always the only way to survive in an enterprise. High-reliability and high-quality products play an important role in achieving customer satisfaction. To achieve customer satisfaction and high-quality products is the key element to enhance an organization's competitive position in the marketplace. However, poor process decisions from any individual may lead to poor customer satisfaction. The ultimate goal is to achieve better collaboration for making right decisions all the time in every process involved [1].

Product design and manufacturing are important for the production of high-quality goods. In addition to high-quality manufacturing, inspection and testing, quality should be taken into consideration in the design stage. In order to reduce the cost of product rework, quality predictions can be used to perform manufacture feasibility evaluation, identify potential quality problems and provide guidance for quality improvement. In fact, to achieve high quality is not the responsibility of any one person or functional area; it is everyone's duty in the entire corporation.

Although numerous empirical and scientific approaches have been developed in the field of quality management, past research has not addressed this issue well enough, nor has actual practice managed to optimize the integrated workflow in order to make sure that all the participants have the possibility to act successfully in their processes. The concept of total quality management (TQM) is a technique for continuous improvement of production processes, which leads to high-quality products with lowest cost.

Having the concept of TQM in mind, it is possible to develop an intelligent system to capture quality audit data from different processes during manufacturing so as to discover meaningful patterns and knowledge for future improvement.

Traditionally, various functional disciplines have had their own information systems for quality control. However, the fact that quality improvement is a distributed and cooperative problem-solving activity has been neglected. Therefore, attention should be paid to capturing the distributed process data to support knowledge discovery (KD) within the workflow of the enterprise. Knowledge takes different forms and lacks a structure; artificial intelligence (AI) makes it possible to store premises, rules, and variables in the knowledge base in a structured manner. The knowledge management (KM) can effectively produce and deliver intelligence for decision-making in both government and business. The extraction of knowledge from the current information is called data mining (DM), and the ultimate goal of DM is to discover knowledge about processes from correlative databases, i.e. knowledge discovery in databases (KDD).

In this paper, we proposed the quality knowledge discovery model and the realization scheme of subsystem in large-scale quality database according to the characteristic of TQM. This research can effectively solve the "knowledge bottleneck problem" in expert decision-making system, provide new knowledge for it, and create conditions for realizing real intelligent quality control.

II. KNOWLEDGE DISCOVERY DATABASE

KDD can be considered an interdisciplinary field involving different concepts from machine learning, statistics, database query, and visualization. While the purpose of database technologies is to find efficient ways of storing, retrieving, and manipulating data, the main concern of the machine learning

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and statistical communities is to develop techniques for extracting knowledge from data. KDD is the process of identifying valid, novel, potentially useful, and ultimately understandable patterns or models in data [2]. And as a process, it implies the accomplishment of different tasks, most of which can be realized only by means of automatic tools. Such tools come from different research areas, like databases, machine learning, artificial intelligence, statistics and so on.

KDD also refers to the overall process of discovering useful knowledge from data. It involves the evaluation and possibly interpretation of the patterns to make the decision of what qualifies as knowledge. DM is a step in the knowledge discovery [3][4] process consisting of algorithms that, under some acceptable computational efficiency limitations, find patterns or models in data. Practical data mining requires a lot more than application of sophisticated techniques like neural networks or decision trees to a table of data. The two "high-level" primary goals of data mining, in practice, are prediction and description.

• Prediction involves using some variables or fields in the database to predict unknown or future values of other variables of interest.

• Description focuses on finding human-interpretable patterns describing the data.

The process of data mining consists of three stages:

(1) The initial knowledge gathering. (2) Pattern identification with validation and verification. (3) Predictions.

Data mining techniques [5][6] can be applied in solving problems across different industries and business sectors like Banking, Biotechnology and pharmaceutical industry, Customer Relationship Management (CRM), e-Commerce, Fraud detection, Human resources, Marketing, Real time decision making, Stock and investment analysis and prediction.

III. Issues Within Total Quality Mangaement

"Total Quality Management" system is a kind of quality control system based on the information integration technology, takes combination between quality control and quality management as main principle, and fulfills enterprise's long-term operating strategies finally [7]. Reviewing previous contributions a dominant insight among experts seems to define TQM as an approach to management characterized by some guiding principles or core concepts that embody the way the organization is expected to operate, which, when effectively linked together, will lead to high performance. Although with some differences, there is a general agreement regarding the assumptions included in the TQM concept, which can be summarized in three main points [8].

