PREDICTIVE ASSESSMENT OF CUSTOMER SATISFACTION USING MULTIVARIATE FUZZY PARAMETERS

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***Abstract*— The research focuses on the simplification of predicting outcomes given a historic data set of independent variables using fuzzy logic. For such applications, complex methods are used. Models and formulas can be difficult to model as more variables are considered. With fuzzy logic, the system only requires setting up the membership functions and weights of inputs. These weights can be derived from a historic dataset with simpler approaches to each variable. The researcher will use the simplest regression model for weighting the membership function: Linear Regression Analysis. The researchers will use the resulting Slope and Intercept of the line model in determining the weight of the membership function corresponding to an independent variable. The Fuzzy Logic toolbox in Matlab makes setting up of the Fuzzy Inference System, FIS and Mamdani method. It can be modeled using a very intuitive interface. Furthermore, the researchers can automate the modelling of the FIS thru Matlab code.**

Keywords — fuzzy logic, linear regression, Fuzzy inference system, membership functions, Mamdani.

I. INTRODUCTION

There has been an increasing demand in an organization to produce high-quality consumer products. Those products can be identified by measuring the appropriate customer satisfaction level. Market analysis is a powerful and effective way to understand customer's point of view for a good consumer products [10]. "Customer satisfaction has a direct influence on customer retention [21][19] and company's profitability" [14]. With this, it is important and crucial to improve customer satisfaction and be able to illustrate the design attributes that would ensure customer loyalty and competitiveness for the firm[22]. Previous studies have attempted to develop customer satisfaction models with statistical regression, fuzzy regression, neural networks, quantification analysis I, and fuzzy rule-based modeling[17][18]. In this paper, the proponents will use the a simple regression model for weighting the membership functions and weights of inputs which is a Linear Regression analysis. A simple linear regression analysis involves estimating the mean value of a response variable Y or predicting some future value y based on knowledge of a set of related variable X [26][25]. We may refer to X as the independent variable that is used to predict the dependent variable Y [26]. Examples of these cases are :The demand Y for a commodity in terms of units sold is inversely proportional with its price X. When department stores go on "sale", more people troop to buy things there because the prices are cheaper. The same goes for new cellphones models whose prices go down, there will be more people who buy them [26], A person's weight (Y, in kilograms) is related to his/her height (X in centimeters). If we know the person's height, we can predict his/her weight. Taller people are heavier than shorter ones, in most cases [26][25]. The volume of water (X, in liters) in a kettle left to boil on an oven determines how long (Y, in minutes) it will take before the whole vat of water boils. A full kettle of tap water takes a longer time to boil than a half-full one[26]. Regression analysis is a statistical tool for the investigation of relationships between variables. The researcher seeks to ascertain the causal effects of one variable upon another. Using Regression analysis, the proponents will know which factors significantly affect the variations of customer satisfaction, and the relative effects of the factors on customer satisfaction.

In this study, the proponent considers eight (8) critical parameters such as delivery speed, price level, price flexibility, manufacturer image, overall service, sales force image, product quality, and usage level in predicting the customer satisfaction rate. The membership functions will be constructed based on relevant market studies and linear regression analysis. This regression analysis identifies the highest and lowest predictor of customer satisfaction.

II. METHODOLOGY OF THE SYSTEM

From our data gathered, the proponents constructed fuzzy rules using Mamdani method and Linear Regression Analysis.

1. ***Normalization and Linear Regression.*** Using the data gathered we normalize the values for each of the eight (8) critical parameters using the formula of getting the highest value divided by number of data.

2. ***Weight Computation.*** Weight computation is based on Fuzzy Logic Inference System, and through the help of Matlab 2014a applying the data gathered as our input valus which serves as the input expert value system, in this paper, we are able to come up with a good result of computations.

3. ***Mamdani Method.*** Both Mamdani and Sugeno methods can be applied to the data that we gathered to illustrate in fuzzy logic representations but Mamdani method is most easy to use for these kind of data. According to Matlab2011b, some of the advantages of this method are : It is intuitive, It has wide acceptance , it is well suited to human input.

