

QFD and Data Mining: Analysis and Incorporation

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ABSTRACT

In today's fast-paced business environment, with floods of data available, decision-making has become a complex task. These data contains nuggets of valuable information in hidden form, which are often not effectively utilized due to lack of suitable analytic tools and techniques. Data Mining is a buzzword for the present era. Data Mining is the non-trivial process of identifying the valid, novel, potentially useful and ultimately understandable patterns in data. However, with the advent of some technology like Data Mining, the data can now be suitably analyzed and mined to yield valuable outcomes. Quality Function Deployment (QFD) is an extensive customer oriented product development process that strives for improving quality and gaining higher customer satisfaction. QFD contains voluminous data, which can be suitably mined to deduce important and pertinent information. As is the case with QFD – since the data happens to be voluminous, suitable mining of data may lead to product quality improvement and hence higher customer satisfaction. The paper thus aims to analyze the Data Mining in context of QFD process. In the light of above the paper talks about the QFD and Data Mining and then discusses the ways and means of incorporating Data Mining in the QFD.

Keywords: QFD, Data Mining, Data, Product Quality, Voice of customer

1. INTRODUCTION

In today's intensely competitive environment organizations must secure a high customer satisfaction in order to survive. The interest in customers has increased enormously during the last two decades and customer satisfaction has become an issue of strategic importance. Customers are becoming increasingly aware of their power in the marketplace. Product must be designed in such a way that they quickly deliver the quality and functionality as demanded by customers while generating the desired level of profits for the organization. Of crucial importance is - how well the new product meets market requirements. This calls for a new and innovative product to meet market requirements. However, the said approach creates challenges for incorporating market issues that combines external and internal assessment. This urges a strong need for efficient and simplified product development model that guides and directs the product developers in customer driven product development by incorporating the 'voice of customer' in the process. Quality Function Deployment (QFD) is a customer focused product development process through which the quality of the product can be enormously improved [1]. QFD one of the key quality systems of TQM, was built to assure value to customers [2]. QFD is a tool wherein the voice of the customer is deployed throughout the product planning and design stages. Yoji Akao defined QFD as "a method for developing a design quality aimed at

satisfying the consumer and then translating the consumer's demands into design targets and major quality assurance points to be used throughout the production phase". Albeit QFD started off with manufacturing environment but now it has found wide acceptance in diverse fields. QFD is an innovative approach bringing quality as demanded by the customers upstream into the product development process [3]. QFD uses the House of Quality (HOQ) as a visual model. Generally speaking, the HOQ is the matrix, which analyzes customer requirements in detail and translates them into the developers' language [4]. The HOQ is the heart of any QFD application and is framework of most of the matrices used in QFD. QFD is one such model that comprises of sets of matrices, and is rather a lengthy process, which involves large volumes of data and complex calculations. As a result, dealing with the data manually is quite cumbersome and time consuming [5]. Companies with a strong consumer focus - retail, financial, communication and marketing organizations, primarily use Data Mining today. Data Mining is the non-trivial process of identifying the valid, novel, potentially useful and ultimately understandable patterns in data. Data Mining is the search for relationships and global patterns that exists in large databases but is hidden among vast amount of data. One important aspect of Data Mining is that it scans through a large volume of data to discover pattern and correlations between attributes [6]. This pattern and correlations between attributes obtained can then be used for predicting purpose. Effective utilization of data-mining can not only assists the organizations in predicting the product or service requirements but also in identifying the right customers for a particular product family or service. QFD is a process that makes use of massive amount of data. With the huge amount of data available in QFD, QFD has become a fertile area for Data Mining research. However, gathering and making sense of this data is very cumbersome, as a result the data is not duly utilized. The proper utilization of this data can be of great help in deducing important and pertinent information. Using Data Mining in the QFD process will certainly assists in improving its services, making it more comprehensible and increasing its usability. As is the case with QFD - since the data happens to be voluminous, suitable mining of data may lead to product quality improvement and hence higher customer satisfaction. The paper thus aims to analyze the Data Mining in context of QFD process and discusses the ways and means of incorporating it in the QFD.

The paper is divided into following sections. The paper begins with the discussion of QFD. The next section is concerned with Data Mining. This section begins with the general introduction of Data Mining. It explores the concepts and techniques involved in Data Mining and application domains of Data

Mining. Finally, the last section analyzes the Data Mining in context of QFD process and discusses the ways and means of incorporating it in the QFD.

