PREDICTING THE QUALITY OF ICE CREAM USING NEURO-FUZZY

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ABSTRACT: *This paper presents the quality prediction system for ice cream using neuro-fuzzy technique. Now a days neural network technique is also implemented in food engineering to reduce production cost and to estimate the quality of food product. Ice cream is mixture of different flavors, proteins, milk, water and emulsifiers. To produce the acceptable quality of ice cream different ingredients are mixed under standard conditions of temperature and pressure. The quality of the ice cream depends on its viscosity, overrun, melting rate and firmness. All these factors affect the overall quality of the ice cream. Viscosity, overrun, melting rate and firmness have been taken as input parameters and the overall quality of the ice cream has been taken as output. Neuro- fuzzy system is actually a combination of fuzzy logic and neural networks. This combined technique is very effective in solving complex real time problems. Fuzzy systems can work with vague information and can explain how to make decisions but they cannot automatically generate rules they use for decision making. On the other hand neural networks recognize patterns and predicts but they cannot explain how to reach at particular decision. The combined neuro fuzzy technique overcomes the limitations of both techniques. In this quality prediction system to make it more like human, fuzzy logic has been incorporated into the neural works.*

Keywords: ANFIS, Fuzzy Logic, Neural Networks

1. INTRODUCTION

For any business success it is necessary to provide good quality of product to your customers. For this purpose companies are trying to attract their customers by giving them high standard of products. [1]. There are different types of evaluation methods to control quality of food items and to estimate the consumer acceptance or to get the different attributes of product illustrating the perception of a product [2, 7].

Linear equations and polynomial modeling have been used for optimizing the different processes and the assessment and preparation of food products [3, 13-14].New development in the computing technology has automated the complex real time problems. ANFIS (Adaptive Neuro-Fuzzy Inference System) has introduced a combined methodology combining fuzzy system and neural networks. Only Sugeno type fuzzy system are combined with ANFIS.ANFIS is actually a hybrid technique consisting of two parts: one is gradient method to calculate the input membership functions and least square method is used to calculate the output function parameters [4]. Intelligent systems have the features of decision making and learning by using previous knowledge [10-11]. Fuzzy inference system is capable of reasoning under uncertain situations and neural network is able to learn and adapt in unsure situations, both techniques combine to form a hybrid system called, ANFIS (Adaptive Neuro-Fuzzy Inference System) [5].

This proposed quality prediction system for ice cream takes four input parameters: viscosity, overrun, melting rate and firmness. There is only one output parameter, quality. Production of ice cream has been made under different temperatures and air pressure. These physical conditions affect the overall quality of the ice cream .A good quality of ice cream has creamy texture and appropriate level of firmness and high melting rate. Good viscosity of ice cream keeps the ice cream mixture homogenized and gives it smooth creamy texture. Overrun input factor adds fluffiness in the ice cream and it is affected by the air pressure. Good melting rate keeps the ice cream quality excellent and makes its melting point decreased.

This paper is divided into five sections. Section 2 elaborates the Fuzzy Inference systems and Neuro-fuzzy systems. Section 3 describes the structure of proposed quality prediction system and shows MAT lab simulations. Section 4 consists of results and discussions. Section 5 shows conclusion and future work.

2 OVERVIEW OF FUZZY INFERENCE SYSTEM AND ADAPTIVE NEURO FUZZY INFERENCE SYSTEM

Fuzzy logic has been widely used in complex real time problems with uncertain inputs to achieve solutions of complex problems. Fuzzy logic basically works with IF-THEN rules. There are membership functions and fuzzy rules that perform inference mechanism on fuzzy rules and provide solutions. In Fuzzy systems there is a mapping of input membership functions to the output functions and give logical output. Fuzzy logic systems work with linguistic values and also adapt itself on numeric values to improve its performance. Fuzzy inference systems are successfully implemented in different domains like banks, medical diagnosis, and industrial control systems [9].

2.1 Neuro-fuzzy Systems

Neuro-fuzzy combines the advantages of both fuzzy logic and neural networks. Hybrid systems perform learning and computations of ANN and knowledge representation of Fuzzy Logic Systems. The adaptive neural networks and artificial neural networks are nonlinear computational models in nature and successfully used in the food engineering industry to map input/output relationship modeling since food production systems are complex systems [8]. Previously there is a lot research has been done in the field of food processing industry to predict the rheological features of liquid food [12]. Adaptive Neural Networks and Artificial Neural Networks are commonly used in industry to predict different dependent parameters.

