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A Neuro-Fuzzy Based Approach to Modeling Affective Customer Satisfaction towards Car Seat Design

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ABSTRACT

Today numerous car seat models are available in the market but no car seat is actually satisfying customer needs to satisfactorily level. In fact customers comprise with available car seats. By considering this factor this paper mainly concentrated on the human comfort. This research papers helps to understand the current seat problems and its recommended solutions. This paper proposes a neuro fuzzy rule-based approach to generate models relating car seat design variables to affective user satisfaction. Affective user satisfaction such as body contact, sweat and heat generation, shoulder support, head rest support, lumbar support and child safety were modeled for Car seat designs. The main objective is to generate a new car seat model in order to provide maximum human comfort. Maximum human comfort is estimated by an intelligence system called Neuro fuzzy system, where it gives the comfort of seat with respect to its influencing parameters. By adopting this neuro fuzzy logic eliminate the antiquity of modifications, whether they are correct or not and the results gives us an accurate decision to adopt the change or not. Developed model suits best whenever there is lot of vagueness in decision making using MATLAB M-code.

Keywords: Affective customer satisfaction, Car seat design, Human Comfort, Neuro-fuzzy

I. INTRODUCTION

In many industrial sectors such as food, automobiles and textiles, manufacturers want to launch on the market "qualified" and "best" products as soon as possible. That is to say considered as the best "compromise" on all criteria to a target "market" evolving over time. In this context, the decision-maker takes into account a multi-objective dimension during the design or manufacturing of products. The human aspect becomes the central element of the resolution problem. A modeling of the decision-maker preferences is necessary and which tends to the artificial intelligence systems.

Design process is iterative and highly interactive. During the design process, the designer has to consider countless constraints with usually opposing goals. Automatic design, analysis, evaluation, modification and optimization of designed parameters are important issues to be addressed in design process. There are many individual intelligent approaches such as expert system, fuzzy logic, neural network and genetic algorithm that can accomplish these tasks (Dagli 1994, Wang and Takefuji 1993, Zha 2004b). However, due to particular computational properties of individual intelligent system techniques, hybrid solutions in the intelligent systems community are required to solve complex design problems, which may integrate one or more of the above individual intelligent techniques (Jang 1992, Medsker 1995, Goonatilake and Khebbal 1995, Zha 2004a-b).

Market analysis is a strategic move to scrutinize the market trends of consumer products. Typically, questionnaire or survey is one of the traditional methods to gather information from end users. Based on the survey data, customer perception as well as customer satisfaction level can be possibly quantified and identified. If customers are well satisfied, suppliers can gain more market share so as to increase the profitability (Zeithaml V. A. 2000). Otherwise, the firms may have low customer retention. Therefore, it is crucial to improve customer satisfaction level especially in today's highly competitive world.

Liu, X (2008) et.al proposed a fuzzy model to examine customer satisfaction index in e-commerce. They considered a method to calculate the index based on 5- level quantity table using fuzzy logics. However, the developed model is implicit. Grigoroudis et.al (2002) developed the Multicriteria Satisfaction Analysis (MUSA) method for measuring and analyzing customer satisfaction. MUSA is a preference disaggregation model based on the working principles of ordinal regression analysis. Using the survey data, MUSA aggregated individual judgments into a collective value function so as to quantify customer satisfaction. The model assumes that the global or overall customer satisfaction is solely measured with respect to a number of customer attributes. It implies that the customer satisfaction model towards each customer attribute is ignored.

Park, J. (2004) proposed a fuzzy rule based approach to examine the user satisfaction towards

office chair designs. They reported that the fuzzy rule based approach outperformed multiple linear regression approach in terms of the number of variables used. In general, the model of the fuzzy rule-based approach is explicit. However, the model is relatively simple such that the maximum number of rules is only 4 for a single attribute. You.et.al (2006) developed the customer satisfaction models for automotive interior material using quantification I analysis. Based on the models, the relatively design variables and preferred design features are examined. Hence, significant design variables and their values affecting customer satisfaction are identified.

To maximize these advantages, the models should represent the true responses of consumers in a simple and understandable form. However, there is a trade-off between model complexity and understandability. Simple models cannot provide sufficient information necessary to understand the true relationship. Too complex models, on the other hand, are not easy to interpret. It is important to select an efficient model structure appropriate to the nature of a problem.

To successfully develop any customer satisfaction models, the vague relationship between different design attributes and customer attributes must be thoroughly investigated (Kwong et.al, 2007). Kwong et.al (2008) proposed a neuro fuzzy to generating customer satisfaction model for new product development using ANFIS and a modified M-ANFIS model and it was compared with a Multiple Linear Regression (MLR). It is vital to identify the customer perception such that decision makers can better design products related to the target attribute. In this connection, the development of customer satisfaction models towards customer attributes is very critical, in which in these situations artificial intelligence techniques are very much useful.