2. QUALITY FUNCTION DEPLOYMENT (QFD)

Quality Function Deployment (QFD) is a customer oriented product development process that strives for high quality in the product and improved customer satisfaction. QFD is a set of matrix tools, which are used in product development in deploying customer requirements into a product, service and business operations [7]. Quality function deployment is a system to assure that customer needs drive the product design and production process. It is a TQM technique that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development. The principle of QFD is similar - the idea is to take the customer into the product development process to ensure that the core quality will be in the product or service - the customer satisfaction [8]. The voice of the customer is often referred to as the “cornerstone” of the QFD process as it drives the rest of the subsequent value analyses. QFD is a method that uses matrices to show the relationship between two or more sets of concepts. QFD directly facilitates a customer-focused product and process design by making explicit the relationship between design characteristics and customer requirements. The traditional matrices and process can be modified in many different ways to fit the needs of the product team [9]. QFD is a set of powerful product development tools that were developed in Japan to transfer the concepts of quality control from the manufacturing process into the new product development process. In a QFD procedure, the product design team is forced to consider what the customer wants, then identify possible ways to achieve that end, instead of concentrating only on the design’s aspects. Thus, QFD methodology provides a way to translate conceptual requirements into items that are workable, measurable, and capable of design enhancement. The result is a better design, shorter product development cycles, better product quality, and lower costs [10].

2.1 Four Phase Model

QFD is based on the widely used Four Phase Model (Ref. Fig. 1), which focuses on the quality deployment part of Akao’s comprehensive QFD framework. The first matrix corresponds to the House of Quality (HOQ), which transforms customer requirements into measurable quality elements. The most important of these quality elements are then set against the characteristics of possible product components in a second matrix. These in turn correlate with the central process parameters in the third matrix, which are connected with definite production plans and means of production in the fourth matrix. During the construction of

the Phase I matrix, the relationship between customer requirements and the product design concept are examined to determine which product features are most crucial. In Phase II matrix, individual part characteristics are compared to design features; in Phase III, process plans are compared to part characteristics; and in Phase IV, operational plans are coordinated with process plans [9].

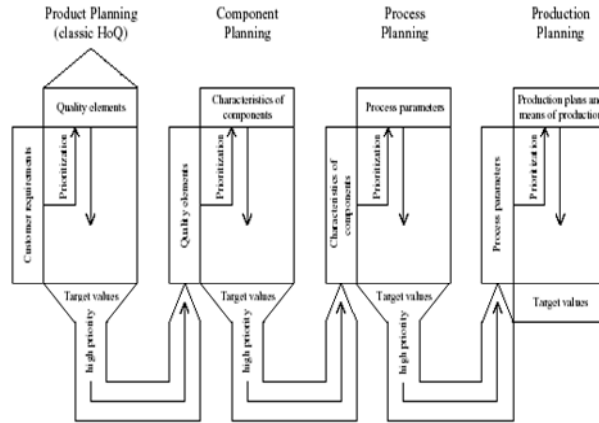


Figure. 1 Four-Phase model of QFD

3. DATA MINING

Data Mining is the analysis of huge amounts of data by automatic or semi-automatic means, in order to identify significant patterns or rules [11]. Data Mining is automated extraction of predictive information from large databases. Data Mining lets you be prospective rather than retrospective. The evolution of Data Mining began when business data was first stored in computers and technologies were generated to allow users to navigate through the data in real time. Data Mining takes this evolutionary process. This evolution is due to the support of three technologies massive data collection, high performance computing and Data Mining algorithms [6]. Data Mining referred to as knowledge discovery in database is process of nontrivial extraction of implicit, previously unknown and potentially useful information like patterns from data in databases. Data Mining is only one of the many steps involved in Knowledge Discovery in Databases (KDD). KDD is considered to be a more encompassing process that includes data warehousing, target data selection, data cleaning, preprocessing, transformation and reduction, Data Mining, model selection, evaluation and interpretation and finally consolidation and use of the extracted “knowledge” [12].

3.1 Concepts and Techniques

Data mining analysis tends to work up from the data and the best techniques are developed with an orientation towards large volumes of data making use of as much data as possible to arrive at reliable conclusions and decisions. [12] distinguish between KDD and Data Mining by giving the following definitions. KDD is the process of identifying a valid potentially useful and ultimately understandable structure in data. Data Mining is a step in KDD process concerned with the algorithmic means by which patterns or structures are enumerated from the data under acceptable computational efficiency limitations. Thus the structures that are the outcome of the Data Mining processes must meet certain conditions so that this can be considered as knowledge. These conditions are validity, understandability, utility, novelty and interestingness". Data Mining is a step in the knowledge discovery process consisting of particular Data Mining algorithms that, under some acceptable computational efficiency limitations, find patterns or models in data. Techniques involved in Data Mining represent a blend of statistics, pattern recognition and machine learning. Problem understanding is very important in Data Mining as problems could be diverse - optimizing response of customers to some marketing campaign, prevent fraudulent usage of credit cards, detection of hostile logging on computer systems, etc. However, since outputs of the Data Mining process differ depending on the techniques used, it is good to describe intended Data Mining outputs of the project [13].

