Application of artificial neural engineering and regression models for forecasting shelf life of instant coffee drink

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Abstract

Coffee as beverage is prepared from the roasted seeds (beans) of the coffee plant. Coffee is the second most important product in the international market in terms of volume trade and the most important in terms of value. Artificial neural engineering and regression models were developed to predict shelf life of instant coffee drink. Colour and appearance, flavour, viscosity and sediment were used as input parameters. Overall acceptability was used as output parameter. The dataset consisted of experimentally developed 50 observations. The dataset was divided into two disjoint subsets, namely, training set containing 40 observations (80% of total observations) and test set comprising of 10 obs ervations (20% of total observations). The network was trained with 500 epochs. Neural network toolbox under Matlab 7.0 software was used for training the models. From the investigation it was revealed that multiple linear regression model was superior over radial basis model for forecasting shelf life of instant coffee drink.

Keywords: *artificial neural engineering, instant coffee drink, regression, neurons, shelf life*

1. Introduction

The word "coffee" entered English in 1598 via Dutch koffie. This word was created via Turkish kahve, the Turkish pronunciation Arabic qahwa, a truncation of qahhwat al-bun or wine of the bean. One possible origin of the name is the Kingdom of Kaffa in Ethiopia, where the coffee plant originated; its name there is bunn or bunna [1]. Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. It is natural proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. This new approach to computing also provides a more graceful degradation during system overload than its more traditional counterparts. These biologically inspired methods of computing are thought to be the next major advancement in the computing industry. Now, advances in biological research promise an initial understanding of the natural thinking mechanism. This research shows that brains store information as patterns. Some of these patterns are very complicated and allow us the ability to recognize individual faces from many different angles. This process of storing information as patterns, utilizing those patterns, and then solving problems encompasses a new field in computing. The fundamental processing element of a neural network is a neuron. This building block of human awareness encompasses a few general capabilities. Basically, a biological neuron receives inputs from other sources, combines them in some way, performs a generally nonlinear operation on the result, and then outputs the final result [2]. These are some algorithms which are used in prediction by neural networks, *i.e.,* Backpropagation, Delta Bar Delta, Extended delta bar delta, Self Organizing Map into Backpropagation, Directed random search, Higher order Neural Networks.

1.1 Training of Artificial Neural Engineering Models

Once a network has been structured for a particular application, that network is ready to be trained. To start this process the initial weights are chosen randomly. Then, the training or learning begins. There are two approaches to training: supervised and unsupervised. Supervised training involves a mechanism of providing the network with the desired output either by manually "grading" the network's performance or by providing the desired outputs with the inputs. Unsupervised training is where the network has to make sense of the inputs without outside help [2].

1.1.2 Application of Radial Basis Model

Radial basis networks consist of two layers: a hidden radial basis layer of neurons, and an output linear layer of neurons. Radial basis networks can be designed with either *newrbe* or *newrb*. The radial basis function has a maximum of 1 when its input is 0. As the distance between weight vector *w* and input vector *p* decreases, the output increases. Thus, a radial basis neuron acts as a detector that produces 1 whenever the input p is identical to its weight vector *w.* The bias *b* allows the sensitivity of the *radbas* neuron to be adjusted. For example, if a neuron had a bias of 0.1 it would output 0.5 for any input vector *p* at vector distance of 8.326 (0.8326/b) from its weight vector *w*. radial basis neuron with a weight vector close to the input vector *p* produces a value near 1. If a neuron has an output of 1, its output weights in the second layer pass their values to the linear neurons in the second layer. In fact, if only one radial basis neuron had an output of 1, and all others had outputs of 0's (or very close to 0), the output of the linear layer would be the active neuron's output weights. This would, however, be an extreme case. Several neurons are always firing, to varying degrees. The first layer operates as for each neuron's weighted input is the distance between the input vector and its weight vector, calculated with *dist*. Each neuron's net input is the element-by-element product of its weighted input with its bias, calculated with *netprod*. Each neuron's output is its net input passed through *radbas* [3].

1.2 Regression Analysis

The goal of regression analysis is to determine the values of parameters for a function that cause the function to best fit a set of data observations that we provide. In linear regression, the function is a linear (straight-line) equation [4].

1.2.1 Multiple Regression Analysis

Multiple linear regression is a technique that allows additional factors to enter the analysis separately so that the effect of each can be estimated. It is valuable for quantifying the impact of various simultaneous influences upon a single dependent variable. Further, because of omitted variables bias with simple

IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 4, No 1, July 2011
ISSN (Online): 1694-0814
www.IJCSI.org

regression, multiple regression is often essential even when the investigator is only interested in the effects of one of the independent variables [5].

Some of the applications of Artificial neural engineering in foods are in fruit ripening [6], freshness of milk [7], fruit juice [8].The information on foods using radial basis and multiple regression model is quite scanty. Till date no one has done any research on instant coffee drink using these techniques. The main focus of this study is to develop artificial neural network's radial basis and statistical multiple linear regression model and to compare them with each other for predicting shelf life of instant coffee drink.