3 STRUCTURE OF PROPOSED QUALITY PREDICTION SYSTEM FOR ICE CREAM

Table 1 Input/output Relation

Input Variables				Output
Viscosity	**Overrun**	**Melting rate**	**Firmness**	**Quality**
Low	Low	Low	Low	Poor
Low	Low	Low	Medium	Poor
Low	Low	Low	High	Poor
Low	Low	Medium	Low	Poor
Low	Low	High	Low	Poor
Low	Medium	Medium	Low	Poor
Low	High	Low	Low	Poor
Medium	Medium	Medium	Medium	Good
High	Medium	Medium	Medium	Excellent
High	High	High	High	Excellent

Ice cream is one of the favorite frozen dessert and now a days there is big competition among different companies to give better quality of ice cream in low cost. The standard ice cream ingredients are cream, vegetable fats, on fat solids and stabilizers and the mixture undergoes different chemical process under different temperature and pressure conditions. These physical conditions affect the overall quality of ice cream in terms of its texture, melting rate, rheological properties and hardness. Different formulation of ingredients also affects ice cream cost factor. ANFIS model accurately predicts the quality of ice cream by measuring the input parameters (viscosity, overrun, melting rate and firmness). The brief description of input variables and output has been shown in the Table 1. The back propagation algorithm has been used in neuro- fuzzy to predict quality and manage uncertain conditions describes the control rules for fuzzy data. The output membership functions define the output variable and give the final output

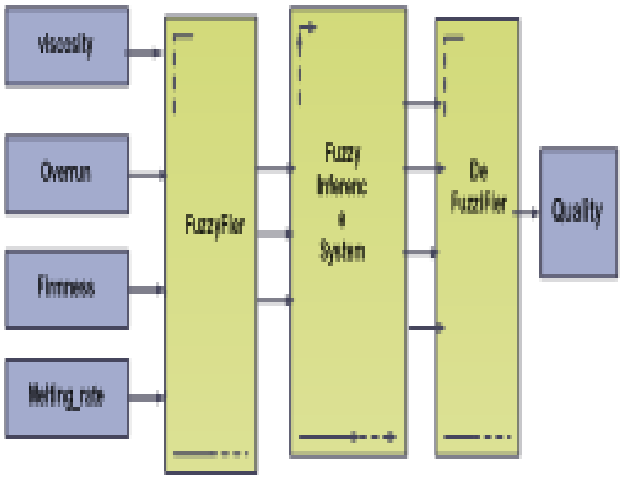

Figure 1 Fuzzy Based Quality Prediction system

3.1 Design Model of Fuzzy Inference System for Quality Prediction

There are four input parameters in this proposed Fuzzy Inference System and there only one output variable to show quality. Figure 1 shows a fuzzy based quality prediction system. The input variables are fuzzifiered by the fuzzifier. These inputs are provided to the Fuzzy Inference System which comprised of three components: a database, a rule base and a reasoning mechanism. Input variables are member functions used in fuzzification and output is generated by the defuzzification that shows the quality of the ice cream. Linguistic values for input variables are High, Medium and Low and for output variable it is Poor, Good and Excellent. These linguistic values are called membership functions in FIS.

In fuzzification four crisp values of input variables viscosity, overrun, melting rate and firmness are passed through the FIS and generates linguistic values Poor, Good, Excellent against each input variable by comparison. These linguistic values are then passed through the knowledge base. The knowledge base manipulates these values and

