International Journal of Electrical and Computer Engineering (IJECE)
Vol.2, No.3, June 2012, pp. 333~338
ISSN: 2088-8708

Artificial Neural Expert Computing Models for Determining Shelf Life of Processed Cheese

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Article Info

Article History:

Received Apr 12th, 2012
Revised May 25th, 2012
Accepted Jun 2nd, 2012

Keyword:

Artificial neural network
Shelf life prediction
Time-delay
Processed cheese
Central nervous system

ABSTRACT

Time-delay single and multi layer models were developed for predicting shelf life of processed cheese stored at 30°C. Processed cheese is very nutritious dairy product, rich in milk proteins and milk fat. For developing computational neuroscience models,experimental data relating to body & texture, aroma & flavour, moisture, free fatty acids were taken as input variables, while sensory score as output variable. 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 computational models. The results of the study established excellent correlation between experimental data and the predicted values, with a high determination coefficient. From the study it was concluded that artificial neural expert time-delay models are good for predicting the shelf life of processed cheese.

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1. INTRODUCTION

Processed cheese is protein rich food, a comparable supplement to meat protein. It is generally manufactured from medium ripened (4 to 6 months old) grated Cheddar cheese, but sometimes less ripened Cheddar cheese is also added in lesser proportion for getting optimum body & texture in the finshed product. Its manufacturing technique includes addition of emulsifier, salt, water and selected spices (if desired). The mixture is heated with steam in a stainless steel double jacketed vessel with continuous stirring with a flattened ladle in order to get homogeneous mass. This variety of cheese is very popular due to its pleasant taste and unique flavour. Processed chese being a value added product has several advantages over unprocessed cheese like extended shelf-life and great demand for the product.

1.1. Central Nervous System (CNS)

The original inspiration for the term Artificial Neural Network (ANN) came from examination of Central Nervous System (CNS) and their neurons, axons, dendrites, and synapses, which constitute the processing elements of biological neural networks investigated by neuroscience. In an artificial neural network, simple artificial nodes, called by different names,*viz.*, "neurons", "neurodes", "Processing Elements" (PEs) or "units", are connected together to form a network of nodes mimicking the biological neural networks. CNS is the part of the nervous system that integrates the information that it receives from, and coordinates the activity of all parts of the bodies of bilaterian animals, *i.e.*, all multicellular animals except sponges and radially symmetric animals such as jellyfish. It contains the majority of the nervous system and consists of the brain and the spinal cord. These networks are also similar to the biological neural networks in the sense that functions are performed collectively and in parallel by the units, rather than there being a clear delineation of subtasks to which various units are assigned. Currently, the term ANN tends to refer mostly to neural network models employed in statistics, cognitive psychology and artificial intelligence [1], [2].

1.2. Time – Delay

Time -Delay Neural Networks are special artificial neural networks which receive input over several time steps. Time delay neural network is an alternative neural network architecture whose primary function is to work on continuous data. The advantage of this architecture is to adapt the network online and hence helpful in many real time applications, like time series prediction, online spell check, continuous speech recognition, etc. The architecture has a continuous input that is delayed and sent as an input to the neural network [3], [4].

1.3. Single and Multilayer Perceptron

Single layer perceptron network consists of a single layer of output nodes; the inputs are fed directly to the outputs via a series of weights. In this way it can be considered the simplest kind of feed forward network. Multi-layer networks use a variety of learning techniques, the most popular being back-propagation, where the output values are compared with the correct answer to compute the value of some predefined error-function. The error is then fed back through the network by various techniques [5].

1.4. Shelf Life Study

The modern food industry has developed and expanded because of its ability to deliver a wide variety of high quality food products to consumers on a nationwide and worldwide basis. This has been achieved by building stability into the products through processing, packaging, and additives that enable foods to remain fresh and wholesome throughout the distribution process. Demand of consumer for fresh and convenience food has fueled new innovations in the food product development, packaging and chemical industries, and the widespread desire for products to use in the microwave oven has added further impetus to this effort. 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 [6]. Accelerated studies have been innovated as long time taking shelf life studies in the laboratory do not fit with the speed requirement of the food products.