2. Materials and Methods

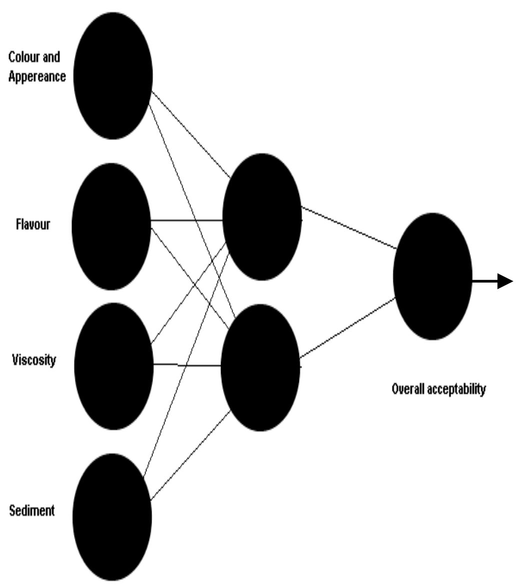

Fig. 1. Parameters used in artificial neural engineering models

Colour and appearance, flavour, viscosity and sediment were used as input parameters. Overall acceptability was used as output parameter as shown in Fig.1. The dataset consisted of experimentally developed 50 obs ervations. The dataset was divided into two disjoint subsets, namely, training set containing 40 observations (80% of total observations) and test set comprising of 10 obs ervations (20% of total observations). The network was trained with 500 epochs. The performance measures used in the research are illustrated in equation 1, 2 and 3 respectively. Neural network toolbox under Matlab 7.0 software was used for training the models as shown in Fig.2.

Performance measures used for prediction

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

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

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

$Q_{\exp}$ = Observed value; Q_{cal} = Predicted value; n = Number of observations in dataset.

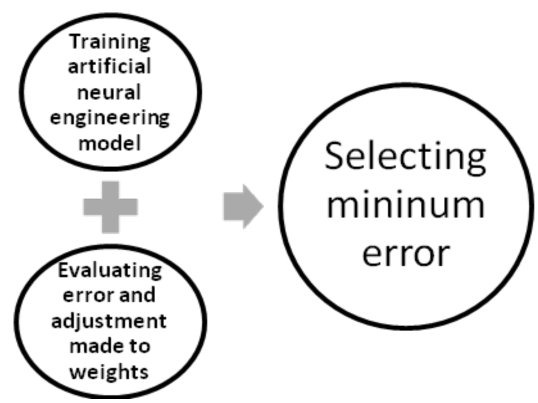

Fig.2. Training pattern for network

3.0 Results and Discussion

The results of Radial Basis (Exact Fit), Radial Basis (Fewer Neurons) and Regression Models developed for forecasting shelf life of instant coffee drink are displayed in the table 1, 2 and 3 respectively.

Table 1: Performance of Radial Basis (Exact Fit) Model

Spread Constant	MSE	RMSE	R^2
50	0.202307	0.449786	0.797692
150	0.202219	0.449687	0.797780
200	0.202219	0.449687	0.797780
250	0.202212	0.449680	0.797787
300	0.202212	0.449680	0.797787
450	2.022122	1.422013	0.797787

Table 2: Performance of Radial Basis (Fewer Neurons) Model

Spread Constant	MSE	RMSE	R^2
1	0.2508430	0.500842	0.749156
50	0.2023075	0.449786	0.797692
100	0.2022326	0.449702	0.797767
250	**0.0821138**	**0.286555**	**0.917886**
300	0.2022122	0.449680	0.797787
400	0.0821138	0.286555	0.917886

Table 3: Performance of Regression Model

Regression Model	MSE	RMSE	R^2
MLR	**0.0002719**	**0.0164898**	**0.9998085**

Radial basis and multiple linear regression models were developed to study there prediction capability for instant coffee drink. Several experiments were carried out and it was observed that MLR model gave far better results than Radial Basis neural computing model in predicting shelf life of instant coffee drink. The best result for radial basis model were: **MSE 0.082113843; RMSE: 0.286555131; R^2: 0.917886157,** and for MLR model: **MSE 0.000271917; RMSE: 0.016489898; R^2: 0.999808569.**

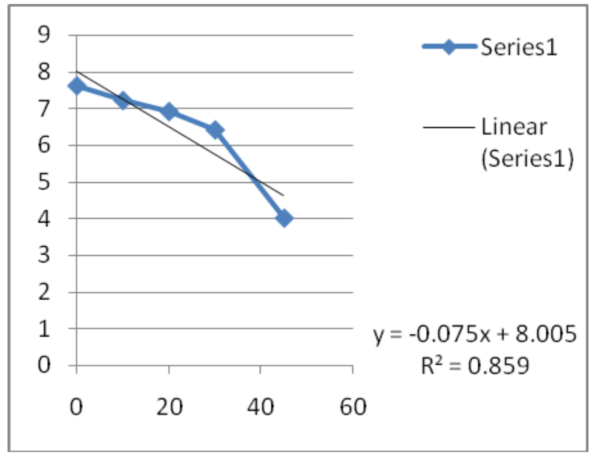

Fig.3. Performance of regression equations

Therefore, MLR model was selected for predicting shelf life of instant coffee by building regressions equations based on sensory scores and constant came out as 8.005, regression coefficient as -0.075, and R^2 was found to be 85 pe rcent as represented in Fig.3, after solving them 7.7095 came as the output which was subtracted from the actual shelf life of the product i.e., 45 days, giving a value of 37.29 days. Since the predicted shelf life is within the experimentally obtained shelf life of 45 days, hence the product should be acceptable.

4. Conclusion

The artificial neural engineering models and regressions models were developed for forecasting shelf life of instant coffee drink. Both the models were compared with each other. From the investigation it was revealed that multiple linear regression model was superior over radial basis model for forecasting shelf life of instant coffee drink.

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