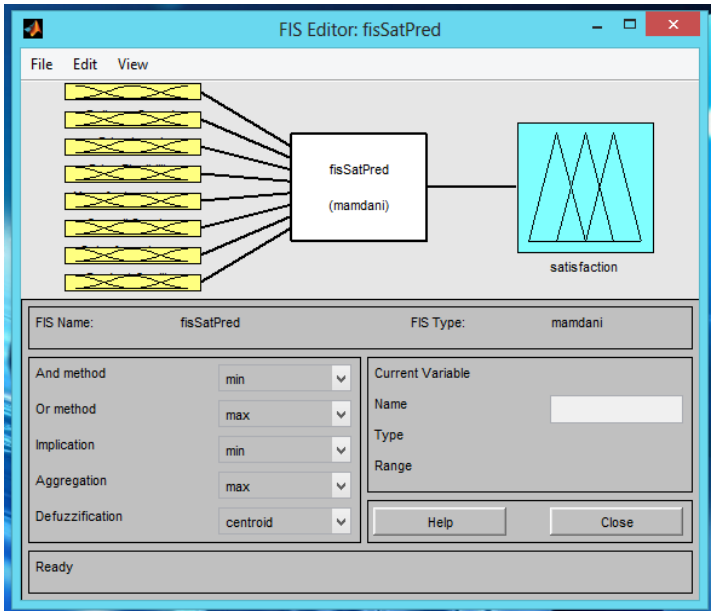


Figure 1. Mamdani Fuzzy Logic Inference System (FIS) Editor

From figure 1, The FIS editor GUI allows you to edit the highest level features of the fuzzyinference system, such as the number of input and output variables, the defuzzification method , and so on. The FIS editor is the high-level display for any fuzzy logic inference system. It allows you to call the various editors to operate on the FIS. This interface allows convenient access to all other editors with an emphasis on maximum flexibility for interaction with the fuzzy system. The diagram displayed at the top of the window shows the inputs, outputs, and a central rule processor. Click one of the variable boxes to make the selected box the current variable. You should see the box highlighted in red. Double-click one of the variables to bring up the Membership Function Editor. Double-click the fuzzy rule processor to bring up the Rule Editor. If a variable exists but is not mentioned in the rule base, it is connected to the rule processor block with a dashed rather than a solid line. The FIS Editor displays a menu bar that allows you to open related GUI tools, open and save systems, and so on. Five pop-up menus are provided to change the functionality of the five basic steps in the fuzzy implication process: And method, or method, implication method, Aggregation, and Defuzzification.

