ARPN Journal of Science and Technology

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Artificial Neuron Based Models for Estimating Shelf Life of Burfi

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ABSTRACT

In the establishment of prediction model for predicting the shelf life of burfi stored at 30ºC moisture, titra table acidity, free fatty acids, tyrosine, and peroxide value were taken as input variables, and overall acceptability score as output variable. Mean square error, root mean square error, coefficient of determination and Nash-Sutcliffe coefficient were applied for comparing the prediction ability of the developed models. Several experiments were conducted and very good correlation was observed between the actual and predicted data, suggesting that the developed generalized regression artificial neural network engineering models are quite efficient in predicting the shelf life of burfi, which is very popular sweet confection prepared from water buffalo milk.

Keywords: *Generalized regression, Artificial Neuron, Soft Computing, Burfi, ANN.*

1. INTRODUCTION

Artificial Neural Networks (ANN), also known as “artificial neural nets” or “neural nets”, are computational tool modeled on the interconnection of neurons in the nervous systems of human brain and that of other organisms. The term “neural net” refers to both the biological and artificial variants, although typically the term is used to refer to artificial systems only. Mathematically, neural nets are nonlinear. Each layer represents a non-linear combination of non-linear functions from the previous layer. Each neuron is a multiple-input multiple-output (MIMO) system that receives signals from the inputs, produces a resultant signal, and transmits that signal to all outputs. Practically, neurons in an ANN are arranged into layers. The first layer that interacts with the environment to receive input is known as the input layer. The final layer that interacts with the output to present the processed data is known as output layer. Layers between the input and the output layer that do not have any interaction with the environment are known as hidden layers. Increasing the complexity of an ANN, and thus its computational capacity, requires the addition of more hidden layers, and more neurons per layer [1].

Generalized regression neural network models are a kind of radial basis network that is used for function approximation. Syntax: net = newgrnn (P, T, spread)

net = newgrnn (P, T, spread) takes three inputs,

P: R-by-Q matrix of Q input vectors
T: S-by-Q matrix of Q target class vectors

Spread: Spread of radial basis functions (default = 1.0) and returns is a new generalized regression neural network. The larger the spread, the smoother is the function approximation. To fit data very closely, use a spread smaller than the typical distance between input vectors. To fit the data more smoothly, larger spread is used. Newgrnn creates a two-layer network. The first layer has radbas neurons, and calculates weighted inputs with dist and net input with netprod. The second layer has purelin neurons, calculates weighted input with normprod, and net inputs with netsum. Only the first layer has biases .newgrnn sets, the first layer weights to P', and the first layer biases are all set to 0.8326/spread, resulting in radial basis functions that cross 0.5 at weighted inputs of +/– spread. The second layer weights W2 are set to T [2].

Shelf life is the recommendation of time that products can be stored, during which the defined quality of a specified proportion of the goods remains acceptable under specified conditions of distribution, storage and display. Most shelf life labels or listed expiry dates are used as guidelines based on normal handling of products. Use prior to the expiration date guarantees the safety of a food product, and a product is dangerous and ineffective after the expiration date. In case of most foods, shelf life is an important factor to health. Bacterial contaminants are ubiquitous, and foods left unused too long often acquire substantial increase in bacterial load and become dangerous to eat, leading to food poisoning [3].

Burfi is an extremely popular sweet confection prepared from water buffalo milk. In Indian subcontinent burfi is customarily served and consumed on all festive occasions and also during social gatherings. Though, several varieties of burfi such as cashew nut burfi, chocolate burfi, coconut burfi, almond burfi, pistachio burfi, cardamom burfi and plain burfi are sold in the market, but the latter variety is most popular which contains milk solids and sugar. The cut pieces of burfi are coated with very thin edible metallic silver leaf in order to make the product more attractive and also to increase its therapeutic value.

ANNs efficiently predicted the shelf life of milky white dessert jeweled with pistachios through linear layer (train) and generalized regression models,