Data Mining offers several powerful techniques that can be relatively applied on the data to produce meaningful outcomes. Data mining techniques, based on statistics and machine learning can significantly boost the ability to analyze data.

- Link Analysis
- Predictive Modeling
- Database Segmentation
- Deviation Detection

3.2 Application Domains

Of late, Data Mining has found a wide acceptance and is being ubiquitously used. Some of the application domains, of Data Mining are –

- Marketing and Sales
- Crime detection
- E-Commerce

- Customer Retention and Customer Relationship Management (CRM)
- Fraud detection
- Biotechnology and pharmaceutical industry
- Health care
- Human resources
- Real time decision making
- Retail business
- Stock and investment analysis and prediction
- Telecom business

4. DATA MINING IN QFD:

The present situation of the market has become more and more information based. The importance of collecting data that reflect your business or scientific activities to achieve competitive advantage is widely recognized now. QFD is a proven technique that can reduce the number of defects, subsequently resulting in gains even during product development phase lead to better customer satisfaction. QFD is a cross-functional planning tool, which is used to ensure that the voice of the customer is deployed throughout the product planning and design stages. QFD is used to encourage breakthrough thinking of new concepts and technology. Its use facilitates the process of concurrent engineering and encourages teamwork to work towards a common goal of ensuring customer satisfaction [14].

The original QFD approach of Akao consists of up to 50 matrices and tables in a wide-ranging matrix network. QFD is a complex and lengthy process, which makes use of sheer amount of data. On account of the massive data generated in QFD, the complexity of dealing and managing the data poses a great challenge [15]. But it also paves a way for a rich and unprecedented Data Mining source. Moreover, this data is generally not effectively utilized due to lack of suitable analytic tools and techniques resulting in obtained results not transformed into meaningful innovation benefits in the industry. However, with the advent of some new technology like Data Mining, this data can be suitably analyzed to yield valuable outcomes. Data Mining is a new technology that helps businesses to predict future trends and behaviours, allowing them to make proactive, knowledge-driven decisions. When Data Mining tools and techniques are applied on the data warehouse based on customer records, they search for the hidden patterns and trends. These can be further used to improve customer

understanding and acquisition [16]. According to [11], Data Mining is the analysis of huge amounts of data by automatic or semi-automatic means, in order to identify significant patterns or rules. Companies with a strong consumer focus - retail, financial, communication, and marketing organizations, primarily use Data Mining today. It enables these companies to determine relationships among "internal" factors such as price, product positioning, or staff skills, and "external" factors such as economic indicators, competition, and customer demographics. Data Mining is the process of discovering new correlations, patterns, and trends by digging into (mining) large amounts of data stored in warehouses, using artificial intelligence, statistical and mathematical techniques. Data Mining can also be defined as the process of extracting knowledge hidden from large volumes of raw data i.e. the nontrivial extraction of implicit, previously unknown, and potentially useful information from data. The alternative names of Data Mining are Knowledge Discovery in Databases, Knowledge Extraction, Data/Pattern Analysis, etc. [17]. An effective use of Data Mining in the QFD process will certainly assist in improving its services, making it more comprehensible and increasing its usability. As is the case with QFD - the data happens to be voluminous, suitable mining of data may lead to product quality improvement and hence higher customer satisfaction. Data Mining will play a dominant role in the extraction of knowledge from the distributed and heterogeneous sources of data. The growing volume of enterprise data raises many challenges, with one being able to extract, store, organize, and use the knowledge generated from data sets. In manufacturing, product quality and consistency is an issue that can be addressed with Data Mining [18].

In the present scenario, a large number of data may be routinely collected and stored in normal business operations. The challenge is to analyze this data so as to derive some concrete conclusions. Data Mining deals with the discovery of hidden knowledge, unexpected patterns and new rules from large databases. QFD makes use of a massive data and thus give rise to an imminent need of turning these data into useful information and knowledge. An amalgamation of the power of Data Mining and nature of QFD can bring out a significant change in the product quality resulting in more customer satisfaction. Data Mining has already been applied in diverse fields and it can effectively be applied in QFD. Data Mining has a broader scope of incorporation in QFD. Data Mining can be incorporated in QFD for the following -

- Locating the target customers
- Analyzing customer needs
- Extracting valuable information using text mining

- Identifying customer voice Patterns
- Improving decision support in QFD
- Predictions and Forecasting