III. ANALYSIS OF RESULTS

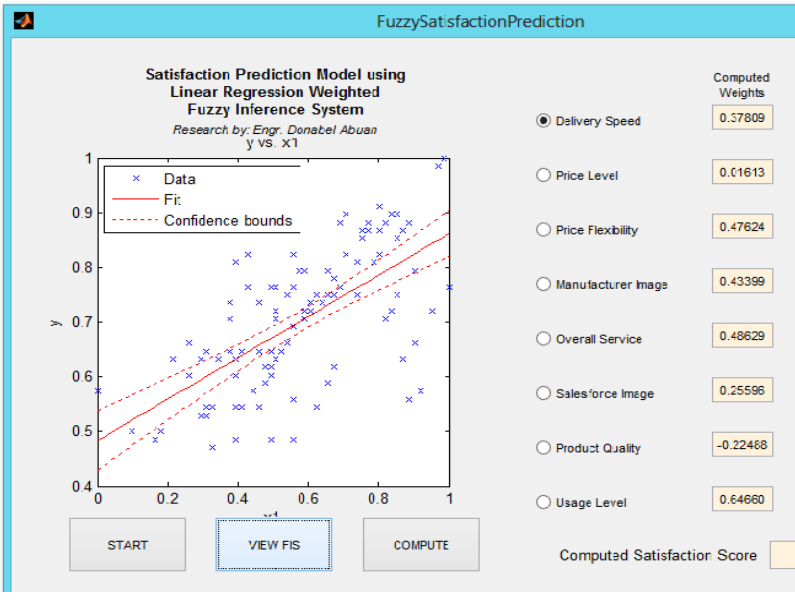


Figure 2. Fuzzy Satisfaction Prediction Diagram for Delivery Speed

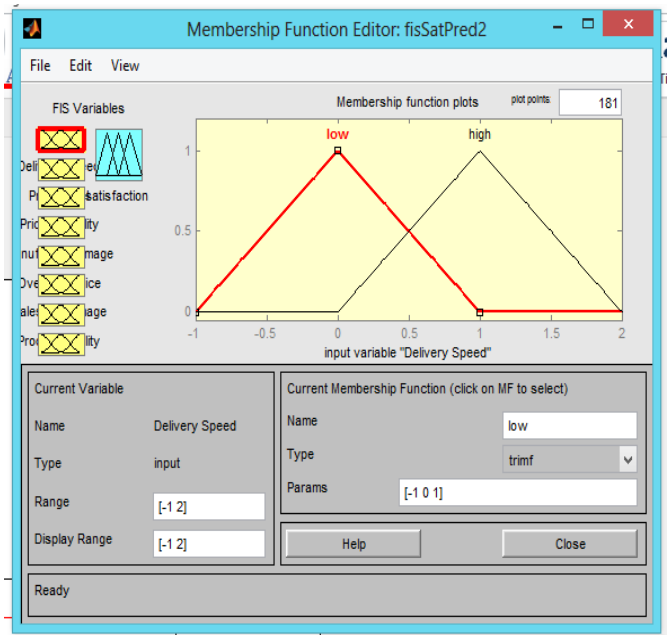


Figure 3. Sample Membership Function Diagram i.e. for Delivery Speed

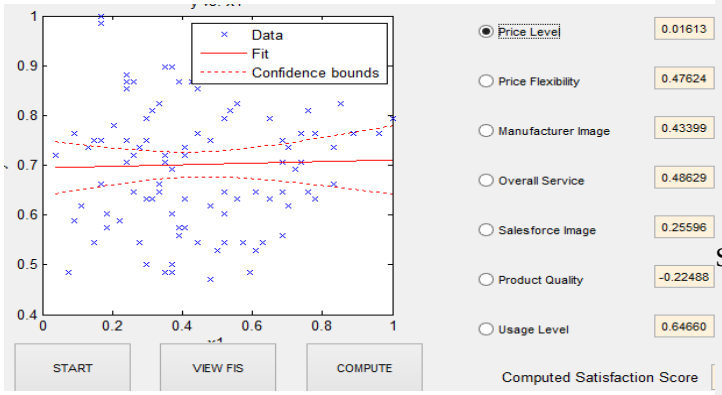