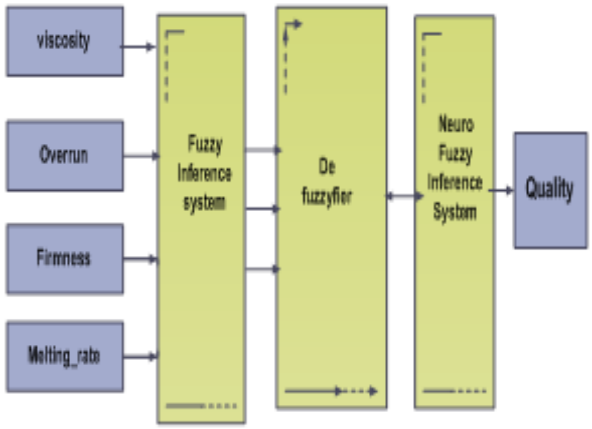

Figure 2 show the block diagram of ANFIS based quality prediction system

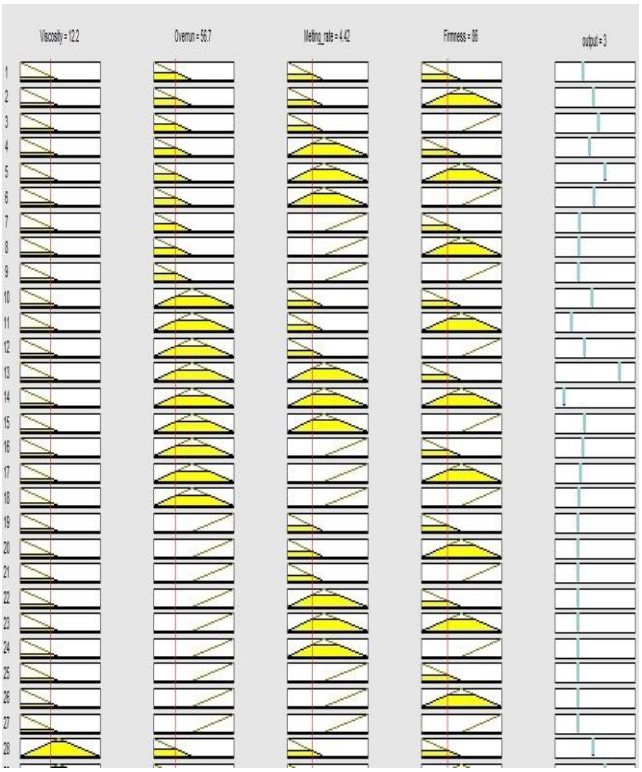

Figure 3 FIS Rules

The FIS rules have been shown in the figure 3. There are total 81 rules and 3 membership functions have defined for input and output variables.

Adaptive Neural FIS is a hybrid system which combines the advantages of FIS and ANN and ultimately provide and optimal solutions for complex systems. ANFIS supports Sugeno type fuzzy inference system which gives only one output. The proposed ANFIS model was trained using back propagation algorithm. The ANFIS model was trained with total 209 values of dataset and 95 values were used for testing. The number and type of membership functions were calculated by the Root Mean Square Error (**RMSE**), Mean Absolute Error (**MAE**) and the value of determination coefficient ($\mathbf{R^2}$). The values MAE and RMSE were determined by the following equations [12].

$$RMSE=\sqrt{1/N \sum_{i=1}^{N}[x-y]^2}$$

$$MAE=\frac{1}{N}\sum_{i=1}^{N}|x-y|$$

x is the measured value in the above equation , y is the predicted value of data and N shows the total number of data items.

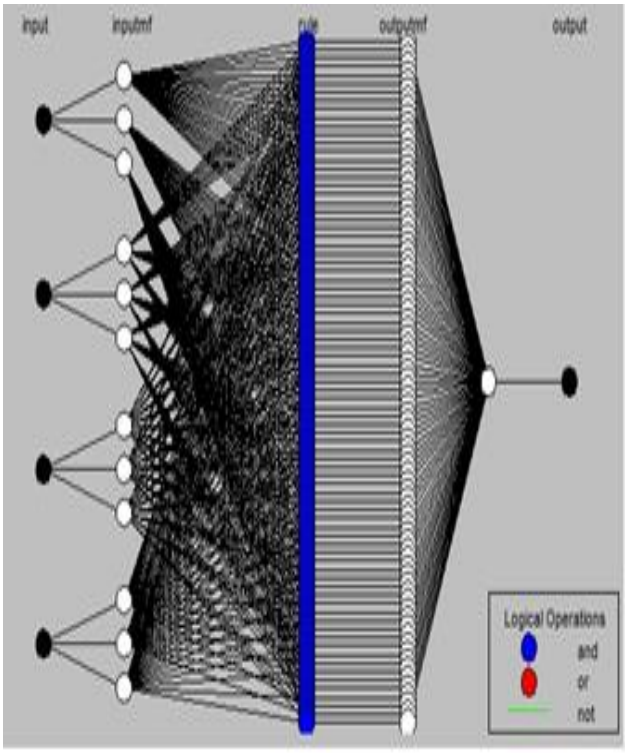

Figure 4 ANFIS Model Structure for Quality Prediction System

4. RESULTS AND DISCUSSIONS

The ANFIS model in the above figure shows four input parameters and each input has been categorize into three membership functions.

ANFIS model was trained with 209 pairs of input values as shown in the figure 5. This figure shows training error was .09 after 300 epochs.

