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A New Scientific Approach of Intelligent Artificial Neural Network Engineering for Predicting Shelf Life of Milky White Dessert Jeweled with Pistachio

Sumit Goyal, Gyanendra Kumar Goyal

Abstract— This paper highlights the capability of artificial neural networks for predicting shelf life of milky white dessert jeweled with pistachio. Linear layer (train) and generalized regression models were developed and compared with each other. Neurons in each hidden layers varied from 1 to 30. Data samples were divided into two sets, *i.e.*, 80% of data samples were used for training and 20% for validating the network. Mean Square Error, Root Mean Square Error, Coefficient of determination and Nash - Sutcliffo Coefficient were applied in order to compare the prediction performance of the developed models. The experimental shelf life is 21 days and the developed intelligent artificial neural network model predicted 20.15 days shelf life for milky white dessert jeweled with pistachio.

Index Terms— ANN, Dessert, Generalized Regression, Intelligent Computing, Linear Layer (Train), Neurocomputing, Shelf Life

1 INTRODUCTION

MILKY white dessert is very tempting and mouth watering. It was prepared from water buffalo milk and stored at 30^{o}C. It is a type of confectionery made from milk, sugar and flavorings. Sometimes different colors are also added to make it look more presentable and they are jeweled with pistachios. Artificial Neural Network (ANN) describes a population of physically interconnected neurons or a group of disparate neurons whose inputs or signaling targets define a recognizable circuit (Fig.1). Communication between neurons often involves an electrochemical process. A typical biological neuron is composed of a cell body, a tubular axon, and a multitude of hair-like dendrites. The dendrites form a very fine filamentary brush surrounding the body of the neuron. The axon is essentially a long, thin tube that splits into branches terminating in little end bulbs that almost touch the dendrites of other cells. The small gap between an end bulb and a dendrite is called a synapse, across which information is propagated. The axon of a single neuron forms synaptic connections with many other neurons; the presynaptic side of the synapse refers to the neuron that sends a signal, while the postsynaptic side refers to the neuron that receives the signal.

- *Sumit Goyal is currently Sr. Research Fellow in National Dairy Research Institute, India, PH-01842259244. E-mail: thesumitgoyal@gmail.com*
- *Gyanendra Kumar Goyal is currently Emeritus Scitentist in National Dairy Research Institute, India, PH-01842259244. E-mail: gkg5878@yahoo.com.*

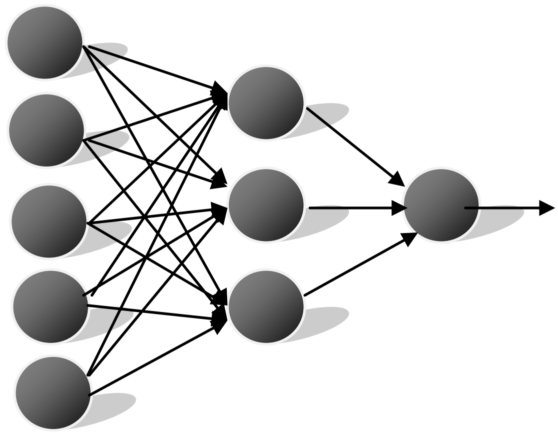

Fig.1 Artificial neural network

ANN consists of an interconnected group of artificial neurons and processes information using artificial approach to computing. ANN model is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In more practical terms, ANN models are non-linear statistical data modelling tools. They can be used to model complex relationships between inputs and outputs or to find patterns inherent in data. ANN model is an interconnected group of nodes, parallel to the vast network of neurons in the human brain. The ANN predicted shelf lives, agreed very well with actual shelf life data pertaining to rice snacks, and ANN could be used as an alternative method for shelf life prediction of moisture-sensitive food products [1].

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1.1 Linear Layer Train (LLT) Model

Linear layers are single layers of linear neurons. They may be static, with input delays of 0, or dynamic, with input delays greater than 0. They can be trained on simple linear time series problems, but often are used adaptively to continue learning while deployed so they can adjust to changes in the relationship between inputs and outputs while being used [2].

1.2 Generalized Regression (GR) Model

Generalized regression models are a kind of radial basis network that are 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 a new generalized regression model. To fit data very closely, use a spread smaller than the typical distance between input vectors. To fit the data more smoothly, use a larger spread. Larger the spread, the smoother the function approximation. *Newgrnn* creates a two-layer neural network. The first layer has *radbas* neurons in it 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 *W*2 are set to *T* [3].