Firstly, the core concepts of TQM can be classified into two broad categories or dimensions: social (soft TQM), and technical (hard TQM). The social issues are centered on human resource management and emphasize leadership, teamwork, training, and employee involvement. The technical issues reflect an orientation toward improving production methods and operations and seek to establish a working method through the establishment of well-defined processes and procedures to make possible the constant improvement of goods and services to customers.

Secondly, the management of social or technical TQM issues cannot be performed in isolation. Social and technical dimensions should be interrelated and mutually support one other reflecting the holistic character of TQM initiatives.

Thirdly, the basic theoretical foundation for this relationship is based on the assumption that TQM provides superior value to the customer by identifying customers' expressed and latent needs, responsiveness to changing markets, as well as through improving the efficiency of the processes that produce the product or service [9].

From hard TQM, a great deal of online detection data, resources allocation data and status information are produced and accumulated on automatic assembling lines everyday, especially in the modernization enterprises. How to extract useful TQM information from this primary database and realize quality control and assistant decision-making based on data mining, is of great value in practical application.

This papers attempts to propose an intelligent quality management system embracing data mining technology and knowledge discovery in databases. The basic thought is to integrate the information of quality control and quality management to primary database, and establish intelligent quality knowledge discovery system and quality evaluation decision system.

IV. Development of KDD in Quality Management Field: Quality Discovery in Databases

In order to survive in the increasingly customer-oriented marketplace, exceeding customer expectations marks the fastest growing quality contributing to an organization's success. Most of the customers do not mind paying a little bit more for a higher quality product. Therefore, in a free enterprise system, it is necessary to improve quality and reduce manufacturing cost on a continuous basis [10].

Quality improvement has got a number of effective AI and data mining techniques with a wide range of applicability. Since there are a lot of techniques available, there are many options for quality engineers to select appropriate techniques in different areas. Nevertheless, this situation poses difficulties as to the correct use of the different techniques, since most of such techniques have their own capabilities and yield results valid only within specified objectives. The need for choosing the most adequate technique for this research shows that it is necessary to coordinate the vastly distributed process data in an integrated manner and conduct a correlation analysis between process parameters and finished quality for continual quality improvement.

The challenge is to develop more sophisticated techniques that can assist quality or process engineers in analyzing distributed process data easily and quickly so as to streamline the integrated workflow within the enterprise [11]. It results machine learning, pattern recognition, large-scale database technique and artificial intelligence to technology convergence

in quality management field, and develops into quality discovery in databases (QDD).

V. QUALITY DISCOVERY IN DATABASES

The quality discovery system in databases is designed to capture the distributed process data from different processes within the integrated workflow and convert the data into knowledge in terms of artificial intelligent method along the workflow, which have positive or negative impacts on the quality of the finished products. In fact, it also allows process or quality engineers to access an object-oriented repository to retrieve the updated current inspection status of different processes.

The generic architecture of the system consists of three main modules namely, data preparation, knowledge discovery and data mining as shown in Figure 1.

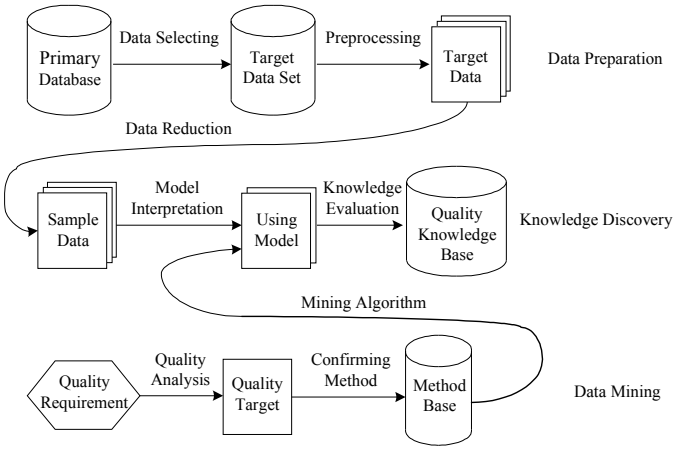

Figure 1. The generic architecture of the QDD system

Data preparation module can reduce data dimensions furthermore, enhance valuable quality information and simplify the operation effectively, through eliminating unnecessary or lighter influential attribute. In the module, there are three main links namely, data selection, preprocessing, data reduction. Data selection is used to collect relevant data from the primary quality database according to the need for quality knowledge discovery. The main function of preprocessing link is reducing the noise, looking over integrality and consistency of quality data and dispelling the redundant data. Data reduction can analyze the initial characteristic attribute of the dataset further after reducing the amount of target data.

