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Fuzzy group decision-making to multiple preference formats in quality function deployment

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Abstract

In a competitive and global business environment, it is certainly a distinct advantage to capture the genuine and major customer's requirements effectively. To take advantage of this, the unique way is to analyze customer's requirements systematically and to transform them into the appropriate product features properly. Quality function deployment (QFD) is a well-known planning methodology for translating customer needs (CNs) into relevant design requirements (DRs). The intent of applying QFD is to consolidate the customers' preferences to the various phases of the product development cycle for a new product, or a new version of an existing product. However, it is more difficult to assess the performance of this process with accurate quantitative evaluation due to its uncertain nature. Moreover, people tend to give information about their personal preferences in many different ways, numerically or linguistically, depending on their background and value systems. In this study, a new fuzzy group decision-making approach is presented to fuse multiple preference styles to respond CNs in product development with QFD in a better way. The approach is illustrated with a numerical example concerning the development of the hatch door of a car.

Keywords: Fuzzy quality function deployment; Group decision-making; Multiple preference; Fuzzy majority

1. Introduction

Producing quality products is a prerequisite for companies that need to survive and make profit in the current highly competitive market. "Quality" product does not simply mean to defect free product. The companies should be aware of the fact that quality includes attractiveness, maintainability, ease of use and these aspects should be perceivable for the customers. In other words, the customer orientation is one of the core components of the quality in product development. Here, the companies should be cognizant of their customers' intentions and needs and the key technologies that can satisfy these needs [1]. Going beyond the customers' expectations by means of innovation and creativity must be the objective [2].

Quality function deployment (QFD) is a comprehensive quality system aimed at satisfying the customer [3–5]. The intent of applying QFD is to consolidate the customers' preferences to the various phases of the product development cycle for a new product or upgrade through marketing surveys and interviews to achieve the quality that customer requires. Its basic concept is to translate the customer needs (CNs) into product design or engineering characteristics, and subsequently into parts of characteristics, process plans and production requirements. Each translation uses a matrix called the house of quality (HOQ) for identifying CNs and establishing priorities of design requirements (DRs) to satisfy the CNs [6].

The more emphasized activity in QFD is the accurate prioritization of the requirements. As the requirements have different importance for a given stakeholder group, the focus is on the customers' expectations. This process generally consists of a group decision-making process in which all the participants have their own opinions on the relative importance of the requirements and look for the weights, which favor their opinions. Furthermore, the decision makers (DMs) tend to give information about their personal preferences in many different ways, numerically or linguistically, depending on their cultural and educational background and value systems. The fact that the judgments of DMs usually vary in form and depth shows us that the group decision-making process needs to derive a single group preference from a number of specific individual preference

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styles. In this paper, an integrated approach of the group decision-making, preference information and fuzzy set theory is presented to tackle the complex and often imprecise problem domain encountered in customer requirement management of the QFD process. Thus, an analytical tool for perceiving and prioritizing the quantitative and qualitative, sometimes vague and imprecise preference of the customer is offered.

The paper is organized as follows. Section 2 gives a brief literature survey and discusses why fuzzy set theory and group decision-making techniques should be incorporated in QFD. It also provides the essence of the proposed approach. Section 3 presents a new fuzzy group decision-making approach and describes its steps in a detailed way. Section 4 illustrates an application of the approach with a numerical example concerning the hatch door development of a car. Section 5 concludes this paper.

2. Literature review

Companies attempting to implement QFD have reported a variety of the benefits and also the problems with the method [7–9]. Table 1 summarizes these benefits and drawbacks. Several attempts have been made to cope with the difficulties in carrying out the QFD process and two of the trends are considered in this study.

(i) Applications of fuzzy set theory in QFD.
(ii) Improved systematic approaches to determine priorities of CNs and DRs in a group environment.

Determining the correct importance weights for the CNs and DRs is essential since they affect a set of the target values for the engineering characteristics significantly. The simplest method to prioritize the requirements is based on a point scoring scale, such as 1 to 5 or 1 to 10 [10]. However, a substantial degree of human subjective judgment has to be involved in this method. Gustafsson and Gustafsson [11] used a conjoint analysis method for determining the relative importance of the customer's requirements. The methodology employs a pair-wise comparison of customer requirements to determine their relative importance. Other methods such as analytic hierarchy process (AHP) [12] have also been proposed to generate the relative importance of the customer's preferences. In all these methods, the input variables are assumed to be precise and are treated as numerical data. Meanwhile, the QFD process may involve various inputs in the form of linguistic data, which are inherently vague, as human perception, judgment and evaluation on the importance of the customer's requirements, design requirements and/or relationship strengths are usually subjective and uncertain. This case can be treated to approximate exactness with the use of fuzzy set theory [13] and some progress has been recently made along this line. Kwong and Bai [14] proposed a fuzzy AHP approach to determine the importance weights for the customer's requirements. The authors argue that the use of fuzzy numbers is preferable due to the fuzzy nature of human judgment in the comparison of CNs and gives the freedom of estimation regarding to overall customer satisfaction goal and actual situations. Erol and Ferrell [15] presented a methodology in which the fuzzy QFD is used for converting qualitative information into quantitative parameters and then combine these data with the other quantitative data to parameterize a multi-objective mathematical programming model. The method provides a set of optimal and near-optimal solutions and their performance relative to the objectives. The decision maker then has a quantitative basis from which he or she can intelligently assess trade-off as well as consider factors not included in the model before making the final selection. Chen et al. [16] formulated a new fuzzy regression-based mathematical programming approach for the QFD product planning. The authors claim that the approach can help determine a set of the level of attainment of engineering characteristics for the new/improved product to satisfy a budget constraint and match or exceed the customer expectation of all competitors in the target market. Büyüközkan et al. [17] used an analytic network process, the general form of AHP, with the fuzzy triangular number to prioritize DRs by taking the degree of the interdependence between the CNs and DRs, and their inner dependences into account. The fuzzy ANP method can offer a more precise analysis by integrating interdependent relationships but it requires more time and resource. It is argued that other methods such as the prioritization matrix or AHP may not offer results as accurate as the fuzzy ANP method. Hence, all these studies underline the necessity and the benefits of applying the fuzzy set theory in QFD.

Considering these cited and other existing up to date studies (see Ref. [5] and references therein), very few researches

Table 1
Benefits and drawbacks of QFD [7]

Benefits	Drawbacks
Customer-oriented	Ambiguity in the voice of the customer
Brings together large amounts of verbal data	Need to input and analyze large amounts of subjective data
Brings together multi-functional teams	QFD development records are rarely kept
Reduces development time by 50% and reduces start-up and engineering cost by 30%	Manual input of customer survey into HOQ is time-consuming and difficult
Helps design quality into the products at the design stage	QFD analyses often stop after the first HOQ, so links between the four QFD phases are broken
Organizes data in a logical way	The HOQ can become very large and complex
QFD is used not only for products, but for processes and services as well	Setting target values in the HOQ method is imprecise
Strengthens good relationship between customer and company	Strength of relationship is ill-defined
Improves customer satisfaction	QFD is a qualitative method