II. PROBLEM BACKGROUND

Product Development is the process of creating a new product to be sold by a business or enterprise to its customers. It is concerned with the efficient and effective generation and development of ideas through a process that leads to new products. In this context, new product design or product development of a Car seat design.

The seating literature contains more papers concerned with office and industrial seating than with automotive seating, probably because of the economic costs associated with discomfort and injury in the office and factory. However, the motor-vehicle environment is also a workplace, with the difference between the situations of a commuter and a professional driver being primarily the length of time in the seat, both cumulative and at a single sitting. Epidemiological studies have shown that low-back pain and lumbar disc herniation risk increase with the amount of time spent driving (Kelsey and Hardy 1975).

In order to identify the customer satisfaction towards the car seat design a survey was conducted. In the survey, they were asked to find the customer satisfaction attributes such as lumbar support, body contact, sweat and heat generation, shoulder support, head rest support and child safety. Car seat is designed based on the influencing parameters, which are considered by different car seat companies to design a new car seat; the new product design is influenced by parameters of a car seat, not specific to one model of an automobile. The influencing parameters are collected from different seat manufacturing companies to design car seat which satisfies almost all features of a car seat in terms of customer satisfaction.

III. METHODOLOGY

In this paper, a neuro-fuzzy inference system is to develop a model in order to have a maximum customer satisfaction towards the car seat design. In order to develop a model we make an effective neuro fuzzy inference system using MATLAB with an effective M-code. Initializing the Neural Network with Input variables and Output variables, for simulation of neural network with car seat influencing parameters and then it is directed to fuzzy inference system.

The customer satisfaction model was generated towards to maximum human comfort of a car seat. Car seat design deploys its attributes like the influencing parameters are shoulder support, sweat, child safety, lumbar support, head rest support. In fact, today neural networks are used to solve a wide variety of problems, some of which have been solved by existing statistical methods, and some of which have not.

In this continuation, the present model focuses on developing a model for customer satisfaction towards car seat, in this context the model was developed in two stages; at initial the neural network is implemented to the attributes of the car seat and then it is simulated by different parameters and further the same influencing attributes are considered in developing fuzzy inference system. For illustration purpose the model is represented in Graphical user interface (GUI) using MATLAB, where actually it is simulated by using M-code for neuro-fuzzy for the generated model.

Initializing the Neural Network with Input variables and Output variables, for simulation of neural network with car seat influencing parameters

Inputs: 6 INPUT VARIABLES

1. BODY CONTACT (BC)
2. SWEAT AND HEAT GENERATION (SH)
3. SHOULDER SUPPORT (SS)

4. HEAD REST SUPPORT (HR)
5. LUMBAR SUPPORT (LS)
6. CHILD SAFETY (CS)

Output: SEAT COMFORT (SC)

In the continuation to the initializing the input data and target data attributes, and the values are considered in simulation of the neural network is considered based on survey conducted in different seat manufacturing companies. Artificial Neural Network and its respective parameters like Hidden layer, Train and Simulate options is initiated. In the part of this, neural network is trained, based on the input parameters.

After training the artificial neural network model, the trained network is simulated to obtain the seat comfort based on input attributes. So, in this connection different simulation data sets are used to predict the simulation output i.e. Seat Comfort of Car Seat with respect to customer satisfaction. Further, the simulation results are integrated to the fuzzy inference system, where further vagueness in decision making is reduced.

Fuzzy logic provides a convenient way to map an input space to an output space. In particular, a fuzzy inference system interprets the values in the input vector and, based on some set of rules, assigns values to the output vector. The mapping then provides a basis from which decisions can be made, or patterns discerned. Fuzzy inference system is developed for the customer satisfaction model and where here for illustrative purpose the GUI of MATLAB fuzzy tool box is used. Using the GUI editors and viewers in the Fuzzy Logic Toolbox, we build the set of rules for the seat comfort, and respective the membership functions are defined, and analyzed the behaviour of a fuzzy inference system (FIS) and it is shown in figure 3.1.

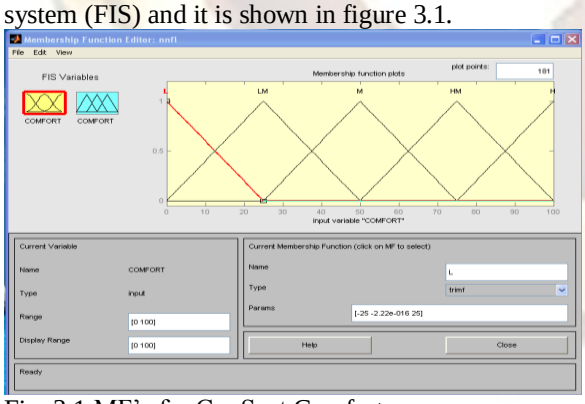

Fig. 3.1 MF's for Car Seat Comfort

Fuzzy logic systems, which can reason with imprecise information, are good at explaining their decisions but they cannot automatically acquire the rules they use to make those decisions. These limitations have been a central driving force behind the creation of intelligent hybrid systems where two or more techniques are combined in a manner that overcomes the limitations of individual techniques.