Customers are indispensable entities. Thus, understanding their needs and wants are of paramount importance for any company. The companies need to understand their customers better and quickly respond to their wants and needs. QFD is a customer oriented product development process, which too requires better understanding of customers needs and wants. QFD database can be suitably mined to produce good results. Time series analysis is one of the most important techniques of Data Mining. A time series based Data Mining cycle is applied to mine the patterns of weights for identifying customer needs in QFD. Identification of future customer needs beforehand can yield fruitful results in finding and satisfying need trend of each customer which in turn will enhance competitiveness of companies in the marketplace [14]. This can be achieved using exponential smoothing analysis which is one of the most important forecasting techniques for time series analysis. Forecasts generated with this method are a weighted average of the past values of the variable. The weights decline for older observations. The rationale is that more recent observations are more essential than older observations. The forecast for period $t+1$ calculated in period t is called F_{t+1} . Therefore, F_t is the forecast for period t calculated in period $t-1$. The forecast for period $t+1$ is given as,

$$F_{t+1} = \alpha A_t + (1 - \alpha)F_t$$

which represents a weighted average of the actual value (A_t) and the forecast (F_t) of the actual value (calculated at $t-1$) and α is a smoothing constant with values between 0 and 1. The higher the value of α , more weight is given to current values [19]. Using this technique with the periodical data of customer needs in QFD, the predicted value of new period can be computed. These predicted weights for the customer needs were chosen for the next stage of processing [14].

Customers are vital part in QFD as it is driven by voice of customers. To meet or even exceed customers' expectations, companies are devoting substantial resources to proactively understand the relationships between their product or service offerings and the associated target customers. Traditional forecasting methods are no longer suitable for these business situations. Thus, determining the target customers can be achieved using a five-step data-mining model

integrated with attribute relevance analysis, decision-tree classification and rules extraction as proposed by [20]. The five steps utilized are –

- Construction of data marts
- Preprocessing of data
- Attribute relevance analysis
- Decision-tree classification rules
- Using the model for prediction

The text mining can be applied in QFD for extracting valuable information. The widespread availability of databases within the QFD driven product development process facilitates the use of data mining as one of the tools. Voice of customer in the QFD in one such area where the data arrives from various sources. This data represents the customer statements expressed in their own words. This data can be mined using text mining to produce meaningful results. Current methods of analyzing textual data include the use of spreadsheets and manual processing to decipher the meaning and relationships from the textual input. Such tasks usually entail a lot of time and resources, which could be otherwise better utilized. Quantitative databases are relatively easy to handle and there are already various established techniques for this. In comparison, textual databases/fields are much more difficult to manipulate and there is a greater level of difficulty in handling such databases. The issue can be addressed using the association analysis in data mining. Prior to the application of association analysis, the following preprocessing steps have to be carried out [21]:

- Decoding fixed-format fields
- Addition of derived fields
- Transforming free-form fields into fixed-format fields

The association analysis can generate all association rules present in the database, subject to confidence and support constraints. In addition, only a small amount of time and resources is required to carry out a complete analysis. The quick results obtained would also allow time-trend studies to be more amenable. The use of text mining is demonstrated in detail by [21]. The proper identification of customer needs, finding the target customers, extracting valuable information from textual database and predicting the future customer needs are some parameters which when suitably evaluated will strongly improve the decision support in QFD. Thus, different data mining techniques can be

effectively applied in QFD to produce better results which in turn will improve quality of product and hence customer satisfaction.

5. CONCLUSIONS

In this era of fierce competition, organizations must secure a higher customer satisfaction in order to survive. This calls for a new and innovative product to meet market requirements. However, the said approach creates challenges for incorporating market issues that combines external and internal assessment, thereby generating a strong need for efficient and simplified product development model that guides and directs the product developers by incorporating the 'voice of customer' in the process. QFD is a customer driven process, which involves voluminous data and complex calculations. Data Mining is a process that can extract useful information from the rough set of data. QFD involves loads of data, which generally is not duly utilized. Thus QFD acts as a fertile area for Data Mining research. This calls for the application of Data Mining in QFD to deduce important and pertinent information. In QFD, product quality and consistency are the issues that have to be appropriately addressed. In view of this an attempt has been made to explore the QFD areas where the Data Mining can be applied to reap the benefits. The areas are highlighted and an attempt is made to look for the ways and means to incorporate Data Mining in QFD. The study reveals that QFD offers a broad scope for Data Mining and using relevant techniques of Data Mining, QFD tool can be enhanced and improved upon to deliver quality product with higher customer satisfaction. Thus, it has been realized that an amalgamation of the power of Data Mining and nature of QFD can bring out a significant change in the product quality resulting in more customer satisfaction.

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