1.3 Significance of Shelf Life

Shelf life is the recommendation of time that products can be stored, during which the defined quality of a specified proportion of the products remains acceptable under expected (or 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. Shelf life is most influenced by several factors: exposure to light and heat, transmission of gases (including humidity), mechanical stresses, and contamination by microorganisms. Product quality is often mathematically modelled around a parameter. For some foods, the shelf life is an important factor to health. Bacterial contaminants are ubiquitous, and foods left unused too long will often acquire substantial amounts of bacterial colonies and become dangerous to eat, leading to food poisoning. Best before or best by dates appear on a wide range of frozen, dried, tinned and other foods. These dates are only advisory and refer to the quality of the product, in contrast with use by dates, which indicate that the product is no longer safe to consume after the specified date [4]. Goyal and Goyal [5] developed radial basis and multiple linear regression models for forecasting shelf life of instant coffee drink. Linear layer (design) and time - delay methods of intelligent computing expert system were developed by Goyal and Goyal [6] for shelf life prediction of soft mouth melting milk cakes stored at 6^{o}C. Both the methods were compared with each other and it was observed that linear layer (design) method had superiority in predicting shelf life of soft mouth melting milk cakes stored at 6^{o}C. ANN predicts soya bean equilibrium moisture content more accurately than mathematical model [7]. The ANN predicted shelf lives, agreed very well with actual shelf life data pertaining to rice snacks, and ANN could be used as an alternative method for shelf life prediction of moisture-sensitive food products [1]. Neuron based artificial intelligent scientific computer engineering models for estimating shelf life of instant coffee sterilized drink were impelemented by Goyal & Goyal [8]. Presently, there is no study to predict the shelf life of milky white desserts jeweled with pistachios. Estimating shelf life in laboratory is very expensive and it takes a lot of time. This study would be useful to desert manufactures, regulatory authorities, consumers and food researchers.

2 Method Material

Tyrosine, moisture, free fatty acids, titratable acidity, peroxide value were input parameters and overall acceptability score was output parameter used for developing ANN models . The data samples consisted of 60 observations. The data samples were divided into two subsets, *i.e.,* 48 data observations (80% of data observations) were used for training the network and 12 for validation (20% of data observations). The number of neurons and spread constant varied from 1 to 30 and the network was trained with 100 epochs. Several combinations were tried and tested, as there is no defined rule of getting good results rather than hit and trail method. As the number of neurons increased, the training time also increased. Two problems should always be kept in mind while training the network, the problem of overfitting and problem of underfitting .Overfitting occurs when size of neurons used in the training of network are more, as it is difficult for the network to train and underfitting

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occurs when too few neurons are used for training the network. Therefore, proper balance should be maintained, while training the ANN. The Neural Network Toolbox under MATLAB 7.0 software was used for development of ANN models. Mean Square Error,Root Mean Square Error, Coefficient of determination and Nash - Sutcliffo Coefficient were used to compare the prediction potential of the developed ANN models.

3 Results and Disscusion

Table 1: Results of LLT

Neurons	MSE	RMSE	R^2	E^2
3	0.0050323	0.070938752	0.939612321	0.994967693
4	0.0079423	0.089119678	0.904692196	0.992057683
5	0.0039312	0.06270007	0.952824415	0.996068701
8	0.0019478	0.044133916	0.97662637	0.998052197
11	0.0075033	0.086621686	0.909960203	0.992496684
14	0.0025250	0.050250772	0.969698319	0.99747486
15	0.0023590	0.048569972	0.971691494	0.997640958
17	0.0014922	0.038629462	0.982093176	0.998507765
20	0.0004062	0.020155449	0.995125094	0.999593758
22	**0.0002851**	**0.016887393**	**0.996577791**	**0.999714816**
24	0.000974	0.031214421	0.988307919	0.99902566
25	0.0022627	0.047568674	0.972846655	0.997737221
26	0.0053409	0.073081987	0.935908278	0.994659023
27	0.0016072	0.040090531	0.980712992	0.998392749
30	0.0061833	0.078634448	0.925799484	0.993816624

Table 2: Results of GR Model

Spread Constant	MSE	RMSE	R^2	E^2
3	0.004840334	0.069572512	0.941915986	0.995159666
7	0.001615548	0.040193878	0.980613426	0.998384452
10	0.003163267	0.05624293	0.962040793	0.996836733
15	**0.000946218**	**0.030760652**	**0.988645388**	**0.999053782**
18	0.007245919	0.085122964	0.913048972	0.992754081
20	0.009002618	0.094882129	0.891968578	0.990997382
23	0.010095776	0.100477741	0.878850683	0.989904224
25	0.010504298	0.102490478	0.873948424	0.989495702
28	0.010698242	0.103432305	0.87162110	0.989301758
30	0.010805149	0.103947821	0.870338207	0.989194851

LLT and GR models were developed for predicting shelf life of milky white dessert stored at 30° C. LLT models gave best result with twenty two neurons: MSE: **0.000285184**, RMSE: **0.016887393**, R^2: **0.996577791**, E^2: **0.999714816;** and for GR model with fifteen spread constant: MSE: **0.000946218**, RMSE: **0.030760652**, R^2 **0.988645388**, E^2: **0.999053782.** Results of both the models were compared with each other and it was found that LLT model with twenty two neurons performed best. Hence, based on this result further regression equations were developed for predicting shelf life of milk dessert.