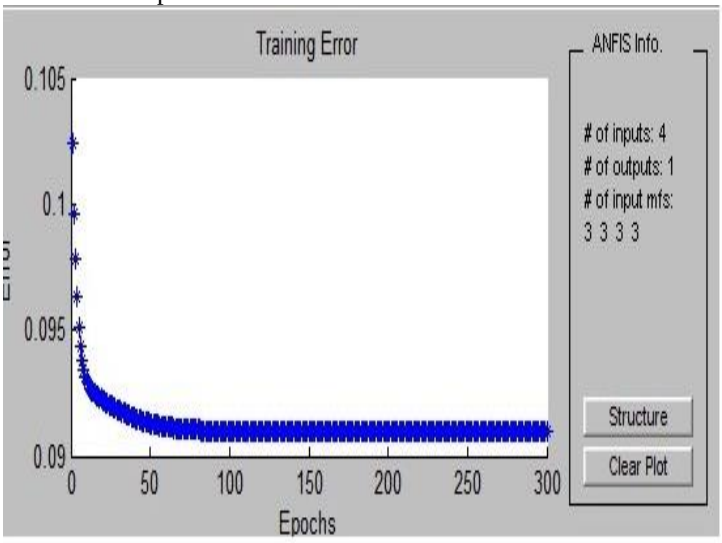

Figure 5 ANFIS Model with Training Data

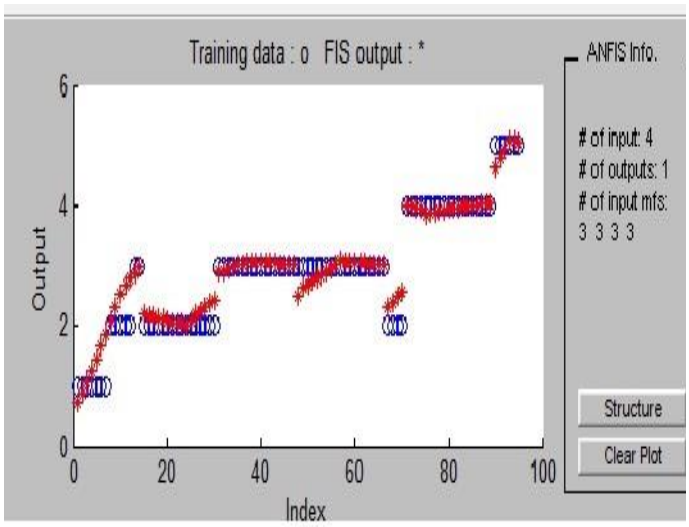

Figure 6 Testing Data Training

Figure 6 shows the training of test data set with 95 samples of input dataset. The error rate was .0723

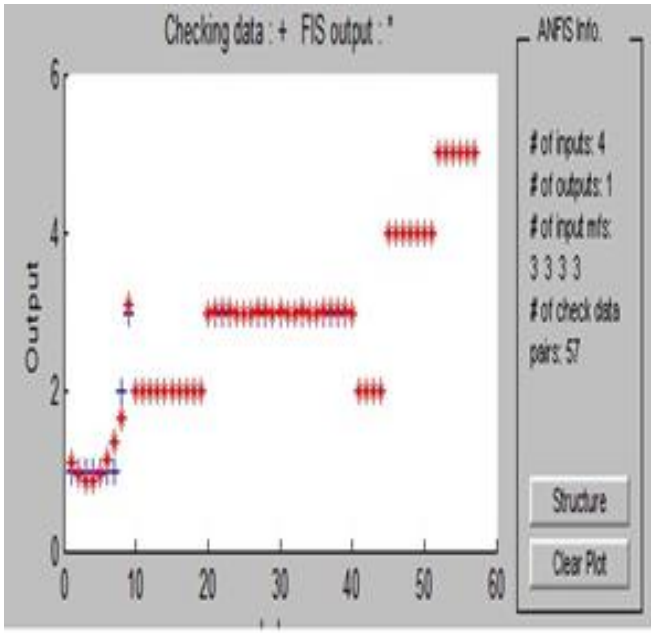

Figure 7 Checking Data Result for Neuro-fuzzy System

Figure 7 shows the checking data result of neuro fuzzy system using 57 dataset values. The error rate