In brief, Neural Network and Fuzzy Inference system is illustrated by using Graphical User Interface (GUI) and M-code as follows.

- Neural Network is initialized with six input variables and one output variable called as Seat COMFORT by using MATLAB Software.
- Neural Network is trained by using TRAINLM function.
- Simulation of Network with different data sets, to obtain best results.
- The difference (also called the error) is propagated backwards through the network from the output layer to the input layer.
- Fuzzy Inference System is created with respective input and its membership functions.
- Output of Neural Network is integrated with Fuzzy Inference system using M-code.

The combination of fuzzy logic and neural networks constitutes a powerful means for designing intelligent systems. Domain knowledge can be put into a neuro-fuzzy system by human experts in the form of linguistic variables and fuzzy rules.

IV. RESULTS AND DISCUSSIONS

The main purpose of this research is to generate a new car seat model in order to provide maximum human comfort. This new car seat ensures that it is suitable for anybody profile and compares different kinds of seat models. Maximum human comfort is estimated by an intelligence system called Neuro fuzzy system, where it gives the comfort of seat with respect to its influencing parameters. Improving new product design is a key factor of success for a company

In this context, the Product considered is Car Seat, today numerous car seat models are available in the market but no car seat is actually satisfying customer needs to satisfactorily level. In fact customers comprise with available car seats. By considering this factor we mainly concentrated to generate a new car seat model in order to provide maximum human comfort. The interpretation with neuro fuzzy is done in MATLAB for the Car Seat Comfort.

The inputs are considered for the model is as follows to determine the seat comfort; these inputs are most influencing parameters for comfort of human which are collected by literature surveys and different car seat manufacturing companies.

CS= [50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2];

LS= [30 28.8 27.6 26.4 25.2 24 22.8 21.6 20.4 19.2 18 16.8 15.6 14.4 13.2 12 10.8 9.6 8.4 7.2 6 4.8 3.6 2.4 1.2];

BC= [10 9.6 9.2 8.8 8.4 8 7.6 7.2 6.8 6.4 6 5.6 5.2 4.8 4.4 4 3.6 3.2 2.8 2.4 2 1.6 1.2 0.8 0.4];

SH= [5 4.8 4.6 4.4 4.2 4 3.8 3.6 3.4 3.2 3 2.8 2.6 2.4 2.2 2 1.8 1.6 1.4 1.2 1 0.8 0.6 0.4 0.2];

HR= [2 1.92 1.84 1.76 1.68 1.6 1.52 1.44 1.36 1.28 1.2 1.12 1.04 0.96 0.88 0.8 0.72 0.64 0.56 0.48 0.4 0.32 0.24 0.16 0.08];
SS= [2 1.92 1.84 1.76 1.68 1.6 1.52 1.44 1.36 1.28 1.2 1.12 1.04 0.96 0.88 0.8 0.72 0.64 0.56 0.48 0.4 0.32 0.24 0.16 0.08]

Targets are the outputs of the given input data, based on these data; the neural network is trained and simulated with new inputs.
COMFORT= [99 95.04 91.08 87.12 83.16 79.2 75.24 71.28 67.32 63.36 59.4 55.44 51.48 47.52 43.56 39.6 35.64 31.68 27.72 23.76 19.8 15.84 11.88 7.92 3.96];

Testing data or Simulation data, this data set are used to simulate the neural network to forecast the Seat comfort with respect to the input parameters; [47 26 08 04 02 01].

Neural Network Seat comfort forecasted output = 93.825, but actually the theoretical comfort is 88 (from survey), it seems that the neural network undergoing some error, for this data set the error is at around 5.8. The error can be further reduced by taking large data sets when training, which makes the neuron to train level. In, Neuro fuzzy technique the neural network output is given as input to the Fuzzy inference system in order to obtain the near solution it means reducing the error. So, in this case the neural output is fed to the fuzzy inference system and the respective steps are given below i.e. for fuzzy inference system.