1.5. Computational Neuroscience Models (CNM)

CNMs have been successfully applied for predicting the shelf life of Kalakand, milk based desiccated sweetened dairy product [7], milky white dessert jeweled with pistachio [8], instant coffee flavoured sterilized drink [9, 10]. Time-delay and linear layer ANN models were developed for predicting the shelf life of soft mouth melting milk cakes [11]. Elman and self-organizing models predicted shelf life of soft cakes [12]. Radial basis models were developed for predicting the shelf life of brown milk cakes decorated with almonds [13] and cakes [14]. Currently, there is no study to predict the shelf life of processed cheese stored at 30^{o} C. The purpose of this study is to develop time-delay neural network models with single and multilayer for predicting the shelf life of processed cheese stored at 30^{o} C and to compare them with each other.

2. METHOD MATERIAL

The experimental data relating to body & texture, moisture, aroma & flavour, free fatty acids were taken as input variables, and sensory score as output variable for developing the computational neuroscience models (Fig.1).

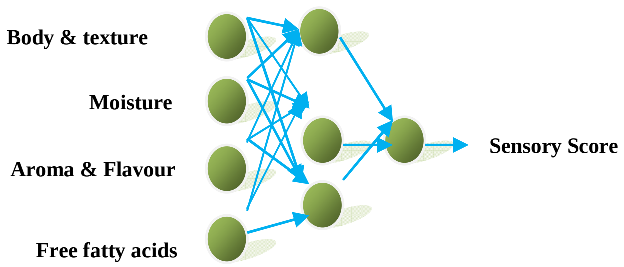

Figure 1. Input and output parameters of model

The data samples employed in the study comprised of 36 experimental observations, which were divided into two disjoint subsets, *i.e.*, 30 observations were used for training the network and 6 for validation. The Neural Network Toolbox under MATLAB software was used for development of CNM models. Mean Square Error (MSE), Root Mean Square Error (RMSE), Coefficient of determination (R^2) and Nash - Sutcliffo Coefficient (E^2) were applied to compare the prediction potential of the developed CNM models. Training pattern of CNM models is illustrated in Fig.2