The aim of data mining module is just ascertaining the target of quality improvement. Because different quality targets will adopt different intelligent algorithms during the concrete process of quality knowledge discovery, the model will first confirm the actual types of quality discovered in the process through analysis of quality demanding. After ascertaining quality target, the suitable mining algorithms are chosen from the existing method base. Then quality mathematics model are set up through corresponding data mining algorithm.

In order to discover more effective quality knowledge, Knowledge discovery module might return to the steps of some preceding treatment sometimes, and execute repeatedly. First the relevant quality knowledge can be discovered from the sample data by using the mining model, which can also be expressed by some commonly used expression methods or specific ways. But the knowledge obtained by the above mining algorithm might not be “new” or “interesting” one.

It is necessary that the knowledge should also pass through mode explanation and knowledge evaluation. Mode explanation inspects whether the modes according with quality requirement. Knowledge evaluation can present the quality knowledge discovered in front of the engineers, check the consistency of quality knowledge, and store the “new knowledge” discovered in the quality knowledge base finally. This module would bring about the improvement of enterprise quality and monitor the processes continuously by using the artificial intelligent algorithms, the implementation process of which is discussed in the next section.

VI. IMPLEMENTATION PROCESS OF QUALITY DISCOVERY

Implementation process of quality discovery is mainly composed of quality knowledge base, primary quality database, method base and data mining module. According to the concrete characteristic of TQM information processing, basing on quality data, production process parameters and monitoring data in comprehensive quality database of TQM system, many kinds of data mining methods can be used to discover valuable quality information.

Having the concept of TQM in mind, it is possible to develop an intelligent system to capture quality audit data from different processes during manufacturing so as to discover meaningful patterns and knowledge for future improvement. A critical aspect of planning for quality improvement is to discover the relationship between process features and quality features or results automatically. Some data mining and artificial intelligence technologies (called method base here) have been shown to contribute to this and are highly effective in addressing many engineering solutions.

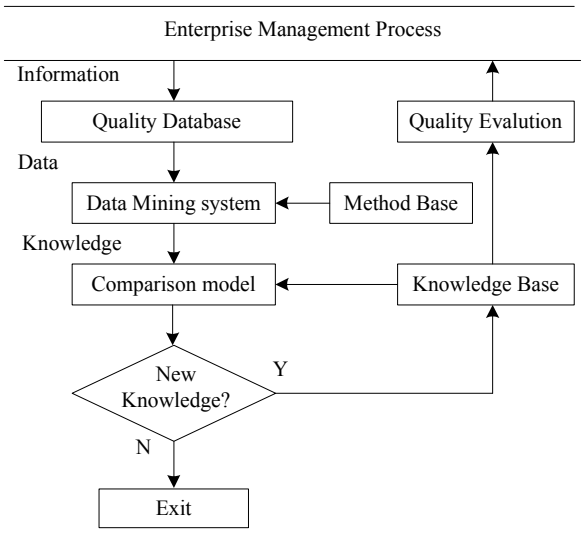

Figure 2. Implementation Process of QD

The QD technology chooses and preprocessing initial quality data in primary database, which plays a role in features extraction of quality information. The system can categorize and reason characteristic from primary quality information by reasoning machine with existing quality knowledge, evaluate the quality state in the on-the-spot production process. At the same time, the suitable artificial intelligent algorithms are chosen from the "method base" to mine quality information, finds potential quality knowledge, and compares the result with the relevant information in the knowledge base. If there is no repetitiveness between them, it can be regard as "new quality knowledge" and be sent to the quality knowledge base after reviewing. The implementation process of quality discovery is shown as Figure 2.

VII. KNOWLEDGE DISCOVERY MODEL OF "TOTAL QUALITY MANAGEMENT" SYSTEM

In the TQM system, the quality information is large-scale and complicated. But the knowledge source of the traditional quality knowledge base mainly comes from the manual summary, which is the experience sum up by relevant experts engaged in quality control. Obviously, the process of quality knowledge discovery, with very strong randomicity and uncertainty, is too complicated to human brain. Therefore, the conventional quality expert system has "bottleneck problem" of poor quality knowledge'.

