Buletinul Ştiinţific al Universităţii "Politehnica" din Timisoara, ROMÂNIA
Seria CHIMIE ŞI INGINERIA MEDIULUI
Chem. Bull. "POLITEHNICA" Univ. (Timişoara) *Volume 53(67), 1-2, 2008*

Use of Artificial Neural Networks as Methodology of Establishing the Shelf Life of Carbonated Soft Drinks

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Abstract : The purpose of this study was to develop an advanced investigation strategy for shelf life estimation of carbonated soft drinks. The strategy was based on the training capability of an Artificial Neural Networks and it has proves to be very successful. The model developed by using the Back-Propagation Neural Networks and simulations, was used to predict the variation in the CO_2 content of carbonated soft drinks, bottled in PET containers.

Keywords: soft drinks, Backpropagation Artificial Neural Netwoks, shelf life

1. Introduction

The follow up of a complete life cycle of an industrial-processed product with long lasting shelf-life can be resource consuming and leads to insignificant delays in its launching on the market.

In order to avoid this problem, predictions can be made with mathematical or computational models as control and prediction instrument for the assessment of the validity term by means of the artificial neural networks (ANN). This is a work instrument more efficient than the regression analysis, as it can model other nontypical systems also [1].

The neural network cross-section diagram is presented in Figure 1.

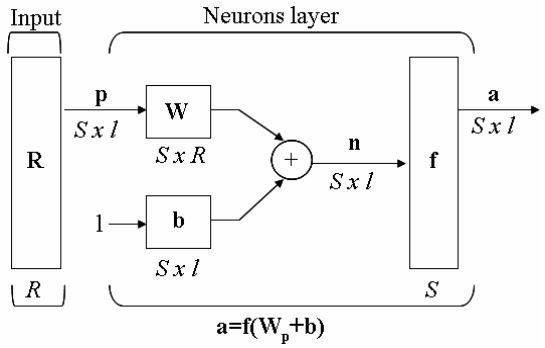

Figure 1.

where: *p* is the input vector, having *R* dimension, *W* is a *S x R* matrix, *a* and *b* are two vectors having *S* dimension. The neurons layer includes the matrices of statistical weight, the *b* bias vector, a summator and an element with the neuron transfer function [2, 3].

In case of back-propagation neural networks with nonlinear activation functions and binary units it has been proven that a single-layer network solves any finite output response function. There are studies on back-propagation ANN with real units that use at least two hidden layers. On one hand, there is no logical argument for the use of multiple-layer BP ANN, and on the other hand, so far, the single hidden layer ANN is reported to have the best performance in the field. Therefore, the use of the multiple-layer BP ANN is not politically incorrect. Avoiding the exclusive use of a single-layer can be interpreted as a preventive measure in order to avoid an impact that might occur after having proved the limits of the single-layer BP ANN [4, 5].

Backpropagation is a supervised learning technique used for training artificial neural networks. Summary of the technique [6]:

1. Present a training sample to the neural network.
2. Compare the network's output to the desired output from that sample. Calculate the error in each output neuron.
3. For each neuron, calculate what the output should have been, and a *scaling factor*, how much lower or higher the output must be adjusted to match the desired output. This is the local error.
4. Adjust the weights of each neuron to lower the local error.
5. Assign "blame" for the local error to neurons at the previous level, giving greater responsibility to neurons connected by stronger weights.
6. Repeat the steps above on the neurons at the previous level, using each one's "blame" as its error.

The algorithm is [7,8]:

```
1) Initialize the weights in the network
(often randomly)
2) repeat
  * foreach example e in the training set do
      1. O = neural-net-output(network, e);
      forward pass
      2. T = teacher output for e
      3. Calculate error (T - O) at the
      output units
      4. Compute delta_wi for all weights
      from hidden layer to output layer;
      backward pass
      5. Compute delta_wi for all weights
      from input layer to hidden layer;
      backward pass continued
      6. Update the weights in the network
  * end
3) until all examples classified correctly
or stopping criterion satisfied
4) return(network)
```

The study presents a new approach regarding the assessment of the food products availability by means of the parameters analysed using neural networks. It has been developed and used a BP ANN instead of a very well defined mathematical model, as an alternative solution to the problem; this is a flexible tool and allows a dynamic adaptation to fluctuating environment constraints.

The scope of the study is to predict the carbon dioxide content – previous studies showing that this is the main physical and chemical parameter that fluctuates in time – from the Adria Pet bottles of 1.5 liters, using a neural network driven by argumented values of the input and output vectors for the elements with this property already determined.

2. Experimental

The experiments was conducted for almost one year, but the starting point results for the present study cover a period of only 0-306 days. Lab researches were based on the daily measurement of the carbon dioxide content during a given period of time, for the Adria PET-bottled Carbonated Soft Drinks of 1.5 liters existing on the market. Note, that for each determination was used a new carbonated soft drink bottle with identical content. Moreover, the carbonated soft drinks were obtained from the same lots of raw material and stored in identical conditions.

The carbon oxide presence is determined using an Afrometer (manometer), which measures the carbon dioxide pressure within the closed bottles. The device is made of the basic body, the mobile body, air-tight joint, penetration needle, scaled pressure gauge and binder collar.