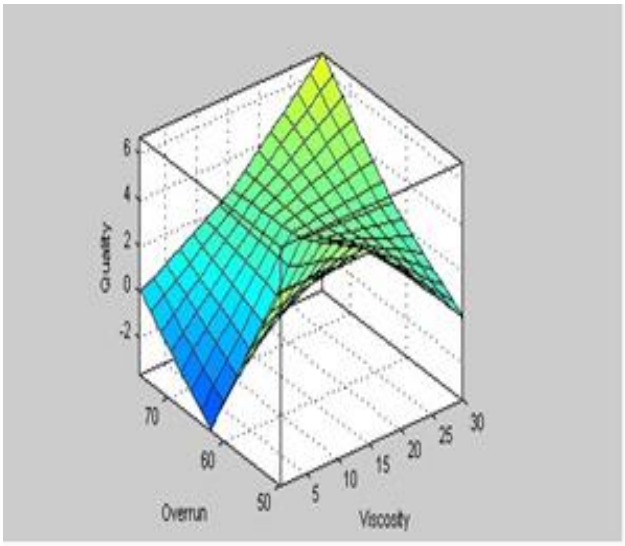

Figure 8 Surface Graphs between Viscosity and Overrun

In figure 8 surface graph shows relationship between viscosity and overrun, how these values affect the quality of the ice cream. As the values of viscosity and overrun increases the quality standard of ice cream increases.

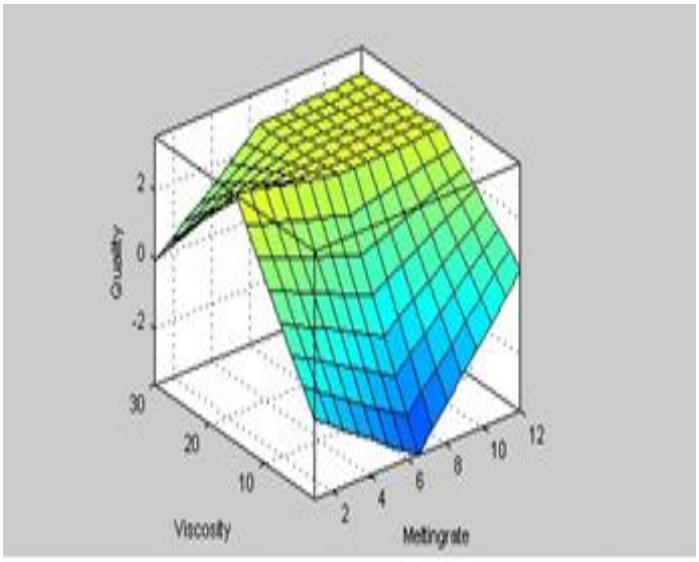

Figure 9 Surface Graph between Viscosity and Melting Rate

Figure 9 shows relationship between two input parameter viscosity and melting rate. The lower values of both parameter decreases the overall quality of the product.

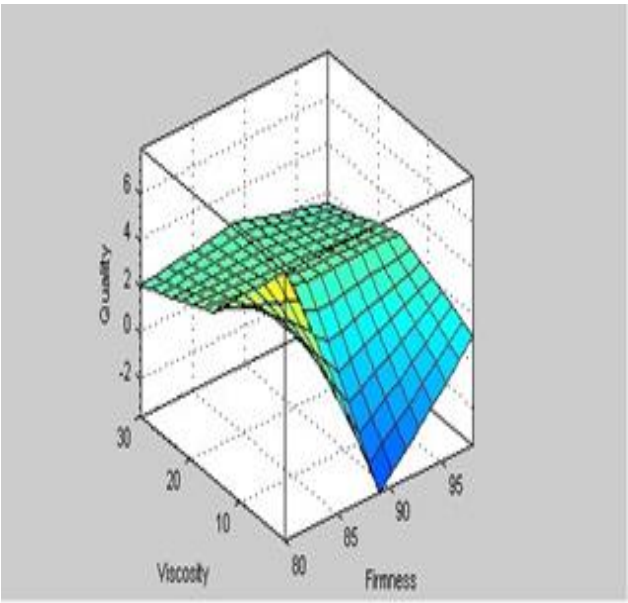

Figure 10 Surface Graphs between Viscosity and Firmness

Figure 10 shows how viscosity and firmness affects quality of ice cream. Higher value of firmness does not was improve the quality 0724

5. CONCLUSION

The ANFIS technique has been used to predict the quality of ice cream. The training error rate is .095 which is acceptable value.MAT Lab simulations result have been shown how different input parameters like viscosity, overrun , melting rate and firmness affects the quality of ice cream. The ANFIS models are successfully implemented in the food engineering to estimate the effects of different factors on the quality of the food product. This proposed system can be implemented in dairy industry and proved to be very help to achieve the acceptable quality product as desired by the consumer.

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