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Radial Basis (Exact Fit) Artificial Neural Network Technique for Estimating Shelf Life of Burfi

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Abstract – Radial basis (exact fit) artificial neural network model for estimating the shelf life of *burfi* stored at 30º C has been developed. Input variables for developing the models were moisture, titratable acidity, free fatty acids, tyrosine, and peroxide value; and the overall acceptability score was output variable. Mean square error, root mean square error, coefficient of determination and nash - sutcliffo coefficient were applied in order to compare the prediction ability of the developed models. High correlation was found between training and validation data, indicating that the developed Radial basis (exact fit) ANN models are good for estimating the shelf life of *burfi*.

Keywords – Artificial Neural Networks; Artificial Intelligence; Radial Basis (Exact Fit); *Burfi*; Shelf Life

1. Introduction

1.1 Artificial Neural Network

A neural network is a parallel system, capable of resolving paradigms that linear computing cannot. An Artificial Neural Network (ANN) is a system based on the operation of biological neural networks. Although, at present computing is quite advanced, but there are certain tasks that a program made for a common microprocessor is unable to perform; even so a software implementation of a neural network can be made with their advantages and disadvantages. Another aspect of the ANNs is that there are different architectures, which consequently require different types of algorithms, but despite to be an apparently complex system, a neural network is relatively simple. Currently ANNs are among the newest signal processing technologies. In the world of engineering, neural networks have two main functions: Pattern classifiers and as non linear adaptive filters. As its biological predecessor, an ANN is an adaptive system. By adaptive, it means that each parameter is changed during its operation and it is deployed for solving the problem in matter. This is called the training phase. ANN is developed with a systematic step-by-step procedure which optimizes a criterion commonly known as the learning rule. The input/output training data is fundamental for these networks as it conveys the information which is necessary to discover the optimal operating point [1].

1.2 Radial Basis (Exact Fit)

A radial basis function network is an ANN that uses radial basis functions as activation functions. It is a linear combination of radial basis functions. They are used in function approximation, time series prediction, and control. Radial basis function network consists of one layer of input nodes, one hidden radial-basis function layer and one output linear layer [2].

1.3 Burfi

Burfi is very popular sweet confection prepared from water buffalo milk. In Indian subcontinent *burfi* is essentially and customarily served and consumed on all festive occasions and also during social gatherings like marriages and birthday parties. Though, several verities of *burfi* such as cashew nut *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. *Burfi* is coated with an edible thin metallic silver leaf.

1.4 Shelf Life Studies

Shelf life studies can provide important information to product developers enabling them to ensure that the consumer will see a high quality product for a significant period of time after production. As the mechanisms of food deterioration became known to food scientists, methods of counteracting these losses in quality have been developed. The rate at which these reactions occur, the effects of temperature, water, and the myriad of other parameters have become characterized factors contributing to the science of accelerated shelf life studies [3].

1.5 Shelf Life Predictions Using ANN

Goyal and Goyal [4] implemented brain based artificially intelligent scientific computing models for shelf life detection of cakes stored at 30^{o}C. The potential of simulated neural networks for predicting shelf life of soft cakes stored at 10^{o}C was highlighted [5]. Cascade single and double hidden layer models were developed and compared with each other for predicting the shelf life of Kalakand, a desiccated sweetened dairy product [6].

For forecasting the shelf life of instant coffee drink, radial basis artificial neural engineering and multiple linear regression models were suggested [7]. ANN models for predicted of sensory quality of instant coffee flavoured sterilized drink [8, 9]. Artificial neural networks for predicting the shelf life of milky white dessert jeweled with pistachio were applied by Goyal and Goyal [10]. The shelf life of brown milk cakes decorated with almonds was predicted by developing artificial neural network based radial basis (exact fit) and radial basis (fewer neurons) models [11]. Also, the time-delay and linear layer (design) intelligent computing expert system models have been developed for predicting the shelf life of soft mouth melting milk cakes stored at 6°C [12]. Computerized models predicted shelf life of post-harvest coffee sterilized milk drink [13].