Comparison of Actual Overall Acceptability Score (AOAS) and Predicted Overall Acceptability Score (POAS) are illustrated in Fig.2 and Fig.4.

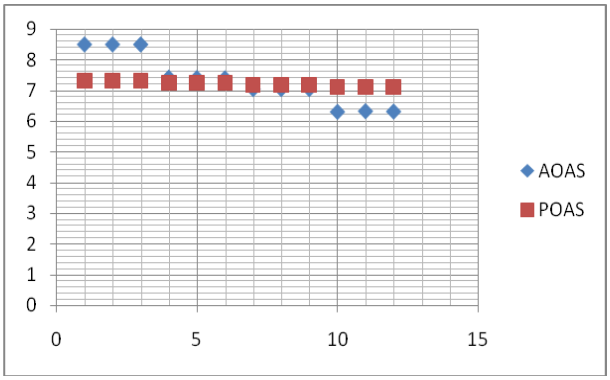

Fig.2.Comparison of AOAS and POAS for Linear Layer (Train) model

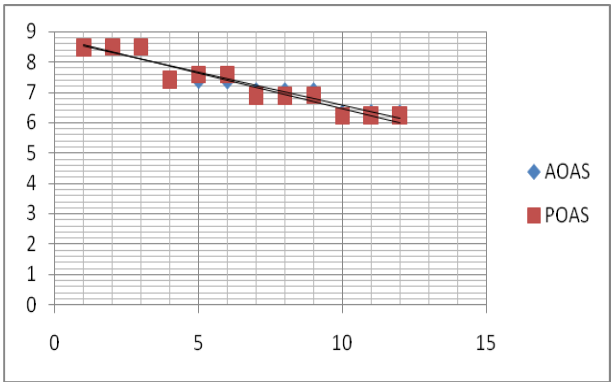

Fig.3.Comparison of AOAS and POAS for GR model

3.1 Shelf Life Prediction

Shelf life can be estimated by sensory evaluation, but it is expensive, very time consuming and does not fit well with the dairy factories manufacturing it. Sensory analyses may not reflect the full quality spectra of the product. Moreover, traditional methods for shelf life dating and small scale distribution chain tests cannot reproduce in a laboratory the real conditions of storage, distribution, and consumption on food quality. In the present era, food researchers are facing the challenges to monitor, diagnose, and control the quality and safety of food products. The consumer demands foods, under the legal standards, at low cost, high standards of nutritional, sensory, and health benefits [9].To predict shelf life of milky white desserts jeweled with pistachio, regression equations were

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developed based on the overall acceptability score. Milky white desserts were stored at 30°C taking storage intervals (in days) as dependent and overall acceptability as independent variable. R^2 was found to be 0.99 percent of the total variation as defined by overall acceptability. Time period (in days) for which the product has been in the shelf can be estimated by overall acceptability score (Fig. 4).

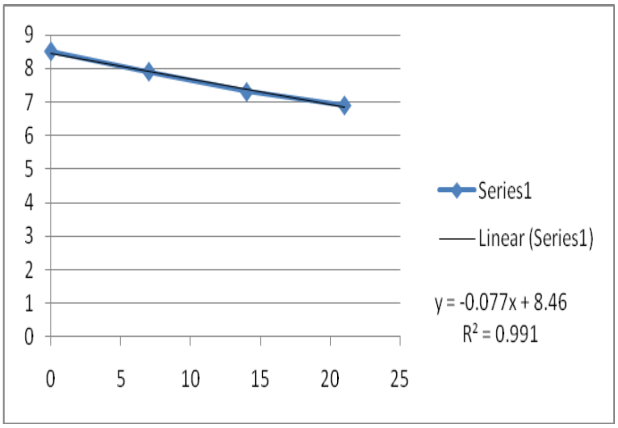

Fig.4. Estimating Shelf life

The shelf life is determined by subtracting the obtained value of days from experimentally determined shelf life, which was found to be 20.15 days. The predicted value is close and within the experimentally obtained shelf life of 21 days, suggesting that ANN based LLT models are very effective for estimating the shelf life of milky white desserts jeweled with pistachio.

4 Conclusion

The possibility of artificial neural network approach was investigated to predict the shelf life of milky white dessert jeweled with pistachio. The linear layer (train) and generalized regression models were developed and compared with each other. Linear layer (train) gave better results than generalized regression model. Based on these results regression equations were developed and shelf life was predicted as 20.15 days, while the experimental shelf life is 21 days, indicating that artificial neural networks are effective tool for determining the shelf life of milky white dessert jeweled with pistachios.

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