Machine Learning ANN Models for Predicting Sensory Quality of Roasted Coffee Flavoured Sterilized Drink

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KEYWORD

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ABSTRACT

This paper highlights the significance of feedforward artificial neural network models for predicting shelf life of roasted coffee flavoured sterilized drink. Coffee is one of the most important products for trade in international market. Single as well as multilayer models were explored and different backpropagation algorithms were investigated, Root mean square error and coefficient of determination R^2 were used to compare the prediction performance of single and multilayer feedforward ANN models. Experimental results suggested that multilayer models take less time and give better results as compared to single layer ANN models for prediction of sensory quality of roasted coffee flavoured sterilized drink..

1 Introduction

The major focus of Artificial Intelligence is to build machines that can work in the similar pattern as human brain does. Artificial Neural Network (ANN) is a group of processing elements that are networked. The working of ANN is on the similar fashion as that of human neurons (Fig.1). An artificial neuron has a number of connections or inputs and only one output. Each input is weighed with a fraction between 0 and 1. The weights of the inputs determine their importance. An important aspect of ANNs is their learning by training. Like the neurons of human brain, ANN can be designed and trained for a particular task. ANNs are widely used in a number of fields like finance, industry, agriculture, business, physics, statistics, cognitive science, neuroscience, weather forecasting, computer science & engineering, spatial analysis and geography [HASSAM WEBSITE, 2011].

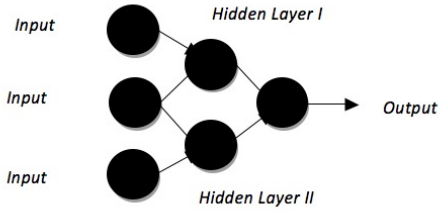

Fig.1. Basic ANN Structure

2 Shelf life

The first term, “feedforward” describes how this neural network processes and recalls patterns. In a feedforward neural network, neurons are only connected forward. Each layer of the neural network contains connections to the next layer (for example, from the input to the hidden layer), but there are no connections back. The term “backpropagation” describes how this type of neural network is trained. Backpropagation is

a form of supervised training. When using a supervised training method, the network must be provided with both sample inputs and anticipated outputs. The anticipated outputs are compared against the actual outputs for given input. Using the anticipated outputs, the backpropagation training algorithm then takes a calculated error and adjusts the weights of the various layers backwards from the output layer to the input layer. The backpropagation and feedforward algorithms are often used together. It would be quite permissible to create a neural network that uses the feedforward algorithm to determine its output and does not use the backpropagation training algorithm [HEATONRESEARCH WEBSITE, 2011]. For centuries, coffee has been brewed and consumed in households, hot shops and restaurants. The term "coffee" comes from Arabic "Qahwah" through the Turkish 'Kahvah' and was originally one of the names employed for wines in Arabic. It is prepared from the roasted seeds (beans) of the coffee plant. Today flavoured milks have become very popular and they contain nutrients as compared with soft drinks.

The paper is organized in five sections. Section I gives the introduction. Section II talks about the significance of shelf life. Section III is material and methods, followed by results and discussion, which discusses the results of this study. The last section is conclusion, which summarizes the findings of this paper.

The shelf life of a product, especially food, is the length of time that it can be kept in a shop or at home before it becomes too old to sell or use [REVERSO WEBSITE, 2011]. 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 [GOYAL & GOYAL 2011A, 2013A,B,C; GOYAL, 2013]. Artificial neural engineering and regression models were developed to forecast shelf life of instant coffee drink [GOYAL & GOYAL, 2011B]. GOYAL & GOYAL (2011C) developed linear layer (design) and time - delay methods for shelf life prediction of soft mouth melting milk cakes. Artificial intelligent scientific computer engineering models for estimating shelf life of instant coffee sterilized drink were applied by GOYAL & GOYAL (2011D). ANN predicted the shelf life of rice snacks by agreeing very well with the actual shelf life data; hence, ANN technique could be used as an alternative method for shelf life prediction of moisture-sensitive food products (SIRIPATRAWAN & JANTAWAT, 2009). ANN has also been successfully applied for predicting soya bean equilibrium moisture content more accurately than mathematical model (CHAYJAN & ASHARI, 2010). The objective of this study is to develop machine learning ANN model for prediction of sensory quality of roasted coffee flavoured sterilized drink and to examine the efficiency of single & double hidden layers.

3 Material and Methods

The data samples were randomly divided into two subsets, namely, training set comprising of 40 observations (80% of total observations) and testing set consisting of 10 observations (20% of total observations).