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where neurons in each hidden layer varied from 1 to 30. The datasets were divided into two disjoint subsets, i.e., 80% of data samples were used for training the network and remaining 20% for validation. Mean square error, root mean square error, coefficient of determination and Nash - Sutcliffe coefficient were included in the study for comparing the prediction performance of the developed models [4]. Cascade single and multilayer ANN models were developed and compared with each other for predicting the shelf life of kalakand, a sweetened desiccated dairy product. In this study network was trained with 100 epochs and number of neurons in single and double hidden layers varied from 1 to 30. Cascade models with single hidden layer having four neurons gave the best outcome (MSE 0.000592818; RMSE: 0.024347850; R^2: 0.992884381). Cascade models with two hidden layers having twenty neurons in the first layer and twenty neurons in the second layer gave the best fit (MSE 0.000988770; RMSE: 0.03144471; R^2: 0.988125331) for predicting the shelf life of kala kand stored at 6°C [5]. ANNs successfully predicted the shelf life of instant coffee flavored sterilized drink [6, 7], soft mouth melting milk cakes [8] and soft cakes [9]. The shelf life of brown milk cakes decorated with almonds was estimated by radial basis (exact fit) and radial basis (fewer neurons) models, and the developed models were compared with each other. Both the models predicted the shelf life of the product exceedingly well. Comparison of the developed models gave very interesting observation, i.e., output results were the same when numerous experiments were conducted after having taken the same spread constant in both the models, suggesting that both the developed ANN computing models are equally convenient, less time consuming and powerful alternative tool to laboratory's expensive and long time taking shelf life testing method for predicting the shelf life [10]. Brain based artificial intelligent scientific computing models were applied for shelf life detection of cakes stored at 30ºC. Cascade neural network (CNN) and probabilistic neural network models were developed. Input variables were moisture, titra table acidity, free fatty acids, peroxide value, and tyrosine; while overall acceptability sensory score was the output variable. Mean Square Error, Root Mean Square Error, Coefficient of determination and Nash - Sutcliffe Coefficient were used in order to compare the prediction performance of the developed models. The best results of all the models were compared with each other, and it was observed that CNN model with single hidden layer having twenty five neurons was better for shelf life detection of cakes [11]. The ANN models have been proposed for several other milk based products [12-20].

At present no study has been reported for predicting the shelf life of burfi stored at 30ºC by employing generalized regression ANN engineering models, hence this investigation was planned. The findings of this study would be very beneficial to food industry, dairy industry, consumers, retailers, regulatory authorities, food researchers and academicians.

2. MATERIAL AND METHODS

For predicting the shelf life of burfi through generalized regression ANN engineering models, input variables were moisture, titra table acidity (TA), free fatty acids (FFA), tyrosine, and peroxide value (PV), while overall acceptability score (OAS) was taken as output variable (Fig.1).

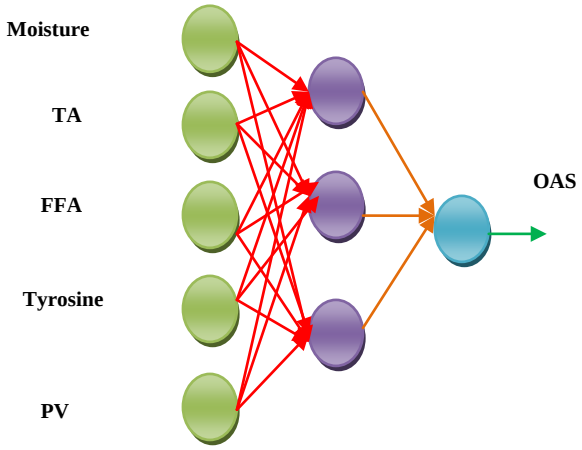

Fig 1: Input and output parameters of ANN

For each input and output variables 48 observations were used for developing the models. The data was randomly divided into two disjoint subsets, viz., training set having 40 observations and testing set 8. Mean square error (MSE) (1), Root mean square error (RMSE) (2), Coefficient of determination: R^2 (3) and Nash - Sutcliffe coefficient: E^2 (4) were applied in order to compare the prediction ability of the developed models. MALTAB software was used for performing the experiments.

$$MSE = \left[\sum_{1}^{N} \left(\frac{Q_{\exp} - Q_{cal}}{n} \right)^2 \right] \quad (1)$$

$$RMSE = \sqrt{\frac{1}{n} \left[\sum_{1}^{N} \left(\frac{Q_{\exp} - Q_{cal}}{Q_{\exp}} \right)^2 \right]} \quad (2)$$

$$R^2 = 1 - \left[\sum_{1}^{N} \left(\frac{Q_{\exp} - Q_{cal}}{Q_{\exp}^{\ 2}} \right)^2 \right] \quad (3)$$

$$E^2 = 1 - \left[\sum_{1}^{N} \left(\frac{Q_{\exp} - Q_{cal}}{Q_{\exp} - \overline{Q_{\exp}}} \right)^2 \right] \quad (4)$$

Where,

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Q_{exp} = Observed value; Q_{cal} = Predicted value; $\overline{Q}_{exp}$ =Mean predicted value; n = Number of observations in dataset. MSE (1), RMSE (2), R^2 (3) and E^2 (4) were used in order to compare the prediction potential of the developed CBA models.