How to make decision effectively on the basis of a large number of quality data seems more and more important for quality engineers. Intelligent quality discovery has already become the important tool in quality evaluation and management decision. Through intelligent quality discovery, the quality knowledge base will be established, and it will become the most important component in intelligent quality management system.

Data mining technology well meets the need of quality knowledge acquisition of TQM system. It can discover new quality knowledge from the primary quality database constantly, establishes and enriches the quality knowledge base constantly, offers the new knowledge evidence for TQM expert system.

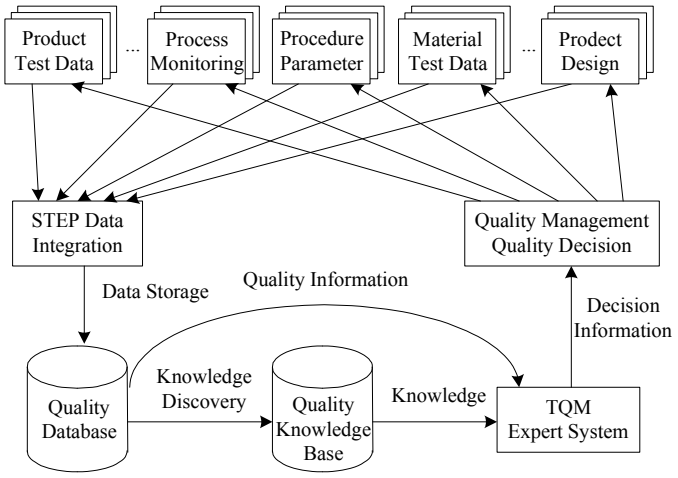

Figure 3. Knowledge discovery model in TQM expert system

The process of knowledge discovery in TQM expert system is shown as Figure 3.

VIII. CONCLUSION

The application of data mining and knowledge discovery technologies in TQM expert system will certainly become one of the focuses of the quality engineering research field. This research provided a generic methodology for the development of an intelligent TQM expert system with knowledge discovery. The methodology can extract the quality information and set up quality knowledge base and improve the self-learning ability and the cooperative ability for monitoring the process effective, efficient, and adaptable.

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REFERENCES

[1] G.T.S. Ho, H.C.W. Lau, and C.K.M. Lee, et al, "An intelligent production workflow mining system for continual quality enhancement," International Journal of Advanced Manufacturing Technology, 2006, vol. 28, no. 7-8, pp. 792-809.

[2] G. NaliniPriya, and P. AnandhaKumar, "Neural network based efficient knowledge discovery in hospital databases using RFID technology," IEEE Region 10 Annual International Conference, Proceedings/TENCON, Hyderabad, India, pp. 1-6, Nov 2008.

[3] U. Fayyad, G. Piatetsky-Shapiro, and Smyth, "From data mining to knowledge discovery: an overview," In Advances in Knowledge Discovery and Data Mining, MIT Press, 1996, pp. 1-34.

[4] D. Hill, and R. Moran, "Enterprise Data Mining Buying Guide: 1997" Edition, Aberdeen Group, Inc.

[5] P. Srinivasan, "Data mining at the crossroads: successes, failures and learning from them", In Proceedings of KDD'2007, pp. 1053-1055, ACM 2007.

[6] M. Chen, J.Han, and P. Yu, "Data Mining: An Overview from the Database Perspective," IEEE Transaction On Knowledge and Data Engineering, 1996, vol. 8, no. 6, pp. 866-883.

[7] A. Azadeh, "Design and development of integrated quality control system," SICE Annual Conference, Okayama, Japan, 2005, pp. 3090-3094.

[8] H. Eriksson, and R. Garvare, "Organisational performance improvement through quality award process participation," International Journal of Quality & Reliability Management, 2005, vol. 22, no. 9, pp.894–912.

[9] J.C. Bou-Llusar, A.B. Escrig-Tena, and V. Roca-Puig, "An empirical assessment of the EFQM Excellence Model: Evaluation as a TQM framework relative to the MBNQA Model," Journal of Operations Management, 2009, vol. 27, no. 1, pp. 1-22.

[10] G.T.S. Ho, H.C.W. Lau, and C.K.M. Lee, "An intelligent production workflow mining system for continual quality enhancement," International Journal of Advanced Manufacturing Technology, 2006, vol. 28, pp. 792−809.\

[11] H. Bae, S. Kim and K.B. Woo, "Process control and management of etching process using data mining with quality indexes", First International Conference on Natural Computation 2005, Changsha China, Aug 2005, pp. 1160-1169.