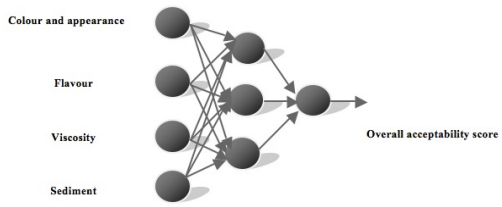

Fig. 2. Input and output parameters of ANN model

The data samples contained 50 observations. Colour and appearance, flavour, viscosity and sediment were used as input parameters, and the

overall acceptability score was taken as output parameter for developing the feedforward ANN models (Fig.2). MATLAB software was used for performing experiments on single and multilayer feedforward ANN models. Experiments were conducted taking neurons from five to fifty. Single and multilayer feedforward ANN models were trained with 100 epochs and transfer function selected was tangent sigmoid, while for the output layer, it was pure linear. Tangent sigmoid transfer function maps the input to the interval (-1, 1). Weights and biases were randomly initialized and sum square error was selected as performance function. Several backpropagation algorithms were investigated like Levenberg–Marquardt algorithm, Polak– Ribiére Update conjugate gradient algorithm, Fletcher–Reeves update conjugate gradient algorithm, Gradient descent algorithm with adaptive learning rate, BFG quasi-Newton algorithm, Powell–Beale restarts conjugate gradient algorithm, and Bayesian regularisation. Bayesian regularisation gave better results over other algorithms; hence it was selected as training function for ANN models. RMSE[1] (1) and R2[2] (2) were used to compare the prediction performance of single and multilayer feedforward ANN models. Flowchart represents the training pattern for ANN models (Fig. 3).

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

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

Where

$Q_{\exp}$ = Observed value;

Q_{cal} = Predicted value;

n = Number of observations in dataset.

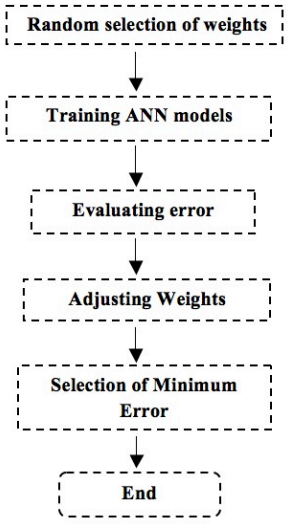

Fig 3. Training pattern of ANN models

4 Results and Discussion

The results of the experiments are presented in Table 1 and 2, respectively.

Table 1. Results of experiments of single layer feedforward ANN models

Neurons	RMSE	R^2
10	0.0023	0.999944
11	0.0024	0.999942
12	0.0020	0.999957
15	0.0028	0.999918
20	0.0044	0.999800
30	0.0022	0.999949
50	0.0084	0.999293

Table 2. Results of experiments of multilayer feedforward ANN models

Neurons	RMSE	R^2
8,8	0.057360738	0.96826520
9,9	0.025030104	0.99309552
11,11	0.001910298	0.99996342
12,12	0.000629995	0.99999602
15,15	0.021358048	0.99518598

Feedforward ANN models were developed for predicting the effectiveness of single and multilayers for prediction of sensory quality of roasted coffee flavoured sterilized drink. Several topologies were developed and tested, as there is no defined method to reach to an

effective conclusion rather than hit and trial approach. Numerous constituents of threshold functions were used in layers, but good results for feedforward ANN models were obtained by combination of TANSIG-TRAINBR-PURELIN as threshold function and bayesian regularization as learning algorithm. Multilayer feedforward networks can potentially learn virtually any input-output relationship; feedforward networks with more layers learn complex relationships more quickly [DEMUTH et al., 2009]. The best results were achieved for Feedforward ANN models with single hidden layer having 12 neurons giving RMSE: 0.0020 and R^2 : 0.999957. Best results for double hidden layer were achieved with the combination of 12 neurons in the first layer and 12 neurons in the second hidden layer with RMSE (0.000629995) and R^2 (0.99999602), respectively .

5 Conclusion

Feedforward ANN models were developed for predicting sensory quality of roasted coffee flavoured sterilized drink. Both the models were developed for testing efficiency of single and double hidden layers for prediction of sensory quality of roasted coffee flavoured sterilized drink. Different backpropagation algorithms were investigated, bayesian regularization gave better results over other algorithms. The study demonstrated that feedforward networks with two hidden layers learn complex relationships more quickly than single layer networks, and are better in prediction of sensory quality of roasted coffee flavoured sterilized drink.

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