3. RESULTS AND DISCUSSION

The performance matrices of the ANN models for predicting the OAS are presented in Table 1.

Table 1: Results of generalized regression model

Spread Constant	MSE	RMSE	R^2	E^2
10	0.001045232	0.032330047	0.967669953	0.998954768
20	0.001114671	0.033386689	0.966613311	0.998885329
30	0.001128125	0.033587572	0.966412428	0.998871875
40	0.001132718	0.033655872	0.966344128	0.998867282
50	0.001135153	0.033692031	0.966307969	0.998864847
60	0.001136236	0.033708102	0.966291898	0.998863764
70	0.001137049	0.033720155	0.966279845	0.998862951
80	0.00113732	0.033724172	0.966275828	0.99886268
90	0.001137862	0.033732208	0.966267792	0.998862138
100	0.001137862	0.033732208	0.966267792	0.998862138
110	0.001138133	0.033736225	0.966263775	0.998861867
120	0.001138133	0.033736225	0.966263775	0.998861867
130	0.001138404	0.033740243	0.966259757	0.998861596
140	0.001138404	0.033740243	0.966259757	0.998861596
150	0.001138404	0.033740243	0.966259757	0.998861596
160	0.001138675	0.033744261	0.966255739	0.998861325
170	0.001138675	0.033744261	0.966255739	0.998861325
180	0.001138675	0.033744261	0.966255739	0.998861325
190	0.001138675	0.033744261	0.966255739	0.998861325
200	0.001138675	0.033744261	0.966255739	0.998861325

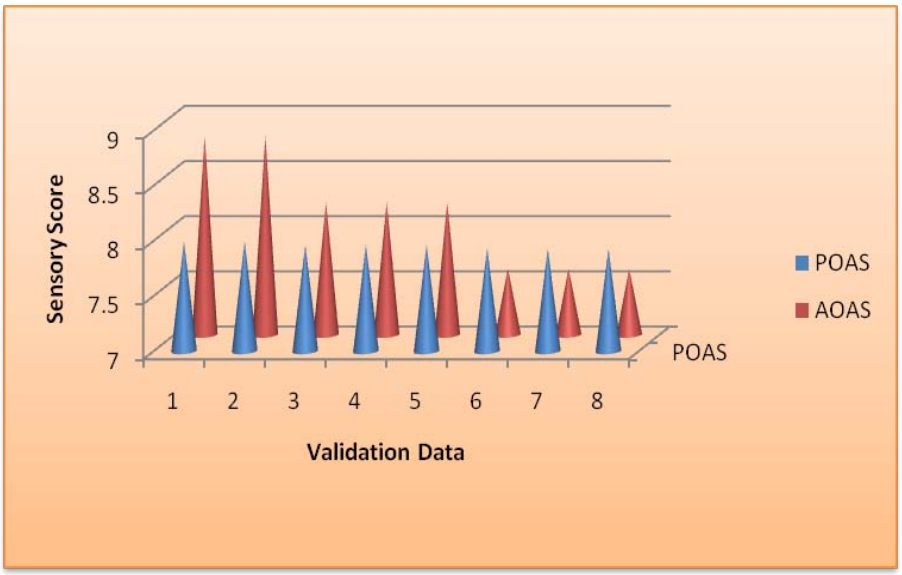

Fig 2: Comparsion of AOAS and POAS for generalized regression model

Generalized regression model was developed for predicting the shelf life of burfi stored at 30ºC. Several experiments were conducted and it was observed that generalized regression model with spread constant 10 gave the best fit with high coefficient of determination 0.967669953 and Nash - Sutcliffo

coefficient 0.998954768 (Table 1), indicating that the developed generalized regression model got very well simulated, and can be used to predict the shelf life of burfi in a much shorter time compared to long time taking laboratory test method.

4. CONCLUSION

For predicting the shelf life of burfi stored at 30ºC generalized regression artificial neural network engineering models were developed. Moisture, titra table acidity, free fatty acids, tyrosine, and peroxide value were taken as input variables and overall acceptability score as the output. Mean square error, root mean square error, coefficient of determination and Nash-Sutcliffe coefficient were applied for comparing the prediction ability of the developed models. The generalized regression model with spread constant 10 showed very good correlation between the actual data and the predicted values, with a high determination coefficient and Nash-Sutcliffe coefficient establishing that the developed model was able to analyze non-linear multivariate data with good performance. From the study it is concluded that generalized regression artificial neural network engineering models can be used to predict the shelf life of burfi.

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