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Fuzzy Logic based decision support systems in variant production

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Abstract

In automobile industry, the product has many facets like engine, brakes, steering system, electronic instrumentation etc. The complex nature of modern automobile industry results in challenging environment for the manufacturer to satisfy customer requirements. Automobile manufacturers today develop products with certain variants for satisfying needs of a bigger group of customer. The customer then selects the option as per individual requirements from the choices available. In this paper a decision support framework is designed for family carsusing the fuzzy logic to assist the customer in selecting most suitable product from predefined product variants. The effectiveness and feasibility of the decision support framework are imperially validated by a case study wherein steering system and braking system are considered as decisive features. To get the most appropriate product as per the customer requirement, combinations of different membership functions such as Triangular, Trapezoidal& Gaussian are used for input as well as output variables. The system is then analyzed for product selection. The developed system is tested using MATLAB and also validated by center of sum and centroid methods. It is observed that input membership function as Gaussian function and output as trapezoidal membership function is mapped very well for decision making. The results are well endorsed by MATLAB for decision support.

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*Keywords:*Variant Production; Fuzzy Logic; Decision Support; Customer Satisfaction; Automobile

1. Introduction

In the current agile manufacturing environment, the customers and the manufacturers are having different sets of priorities because of more demanding customer requirements and the manufacturing constraints. Thus, to manufacture the product exactly as per the customer specification is a great challenge to the manufacturer. The requirements given by the customers are many times poorly understood by the manufacturer and thus are fuzzy and uncertain. This results in tedious or even invalid configuration task for the manufacturer based on vague

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superposition and implicit inference. The divergence in customer preferences and manufacturing requirements exerts the need of collaborative working of manufacturer and customer. Thus, to fulfill the customer requirements, there is need of active integration of the individual customer into the value chain in customization of the product and in product development which will help the manufacturer. To satisfy the needs of the customer, the manufacturer uses a basic product and further modifies some details of that product [1]. The product developed for each customer may be different which results in a 'Make to order' situation. To avoid such situation manufacturer defines some variants of the basic product. In such variant production domain, where product variants are manufactured, the diversity, irregularity and unpredictability of customer's requirements and preferences are the key challenges for the manufacturer. To address these challenges an effective decision making is essential.

The decision support system is an effective tool which can be used by for decision making. The important aspect of decision support system is the utilization of the computational model [2]. Decision support systems are used for different purposes in a manufacturing industry like providing decision support for process control [3], process quality control [4], material and process selection [5] etc. The decision support system is also useful for assisting manufacturing managers for effective decision making [6].One of the tools which can be used for developing decision support system is artificial intelligence which can assists the manufacturer in decision making process. Such decision support system will be able to quickly converge onto a valid configuration that can be transmitted to the customer order entry system and subsequently to manufacturing of variant products. The fuzzy logic system is an intelligent tool which can be used in decision making. The fuzzy logic based decision making is used by Yanwei [7] for decision making for the design scheme and by Farnandez [8] for decision making regarding the subcontracting of part production. The fuzzy logic based decision support system for mass customization has been used by Gilke et al.[9]. They developed model for assisting the customer and not addresses the issues pertaining to decision support for to the manufacturer. The system was designed with triangular membership function for both inputs and output. The analysis was not performed for other types of membership function. The fuzzy logic is closer in spirit to human thinking and natural language than the traditional logic systems. The fuzzy logic system which is based on concept of fuzzy sets [10] provides an effective means of capturing the approximate, inexact nature of the real world [11]. The fuzzy logic allows use of linguistic variables which results in easier working in decision making phase [12]. The fuzzy logic systems can be used for Multiple Attribute Decision Making in which finite possible solutions are available with decision maker [13].

In this paper a fuzzy logic based decision support system is developed for assisting the manufacturer in understanding the customer requirements and selecting the product which fulfill these requirements. This system is designed for selecting automobile components namely braking system type and steering system type. The system is analyzed for different types of membership functions and their combinations for input as well as output functions. The organization of this paper is as follows. Section 2 presents the architecture of fuzzy logic based decision support system. Section 3 describes the problem structure for the fuzzy logic based decision support system for product selection. Section 4 gives the development of the fuzzy logic based decision support system for product selection. Section 5 contains the analysis of fuzzy logic system for product selection along with the results and discussion. The conclusion of this work is presented in section 6.

2. Architecture & Design of Decision Support System

A fuzzy logic based decision support system is developed for selecting the product based on the customer requirements. Figure 1 show the methodology implemented in development of present system. The base architecture for development of decision support system consists of selecting features for customization and providing options for these features. Based on the combinations of these options, the products are defined. These product definitions are further utilized in formation of rule base or rule matrix. With this base structure the fuzzy logic based decision support system is developed in MATLAB. The system developed in MATLAB is tested and the results generated are compared with theoretical results for validation.In this work, two features used namely, Braking System Type (BST) and Steering System Type (SST), define the product variants. For each feature, separate options are provided. The product variant can be completely defined by selecting one option for each feature. Figure 2 shows the structure for the 12 product variant that can be developed, using the options available for the features. The two features BST and SST contain 4 and 3 options respectively which give us total twelve product variants. The options for feature 1 i.e. the BST are