Figure 4. Fuzzy Satisfaction Prediction Diagram for Price Level

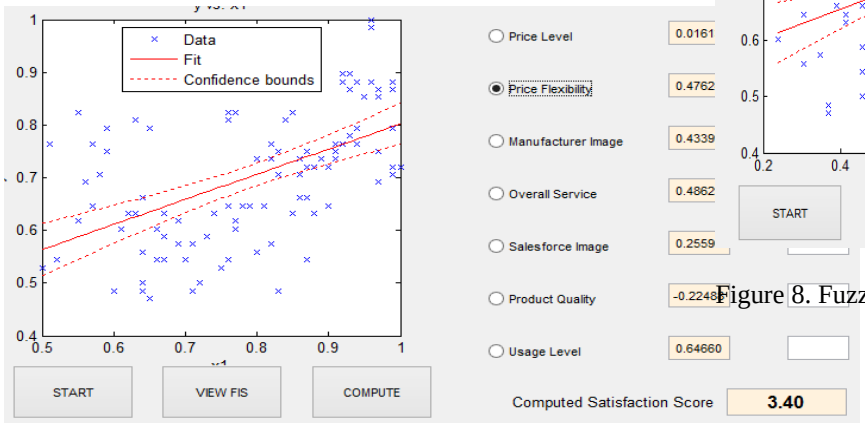


Figure 5. Fuzzy Satisfaction Prediction Diagram for Price Flexibility

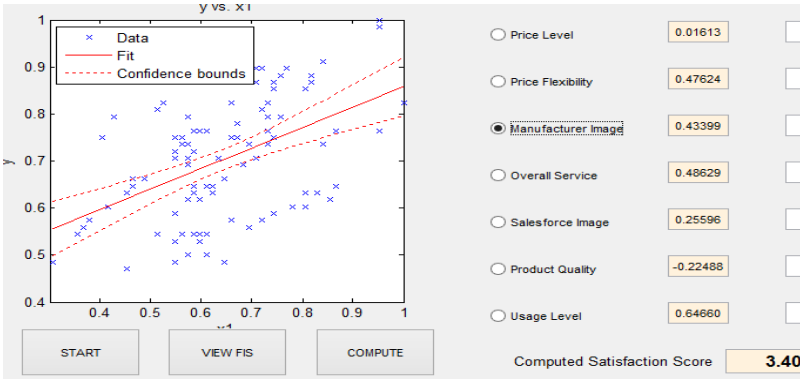
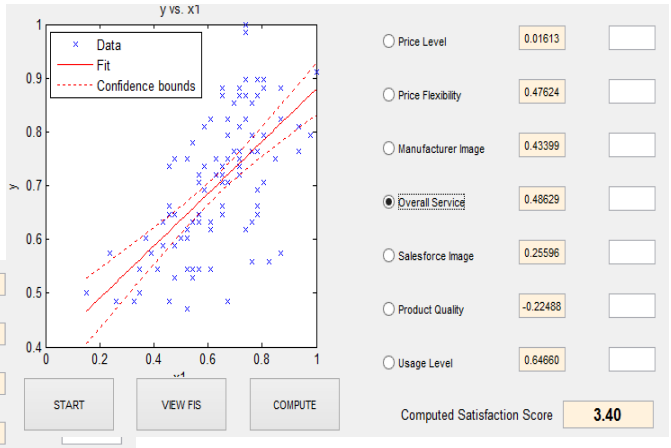


