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Modeling of image, video and text fusion quality data packet system for aerospace complex products based on business intelligence ☆

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ABSTRACT

For the construction of image, video and text fusion quality data packet system during the whole life of complex products, a business intelligence-based logic modeling method is proposed in this paper. As the amount of Polymorphic data from multiple distributed sources continues to grow exponentially, automation tools are becoming critical to decision makers. The balanced scorecard method is used as the basis for modeling, and the traditional dimensions are modified slightly to meet the requirements of quality data management in aerospace enterprises. A data warehouse with predefined fact and dimension tables is created, and a technical solution is provided to meet the requirements and scales of enterprises. In terms of model applications, any enterprise quality manager can extract value from data in the quality data package system for improvement. Online analytical processing (OLAP) cubes support major tasks, such as key quality feature source tracing and analysis, quality issue data mining and integrated quality data delivery.

1. Introduction

Aerospace products involve complex organization structures, high technical standards and multiple disciplines and are capital-, engineering- and information-intensive products. The development and manufacturing process has a high level of quality risk. Any minor quality issue can trigger a series of chain reactions and cause major quality disasters [1]. Collecting complete and accurate quality information during the product life cycle is the core of an enterprise quality management system [2]. Quality information refers to the collection of data, charts, images, texts and videos that reflect the product quality variations during enterprise quality management, which covers each stage of a product's life cycle [4].

With the rapid development of models describing the upgrade frequency of aerospace products, the quality control requirements become stricter, the manufacturing process becomes more complex and detailed quality records accumulate, which results in the geometric growth of aerospace product quality data. These quality data are from different stages of the product life cycle and different individual information management systems. With the massive amount of aerospace product quality data, how to leverage quality information throughout a product's life cycle to achieve the rapid tracking of product quality issues has become an urgent requirement in aerospace product quality management [5].

To improve the quality benefits of aerospace development, enhance the product assurance capability and make the correct decisions, aerospace enterprises face an urgent need to implement statistics, analysis and control of massive aerospace product quality data, manage and control quality data information about the product life cycle, implement quality information collection and management for all stages, including purchasing, research & development, test, design, manufacturing, assembly and delivery, and generate digitized polymorphism quality data packages for aerospace product [6].

With the progress of informatization, each business system has accumulated a large amount of historical quality data, and the quality data package system will collect massive amounts of quality data. If these quality data are not utilized, they will have no value. To fully utilize quality data and support managers in decision analysis, product quality improvement and production cost reduction, business intelligence (BI) has been introduced to solve these problems and help enterprise managers find the information required for business decisions [8]. BI has been demonstrated to be very effective in improving enterprise decision-making. On this

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basis, BI-based quality data packages for complex aerospace products have been developed as a new method that aerospace enterprises can use to monitor, manage and analyze quality data. A review of the existing literature reveals that there are few studies on the construction of BI technology-based quality data package systems for aerospace products.

Based on data warehouse (DW) technology, a data mining algorithm and a multidimensional data modeling and analysis method, Hou et al. created a business analysis system for use in the operation and development of the mining industry; a large mining industry group was used as an example to validate the feasibility and effectiveness of BI-based production operation system solutions for a mining industry group [9]. Gao et al. investigated BI-based quality issue analysis technology for the aerospace development process, and it provided reliable data support for addressing quality issues during aerospace product development [10]. Yang et al. provided a systematic solution for constructing quality data packages for aerospace products and data management [6]. In general, the existing quality data package construction efforts tend to focus on general-purpose functional systems, and research and application regarding introducing BI into quality data packages for analysis decisions in large-scale aerospace enterprises are scarce [3]. How to integrate BI technology into a quality data package management system for aerospace enterprises and create a BI-based quality data package management system for aerospace enterprises is a new challenge for the informatization of aerospace enterprises.