At initial the Triangular MF, is considered and their respective rules are build up by using rule editor in MATLAB, the respective "fis" file is exported to workspace of MATLAB. Maximum human comfort is estimated by an intelligence system called Neuro fuzzy system, where it gives the comfort of seat with respect to its influencing parameters. Improving new product design is a key factor of success for a company. M-Code is developed for the model of Neuro fuzzy inference system to forecast the Car Seat Comfort. In Neuro fuzzy inference system, the integration of Neural Network with Fuzzy inference system reduces the error of forecast. Due to presence of M-code, it can be easily forecast the comfort rather than going for GUI, and the forecast results can be exported to the workspace. In M-code, the Neural output is integrated with fuzzy inference system by using the two different Membership functions are Triangular and Bell MFs for the better results. The results of M-code after the compiling and executing the code in MATLAB, the results are exported to workspace and it is shown in figure 4.1

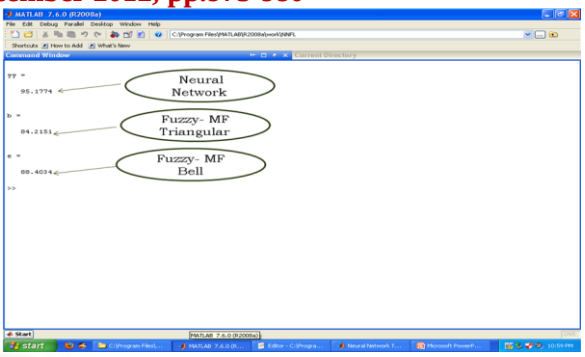

Fig. 4.1 M-Code Results

By simulating the neuro fuzzy inference system by using M-code and the forecast results are as follows based on input parameters. Actual expected Seat Comfort for a given data set (By survey): 88 Forecasted value of Neuro fuzzy inference system –Tri MF: 84.2151 Forecasted value of Neuro fuzzy inference system – Bell MF: 88.4034

Therefore, from the results it is clear that the bell neuro fuzzy inference system gives almost near value to the actual value, thus it validates the developed model. In this connection the simulated results of neuro fuzzy inference system with triangular MFs and Bell MFs are compared and it shown in figure 4.2.

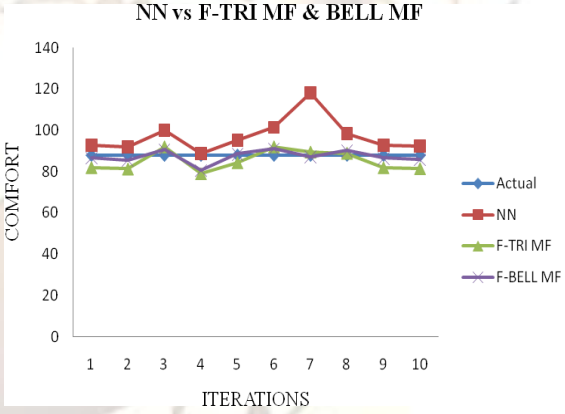

Fig.4.2. NN vs. Fuzzy Tri & Bell-MFs

Therefore, from the simulated results and from the graph it is clear that the forecast values of neuro fuzzy inference system with Bell MFs is most near value to the actual value. In this context, from the results the model can validate for forecasting the seat comfort by using Graphical User Interface and also by M-code for the different data sets and with bounded iterations. The simulated results it is clear that the forecast values of neuro fuzzy inference system with Bell MFs is most near value to the actual value. In this context, from the results the model can validate for forecasting the seat comfort by using Graphical User Interface and also by M-code for the different data sets.

V. CONCLUSION

The main purpose of this research is to generate a new car seat model in order to provide maximum human comfort. This new car seat ensures that it is suitable for anybody profile and compares different kinds of seat models. Maximum human comfort is estimated by an intelligence system called Neuro fuzzy system, where it gives the comfort of seat with respect to its influencing parameters.

By adopting this neuro fuzzy logic we can eliminate the antiquity of modifications, whether they are correct or not and the results gives us an accurate decision to adopt the change or not. Developed model suits best whenever there is lot of vagueness in decision making. It is a hard and also complex process to convert affective user needs into explicit form elements that can be easily understood by designers. To resolve this problem, in this study, a systematic model is suggested to assist designers to perceive emotional and affective requirements of customers. The proposed systematic model transforms affective user requirements not only into quantitative form but also tangible knowledge.

Eventually, emotional and affective requirements of users are converted to "IF-THEN" type fuzzy rules that are easily interpreted by designers. With the help of fuzzy rules, the relationship structure between form elements and affective responses are discovered. In this study, we provide a neuro-fuzzy inference system which is simulated using different data sets for the parameters of car seat which influences the Seat Comfort and simulation process is done by MATLAB Software.

In MATLAB, the neuro fuzzy system is simulated by their respective GUI tools and for the same the M-code is developed. Due to presence of M-code, it can be easily forecast the comfort rather than going for GUI, and the forecast results can be exported to the workspace.In M-code, the neural output is integrated with fuzzy inference system by using the two different Membership functions are Triangular and Bell MFs for the better results. The significance of affective design is increasing more and more as the market becomes more competitive. Therefore, it is possible to use the proposed approach for other consumer products such as home appliances, automobiles, furniture etc.

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