The device shall be fastened vertically, on the bottle neck, so that the rubber fitting and the penetration needle are positioned on the bottle cork. By pressing the binder, the needle punches the cork penetrating in the remaining space above the liquid. The rubber fitting ensures air-tightness, avoiding pressure loss, while the pressure gauge indicates the carbon oxide within the space above the liquid. Based on the value read on the pressure gauge and the determination temperature, by using a correlation table, is determined the carbon dioxide of the carbonated soft drink, in g CO_2/liter.

3. Results and discussion

For the analysis and processing of data, it was used the Microsoft Visual C++ programming language, an interactive classic probabilistic tool, dedicated to numerical calculations, used worldwide by researchers in order to solve the practical problems, analysis and modelling of systems, processing of data, etc [10,11].

By successive carrying away to minimize error occurrence risk and maintaining constant some characteristics of the network, it was considered adequate to make it three-layer, 30 neurons eon each layer, learning rate of 0.05, bias units -0.15 and a unit on the outlet layer.

Based on the probabilistic test generating random numbers, from the range of values, number 2147483647 was chosen at the initiation of the randomization sequence for a reliable prediction capacity of the network. From the set of experimental data (306), a random set of 205 values was chosen for learning purposes, while for testing the network were chosen the last 20 data.

Following the reutilisation of the programme used to predict the carbon dioxide content, the following results were generated, as shown in Table no.1.

Tabelul 1. Prediction values of carbon dioxide content generate by RNA

Time [day]	Parameter RNA	Exp. value	Prediction open circuit	Prediction close circuit
287	3.631	3.6	4.373	4.373
288	3.631	3.6	4.346	4.386
289	3.531	3.5	4.317	4.363
290	3.631	3.6	4.309	4.382
291	3.531	3.5	4.300	4.396
292	3.432	3.4	4.260	4.397
293	3.432	3.4	4.245	4.448
294	3.631	3.6	4.226	4.454
295	3.432	3.4	4.199	4.479
296	3.333	3.3	4.186	4.528
297	3.333	3.3	4.169	4.560
298	3.333	3.3	4.155	4.614
299	3.333	3.3	4.144	4.657
300	3.234	3.2	4.132	4.674
301	3.234	3.2	4.105	4.700
302	3.234	3.2	4.096	4.724
303	3.234	3.2	4.076	4.756
304	3.234	3.2	4.051	4.795
305	3.134	3.1	4.047	4.840
306	3.333	3.3	4.022	4.855

To validate the network, a graphical comparison was made between the variation of the experimental carbon dioxide content and the values predicted by the neural network (figure 2).

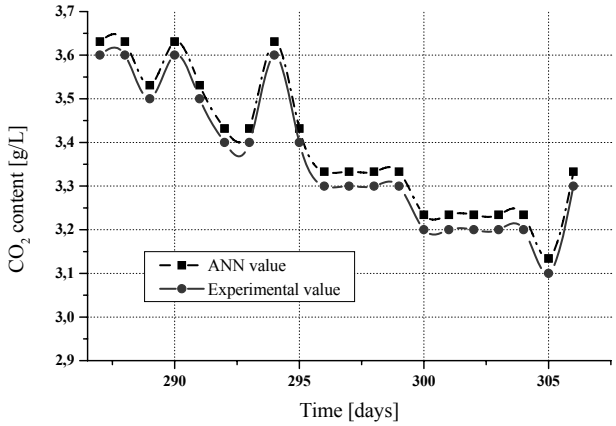

Figure 2. Values comparative representation of experimental CO_2 contents and predicted using RNA

From computational perspective, the algorithms used try to solve the problem of estimating the soft drinks validity term. This aspect has not been strictly determined yet, and for solving it some constraints should be imposed.

The results obtained so far show that a good adequate and efficient use of the network assists the calculation of the product validity term.

4. Conclusions

The neural networks, by their particular characteristics, are a special category of models. The neural modelling is an implicit modelling technique, i.e. it does not generate mathematical relations that characterize input variables influence on the system.

An essential characteristic of the neural models is the self-determination, i.e. estimating connection weight observations between the input and output variables, by means of a controlled self-correction mechanism based on the network parameters and the bias-correction algorithms.

The advantage neural modelling presents the advantage of making a highly accurate assessment of the impact of input variables on the system, regardless of its complexity and the potential interference that might occur between the system variables.

The statistical dynamics were studied by comparison of alternative seizure prediction algorithms, using BP artificial neural models – obtained by systems identification and extending the prediction horizon in comparison with the classical statistics, which lead to the following conclusions:

- When using prediction algorithms, the resulting error is lower than the errors resulting for the limits of the confidence interval;
- Establishing nonlinear mathematical models by using neural networks can ensure the estimated target precision, which can be easily obtained by increasing the number of neurons from the hidden layers.

Due to the high costs incurred by the experiments or the erroneous estimation of the experimentation domain, the neural model can be successfully used for predictive purposes. The predictions made based on the neural model proved to be accurate, this particular characteristic being applicable to estimate the soft drinks validity term. The results obtained show that the use of BP ANN helps to estimate the validity term of the carbonated soft drinks.

The benefits of the use of neural networks in chemistry, chemical engineering and food industry are remarkable in terms of opportunities for intensive exploitation of these modelling type peculiarities for characterizing the investigated systems or envisaged as work approach.

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