The goal of this study is to create a system model of a BI-based Combine quality data package for text, video, and images for complex aerospace products and support quality information management decision-making in aerospace enterprises, thus providing enterprise management the right information at the right time for effective quality information management. BI is a strategy management support that requires corresponding improvement and change, in addition to an initial learning process [7]. Key quality feature source tracing, quality issue data mining and integrated quality data delivery are the key activities in quality data management in aerospace enterprises.

BI is defined as a set of mathematical models and analysis methods that systematically leverage available data to discover valuable data information and knowledge to support complex decision-making [11]. BI refers to various concepts, methods, processes and software applications that were designed to analyze original data, query, produce aggregation, forecast and associate, perform data mining, perform online analysis and generate reports [12], the goal of which is to improve business decisions.

The proposed BI model should support the creation of customized business analyses by users and require minimal information technology (IT) intervention and maintenance in addition to a short learning cycle [16]. It is worth noting that a BI system tool should be selected based on practical requirements. Dogmatism and one-sided views have detrimental effects. To leverage the strategic potential of BI methods, an organization should implement a mathematical model that can convert data into knowledge rather than collecting information to provide proactive decision support [13].

2. Principle

This study is based on a large core aerospace enterprise in the China Aerospace Science and Industry Corporation, Limited, that undertakes the mission of developing aerospace products. The product has a complex structure and high quality standards, which is typical for such enterprises. The quality information management system is investigated. On this basis, a BI model-based quality data package model is proposed. The goal of this study is to implement key quality feature source tracing, fast detection of quality issues and quality issue data mining to improve both the efficiency of the delivery of integrated quality data and the capability of quality management in aerospace enterprises. In this study, quantitative and qualitative methods are combined to analyze each stage of enterprise quality management. The research method is based on archival statistical analysis and case study. A case study is dedicated to understanding the causes and effects of different goals and measures. The delivery is as follows: a BI model is developed for a complex product quality data package management system that supports quality issue mining; key quality feature source tracing; integrated quality data delivery to determine a compatible structure; and a method for solution development. The BI modeling method in this paper is based on a three-stage method elaborated in the literature [1].

In stage one, the key performance index (KPI) and the value and level of BI in a specific domain are defined; application documents are collected, classified and organized; and the project requirements are listed. In stage two, a design and navigation prototype is developed. In stage three, the model is implemented and improved. The balanced scorecard (BSC) method is employed to monitor the key performance index. This method connects more goals in aerospace enterprises, which has multiple models and a complex product hierarchy and involves multiple participating units; it balances enterprise quality management performance evaluation and system development [14].

The vision, objective and strategy of the quality data package management system are analyzed to determine the key index or measure of achievable objectives. Then, they are grouped into logical views. Compared with the traditional model, this model focuses on 3 slightly different aspects, including key quality feature source tracing, quality issue data mining and integrated quality data delivery.

Based on the direction of key quality feature source tracing, there are two major categories: forward tracing (tracing forward along the manufacturing process to predict potential quality risk) and backward tracing (tracing backward along the manufacturing process to identify the root cause of quality issues). For instance, management can query a particular product and trace a specific component to determine who assembled it and at what time and place. Additionally, it supports querying the corresponding material information and quality information.

Based on multidimensional association among quality data, common issues and relations among features are identified. Quality issue information-oriented data mining and association analysis are implemented to provide evidence for decisions about the quality issue closed-loop process and quality improvement in aerospace product development. The extracted knowledge is provided to decision makers as a reference for decision-making. The challenge is how to leverage the value of the historical quality issue data to guide production in the future.

During integrated quality data delivery, component quality data are extracted from the quality data package system based on the predefined criteria, such as product model, product name, development stage, structured data and non-structured data, to create a final data set so a customer can find the required quality data quickly. Will this solution significantly improve the efficiency of quality information utilization for the customer? The goal, measurement, constraint and activity are defined for each view. Each view is shown at the level of strategy decision, management and operation performance. In the BSC method, the impact on the overall quality information management is evaluated via 22 indexes. At first glance, the indexes are not complex because they are based on manual tracking or simple office tool. However, when these measures are distributed to different domains to collect data and create