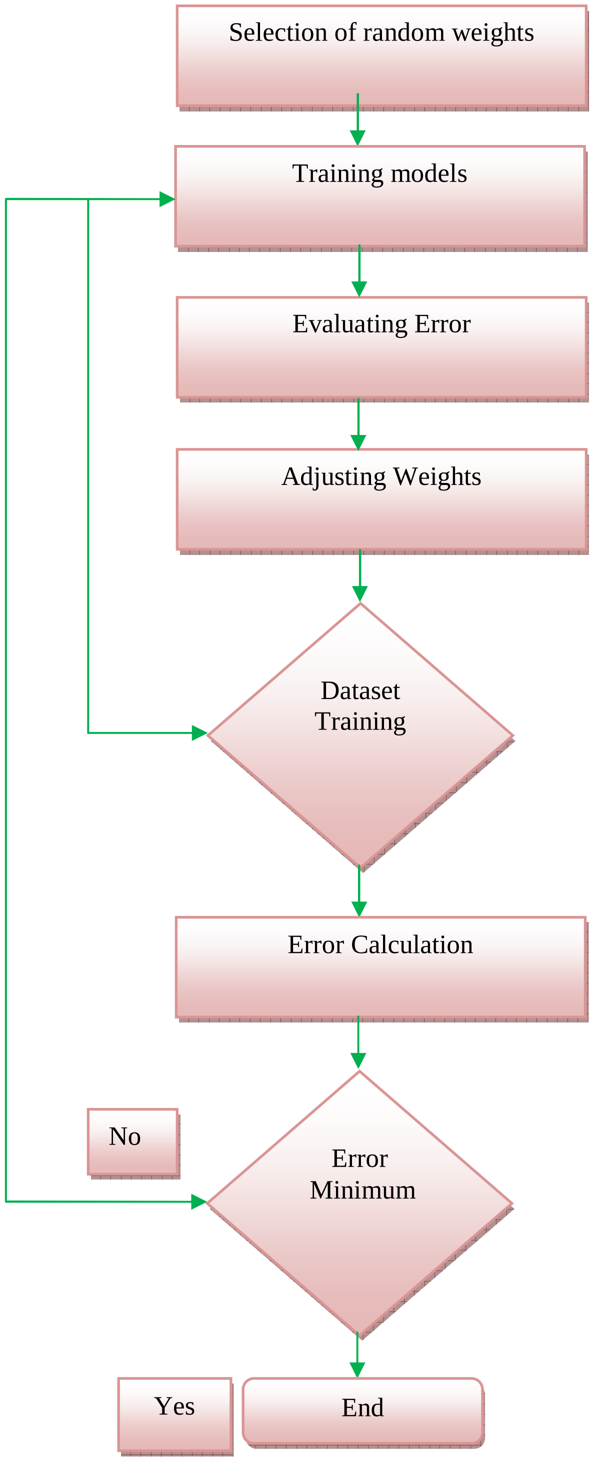

Figure 2. CNM models training pattern

3. RESULTS AND DISCUSSION

Table 1. Results of time-delay single layer model

Neurons	MSE	RMSE	R^2	E^2
3	0.026858106	0.163884428	0.991823373	0.973141894
5	0.001564903	0.03955885	0.990610584	0.998435097
8	0.002188831	0.046784943	0.999941573	0.997811169
10	0.001370748	0.03702362	0.991775509	0.998629252
12	**1.38743E-05**	**0.003724822**	**0.999916754**	**0.999986126**
15	0.001381117	0.037163385	0.991713297	0.998618883
18	6.21236E-05	0.00788185	0.999627259	0.999937876
20	0.000843428	0.02904183	0.994939433	0.999156572
25	0.00154888	0.039355808	0.990706722	0.99845112

Table 2. Results of time-delay multi layer model

Neurons	MSE	RMSE	R^2	E^2
3:3	3.57853E-07	0.000598208	0.999997853	0.999999642
5:5	4.78815E-06	0.002188185	0.999971271	0.999995212
7:7	4.8759E-05	0.006982761	0.999707446	0.999951241
8:8	3.39765E-05	0.005828933	0.999796141	0.999966024
10:10	0.000119318	0.010923263	0.999284094	0.999880682
11:11	1.04948E-07	0.000323957	0.99999937	0.999999895
13:13	0.0002024	0.014226743	0.998785599	0.9997976
15:15	**6.06389E-08**	**0.00024625**	**0.999999636**	**0.999999939**
18:18	5.18442E-05	0.007200289	0.999688935	0.999948156
20:20	0.001590078	0.000265013	0.990459533	0.99999993

Time-delay single layer and multi layer models were developed for predicting the shelf life of processed cheese stored at 30°C. Several combinations of experiments were carried out and the best results for single layer model were **MSE: 1.38743E-05, RMSE: 0.003724822, R^2: 0.999916754, E^2: 0.999986126** with 12 neurons; and the best results for multilayer model having 15:15 neurons were **MSE: 6.06389E-08, RMSE: 0.00024625, R^2: 0.999999636, E^2: 0.999999939)**.