Figure 6. Fuzzy Satisfaction Prediction Diagram for Manufacturer Image



F igure 7. Fuzzy Satisfaction Prediction Diagram for Overall Service

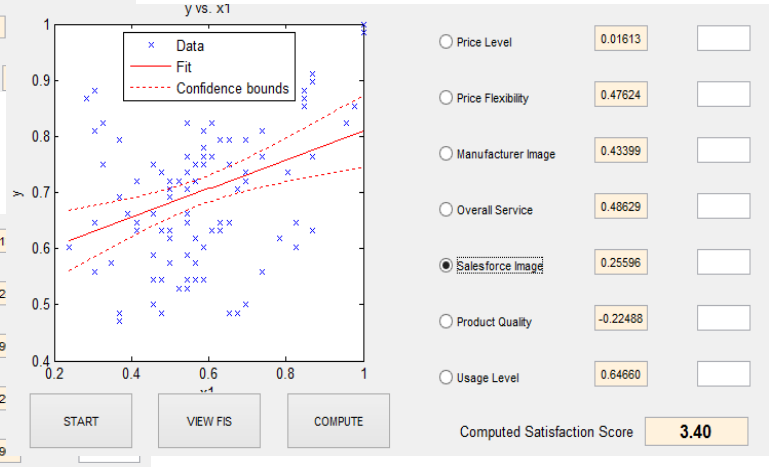


Figure 8. Fuzzy Satisfaction Prediction for Salesforce Image

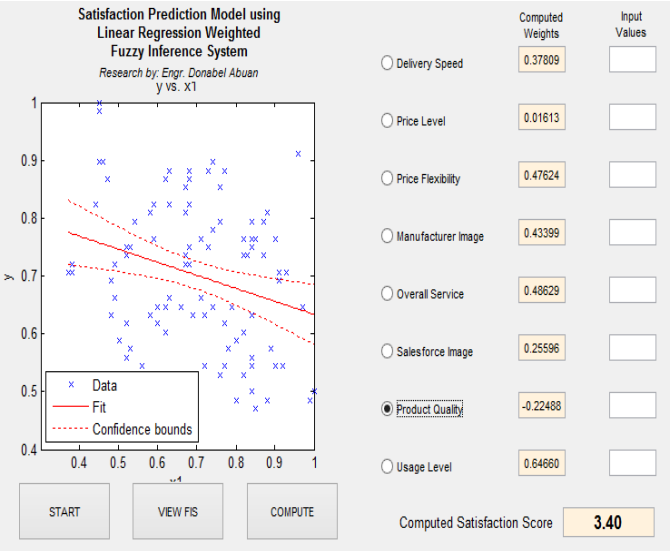


Figure 9. Fuzzy Satisfaction Prediction for Product Quality

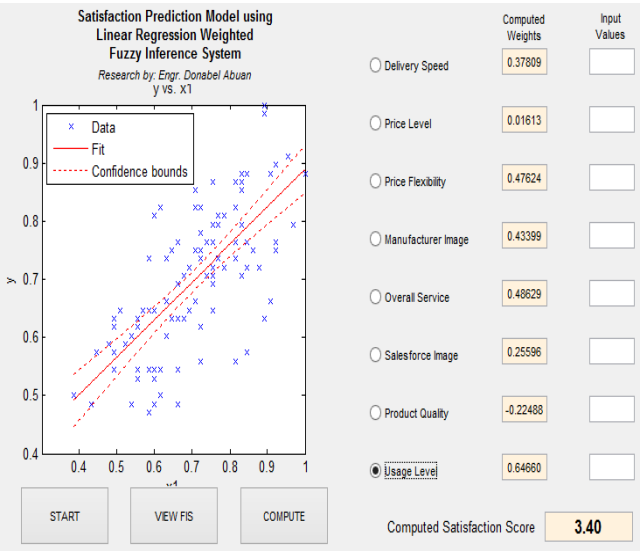


Figure 10. Fuzzy Satisfaction Prediction for Usage Level

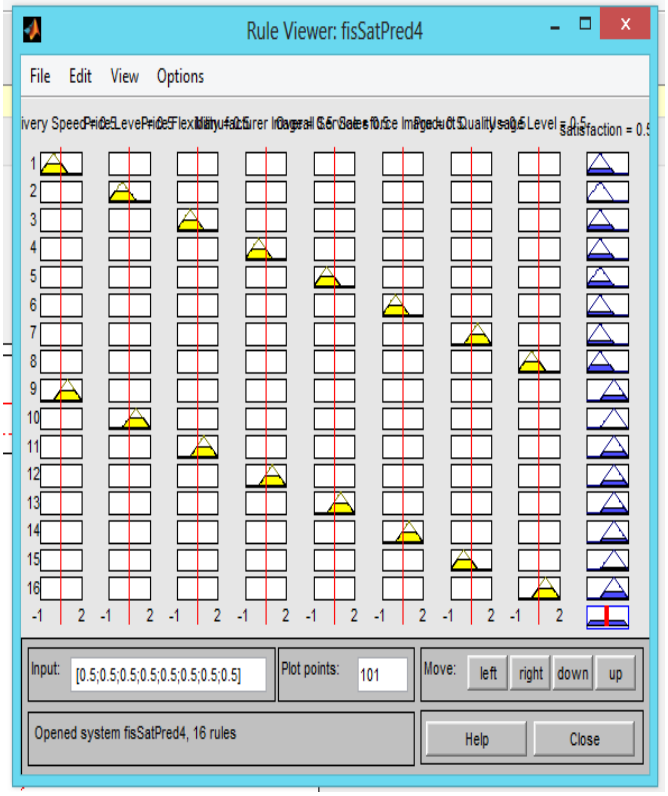


Figure 11. Sample Rule Viewer for FIS Prediction 4 (Manufacturer's Image)