This study aims to develop radial basis (exact fit) ANN models for estimating the shelf life of *burfi* stored at 30° C.

2. Method Material

The input variables used for developing the ANN models were the experimental data of *burfi* relating to moisture, titratable acidity (TA), free fatty acids (FFA), tyrosine, and peroxide value (PV). The overall acceptability score (OAS) assigned by the expert panelists was taken as output variable (Fig.1).

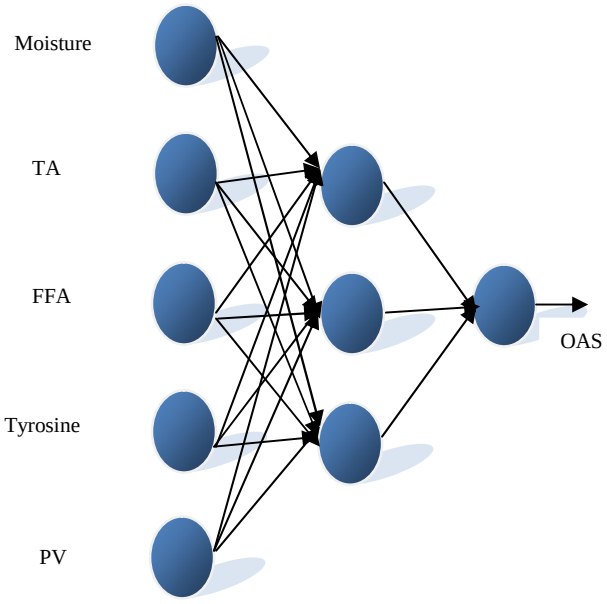

Figure 1. Input and output parameters of ANN model

For each input and output variables 48 observations were used for developing the ANN models. The data was randomly divided into two disjoint subsets, namely, training set having 40 observations and testing set 8 observations.

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

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

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

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

Where,

$Q_{\exp}$ = Observed value;

Q_{cal} = Predicted value;

$\overline{Q_{\exp}}$ =Mean predicted value;

n = Number of observations in dataset.

Mean square error (MSE) (1), Root mean square error (RMSE) (2), Coefficient of determination: R^2 (3) and Nash - Sutcliffo coefficient: E^2 (4) were applied in order to compare the prediction ability of the developed models.

3. Results and Discussion

ANN model's performance matrices for predicting OAS are presented in Table 1.

The comparison of Actual Sensory Score (ASS) and Predicted Sensory Score (PSS) for radial basis (exact fit) model are shown in Fig.2. Radial basis (exact fit) model was developed for predicting the shelf life of *burfi* stored at 30° C. Several experiments were conducted and it was observed that radial basis model with spread constant 190 and 200 gave the best results with high coefficient of determination **0.99999598** and nash - sutcliffo coefficient 1. It is evident from the high values of R^2 and E^2 that the radial basis (exact fit) ANN models are very good in predicting the shelf life of *Burfi*.

Table 1: Results of Radial Basis (Exact Fit) model

Spread Constant	MSE	RMSE	R^2	E^2
10	2.36328E-07	0.000486136	0.99951386	0.999999764
20	1.65289E-06	0.001285649	0.99871435	0.999998347
30	2.44682E-07	0.000494653	0.99950534	0.999999755

40	8.53887E-07	0.00092406	0.99907594	0.999999146
50	0.000739813	0.027199505	0.97280049	0.999260187
60	0.000738066	0.027167364	0.97283263	0.999261934
70	8.703E-05	0.009328988	0.99067101	0.99991297
80	6.96747E-06	0.002639597	0.99736040	0.999993033
90	8.69551E-07	0.000932497	0.99906750	0.99999913
100	8.68802E-05	0.009320953	0.99067904	0.99991312
110	1.00484E-05	0.003169928	0.99683007	0.999989952
120	1.24716E-05	0.003531516	0.99646848	0.999987528
130	0.000135096	0.011623068	0.98837693	0.999864904
140	1.0279E-05	0.003206086	0.99679391	0.999989721
150	1.67936E-07	0.000409801	0.99959019	0.999999832
160	1.00484E-05	0.003169928	0.99683007	0.999989952
170	2.32438E-07	0.000482118	0.99951788	0.999999768
180	1.67936E-07	0.000409801	0.99959019	0.999999832
190	**1.61415E-11**	**4.01765E-06**	**0.99999598**	**1**
200	**1.61415E-11**	**4.01765E-06**	**0.99999598**	**1**