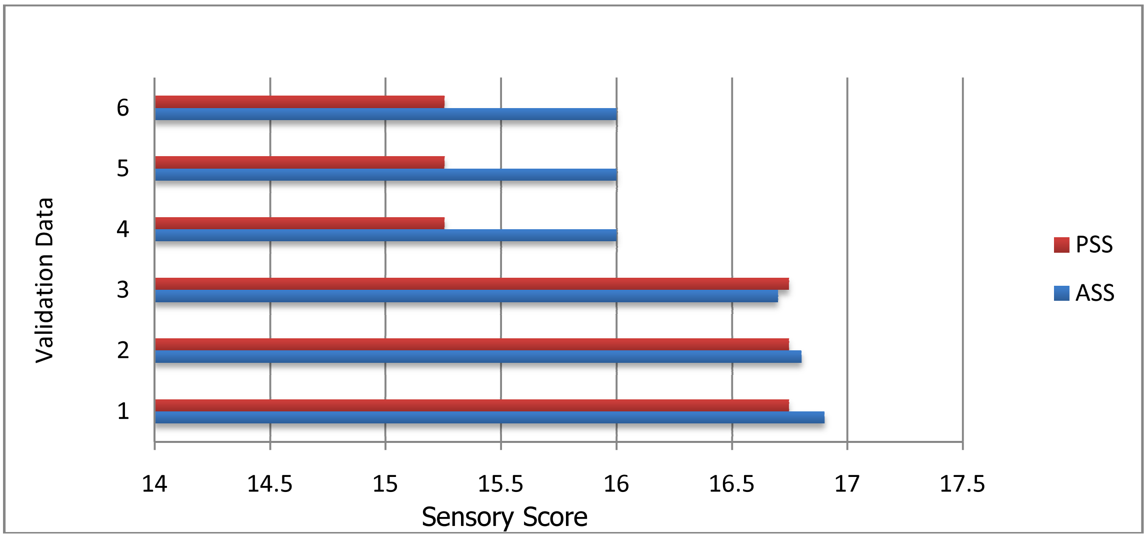

Figure 3. Comparison of PSS and ASS for single layer model

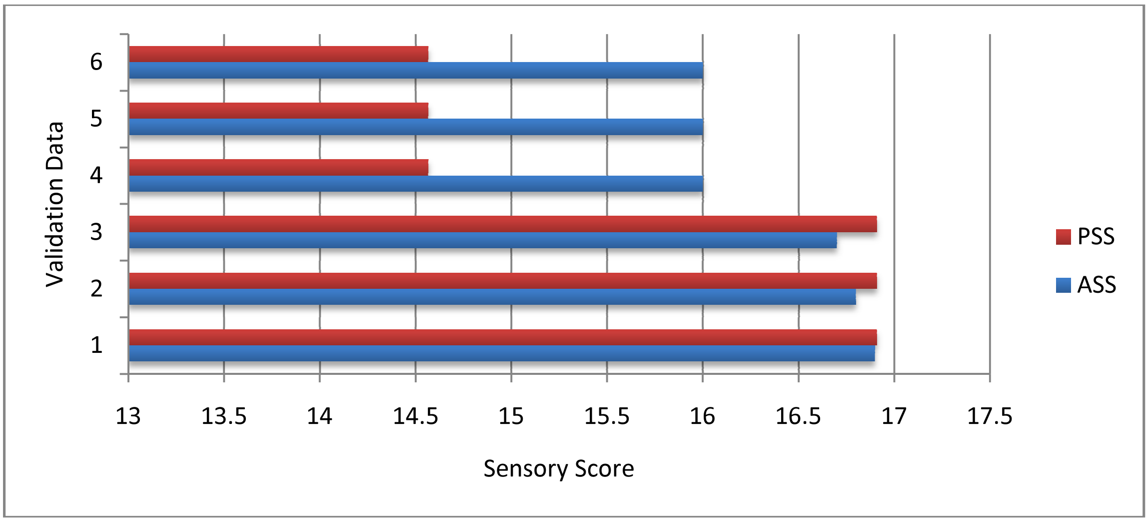

Figure 4. Comparison of PSS and ASS for multi layer model

Comparisons of Predicted Sensory Score (PSS) and Actual Sensory Score (ASS) for for single layer model and multi layer models are illustrated in Fig.3 and Fig.4, respectively. The results of the study show that excellent correlation existed between the experimental data and the predicted values, with a high coefficient of determination and nash - sutcliffo coefficient, establishing that the time – delay ANN models are very effective for predicting the shelf life of processed cheese.

4. CONCLUSION

For predicting the shelf life of processed cheese stored at 30^{o}C computational neuroscience models of time-delay with single layer and multi layer were developed and compared with each other. Body & texture, aroma & flavour, moisture, and free fatty acids were taken as input variables, and sensory score as output variable for developing the models.The results of the investigation revealed good correlation between the experimental data and the predicted values, with high coefficient of determination and nash - sutcliffo coefficient.From the study, it is concluded that the developed time – delay models can be used effectively for predicting the shelf life of processed cheese.

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