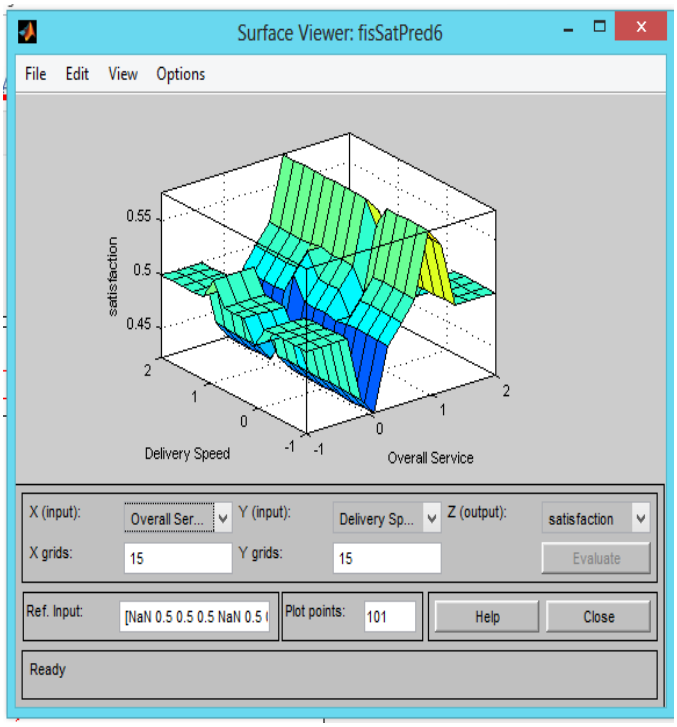


Figure 12. Sample FIS Surface Viewer for Prediction 6 i.e Overall Service

From the given results of Figures 2,4,5,6,7,8,9,10 it illustrates linear regression model for a given set of data from

the normalization values having the x-axis as the eight(8) parameter values and y-axis for the satisfaction values. We can used the data in some way to provide “expert inputs”. We used Linear Regression because the trend signifies effect of input. From figure 4, Fuzzy Satisfaction Prediction for Price Level, we can that slope, m = 0. Figures 2,5,6,8 signifies that slope, m is equal to one(1). Figures 7 and 10 illustrates that slope m is greater than one. Figure 9 has a negative value of weight which is -0.2 that’s why it is viewed on the opposite side.

Figure 3 illustrates the membership function editor where it shows the inputs as high or low. Figure 11 shows a sample rule viewer for these data whrein we have two possible inputs for each eight (8) parameter and come up with sixteen(16) possible rules. The following rules are :

If delivery speed is low, then satisfaction is low.
If delivery speed is high, then satisfaction is high.
If price level is low, then satisfaction is low.
If price level is high, then satisfaction is high.
If price flexibility is low, then satisfaction is low.
If price flexibility is high, then satisfaction is high.
If manufacturer image is low, then satisfaction is low.
If manufacturer image is high, then satisfaction is high.
If overall service is low, then satisfaction is low.
If overall service is high, then satisfaction is high.
If salesforce image is low, then satisfaction is low.
If salesforce image is high, then satisfaction is high.
If product quality is low, then satisfaction is high.
If product quality is high, then satisfaction is low.
If usage level is low, then satisfaction is low.
If usage level is high, then satisfaction is high.

Figure 12 shows another model illustrations for a certain parameter input of fuzzy prediction which is a surface viewer model.

IV. CONCLUSIONS AND RECOMMENDATIONS

Applying fuzzy logic for these data describes that if we have already set of input values, f(i1,i2,i3,i4,i5,i6,i7,i8) = satisfaction, where i1,i2,….i8 are the input parameters such as delivery speed, price level, etc, we can easily predict an output through the help of fuzzy logic rules using Mamdani method. Some of the advantages of these study are : No expert input. The inputs relied on historical data. Complicated multivariate function was created by the Fuzzy Logic Inference System (FIS). However, the disadvantage of these are : It does not improve over time. Success is highly dependent on historical data. Future recommendations for this research is to add a learning algorithm such as Artificial Neural Network (ANN) or ANFIS, artificial neural fuzzy logic inference system. If we will analyze it in our graphical user interface (GUI) diagram , we can set various inputs and integrate it in the ANN system applying also the data gathered and used it as a training data could make it possible for a more widespread of applications.

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