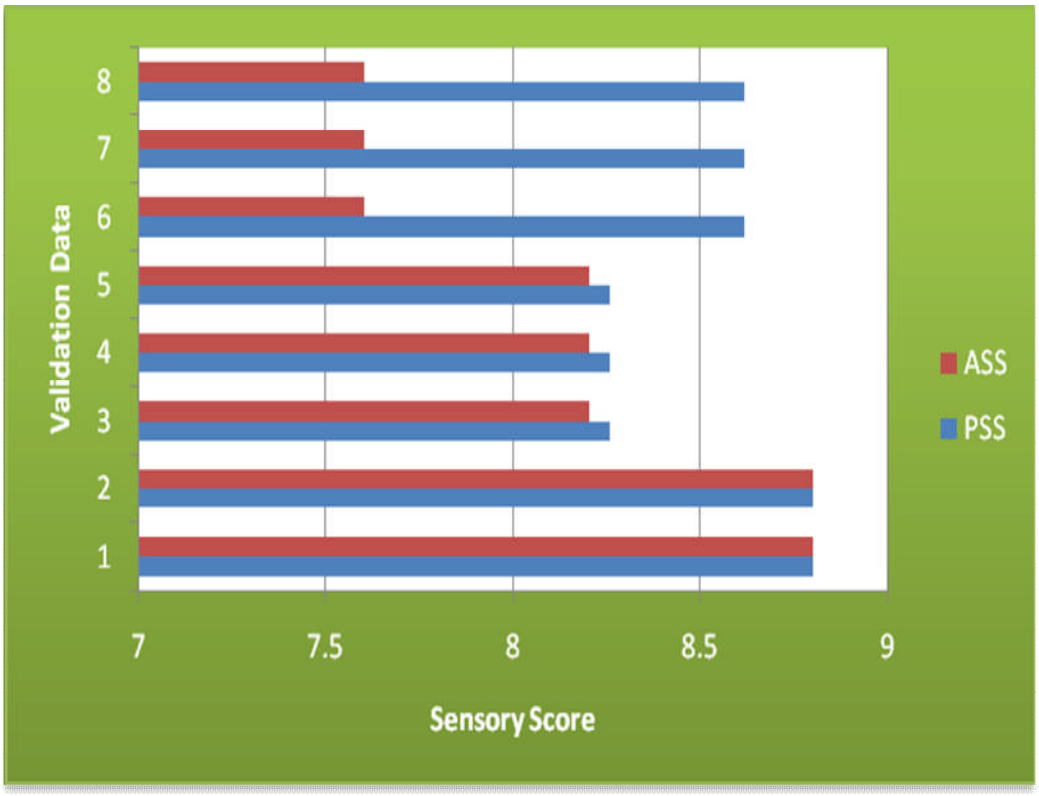

Figure 2. Comparison of ASS and PSS for ANN model

4. Conclusion

Radial basis (exact fit) model was developed for estimating the shelf life of *Burfi* stored at 30ºC. The input variables were moisture, titratable acidity, free fatty acids, tyrosine, and peroxide value, and the overall acceptability score was output variable. Mean square error, root mean square error, coefficient of determination and nash-sutcliffo coefficient were applied for comparing the prediction ability of the developed models. The observations revealed very good correlation between the actual data and the predicted values, with a high determination coefficient and nash-sutcliffo coefficient establishing that the developed models were able to analyze non-linear multivariate data with good performance, fewer parameters, and shorter calculation time. From the study it is concluded that the developed model, which is very convenient, less expensive and less time consuming, can be a good alternative to expensive, time consuming and cumbersome laboratory testing method for estimating the shelf life of *burfi* [14-16].

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