Using Neural Networks for Marketing Research Data Classification

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Abstract: - This paper deals with problems of marketing research data classification by means of artificial Neural Networks algorithms. Two basic methods are described, classification with the aid of Multi-layer Perceptron neural network with Back-propagation algorithm and classification with the aid of Self-organizing (Kohonen's) maps. Finally, applicability of these algorithms is compared. These algorithms are applied over the data from a survey about consumer behavior in the food market in the Czech Republic. The limits of this approach are considered and possibilities of more complex structural recognition methods and semi-supervised learning utilization are suggested.

Key-Words: - Neural Networks, Multi-Layer Perceptron, Back Propagation, Self-Organizing Maps, Consumer Behavior, Classification.

1 Introduction
The issue of consumer behavior falls into the field of marketing. Into issue of consumer behavior fall categories of recognition and understanding of how consumers think, feel, evaluate, choose among different alternatives, how consumers are influenced by their surroundings, how they act during the decision-making and purchasing, how is their behavior limited by their knowledge or ability to process information, what motivates them and how they differ in their decision-making in different ways depending on the importance or product interest [1].

Perception of information and communication technology is gradually transformed from something rather unique, bringing a competitive advantage in the market, to the necessity of conditioning the existence or not existence of business between the competitive business organizations [2]. Currently you cannot imagine marketing without the involvement of information technology. The development of the Internet greatly simplified data collection, and thus the volume of usable data to search for information has increased greatly.

To research on consumer behavior data can be obtained from multiple sources. In secondary research are typically used in national and international sources, such as the Czech Statistical Office or Eurostat, that provide data in electronic form, and are easily accessible via the Web. In the primary research are most often used data from surveys in which consumers respond to specific questions.

2 Problem Formulation
This article will address the possibilities of using artificial intelligence tools [3, 4, 5, 6] over data on consumer behavior in the food market and assess their applicability to this type of data. Article will be based on primary data that was taken out of the research Department of Marketing and Sales at the Faculty of Business and Economics of Mendel University in Brno. These data were processed only by means of statistical methods. More details about this research are given in [7].

2.1 The use of layered Multi-Layer Perceptron neural network
Multi-Layer Perceptron neural network (MLP) is an acyclic forward network. Neurons can be divided into disjunctive layers so that the output of each neuron of one layer are connected to the inputs of each neuron layer following. There are no links between non-neighboring layers of neurons or between neurons in the same layer. Each neuron has as many inputs as there are neurons in the lower layer. The input layer serves only to distribute input values to the first hidden layer. A network with one hidden layer and one output layer is known as a two-layer network, a network with two hidden layers of a three-layer, etc. [3, 8]. As a learning algorithm for MLP neural network is the most widely used back-propagation algorithm.
Back propagation algorithm is an iterative method where the network gets from an initial non-learned state to the full learned one [3, 8, 9]. It is possible to describe the algorithm in the following way:

random initialization of weights;
repeat
repeat
   choose_pattern_from_training_set;
   put_chosen_pattern_in_input_of_network;
   compute_outputs_of_network;
   compare_outputs_with_required_values;
   modify_weights;
until all_patterns_from_training_set_are_chosen;
until total_error < criterion;

Back-propagation algorithm is based on minimization of neural network energy given with the formula (SSE) [3, 8]:

\[ E = \frac{1}{2} \sum_{i=1}^{n} (y_i - d_i)^2 \]  

where \( n \) means the number of network outputs, \( y_i \) means the \( i \)-th output and \( d_i \) means the \( i \)-th output required.

### 2.2 The use of Self-organizing (Kohonen's) maps

Kohonen network is one of the networks that do not need to be trained by teacher. The basic idea of its function is cluster analysis that means the ability of network to find certain characteristics and dependencies in the presented training data with the absence of any outside information [5, 10, 11].

In the Kohonen network is besides the input layer output layer only. Number of inputs that come into the neuron is equal to the number of inputs to the Kohonen network. The weights of these inputs are used to encode the patterns which represent presented patterns. These neurons do not have own transfer function. The only operation performed by the neuron is the calculation of distances (deviations) from the model presented pattern encoded in the weights of the neuron according to the relation [5, 10]:

\[ d = \sum_{j=0}^{N-1} (x_j(t) - w_j(t))^2 \]  

where \( x_j(t) \) are the individual elements of the input pattern and \( w_j(t) \) corresponding neuron weights, which are encoded patterns. Closer information can be found in [5, 10].

### 3 Problem Solution

We decided to apply over the data two different approaches which artificial intelligence offers. First, we tried to classify the data using the MLP. Subsequently, we then focused on the use of Kohonen maps.

We got the data file, which is described in detail in [7]. It is a set of answers to approximately thirty questions on consumer behavior in the food market, where respondents scored on a scale of one to ten, how the factor affects their consumer behavior (quality, price, origin of the product, etc.). These responses are then connected to the corresponding characteristics of respondents, such as age, gender, education, household type, etc.

#### 3.1 Application of MLP

Our goal was to test whether it is possible to classify the characteristics of respondents based on their answers to questions about their consumer behavior in the food market.

For the actual calculation we used a software tool Weka 3.7 [12], which among other allows the classification by MLP. From the above characteristics, we tried to classify respondents' age and education.

As is evident from the following tables, the results are very unsatisfactory.

<table>
<thead>
<tr>
<th>Table 1: Inclusion in the classification of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>classification</td>
</tr>
<tr>
<td>reality</td>
</tr>
<tr>
<td>18-24</td>
</tr>
<tr>
<td>35-54</td>
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<tr>
<td>25-34</td>
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<tr>
<td>12-17</td>
</tr>
<tr>
<td>65+</td>
</tr>
<tr>
<td>55-64</td>
</tr>
</tbody>
</table>

When we calculate the success of the correct classification, we find that only 44.5%. It is also similar for characteristic of education, as demonstrated in Table 2. Here is a 43.6% success rate.

<table>
<thead>
<tr>
<th>Table 2: Inclusion in the classification of education</th>
</tr>
</thead>
<tbody>
<tr>
<td>classification</td>
</tr>
<tr>
<td>reality</td>
</tr>
<tr>
<td>level A</td>
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<tr>
<td>level B</td>
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<tr>
<td>level C</td>
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<td>level D</td>
</tr>
<tr>
<td>level E</td>
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<tr>
<td>level F</td>
</tr>
</tbody>
</table>
Individual groups correspond to achievable levels of education in the Czech Republic, where F is the highest level.

Figure 1 is then displayed, a print screen from the Weka environment during data analysis.

3.2 use of Kohonen's maps
The second approach to data mentioned above was the use of self-organizing (Kohonen's) maps. For the calculation was used MATLAB with the use of Neural Network toolbox [10, 11]. Here we tried to train the network so that coalesced according to the characteristics of individual respondents. Results can be seen in Figures 2 and 3.
Coloring principle of individual components lies in the fact that the richer the color represents more similarity between the elements contained in this section.

As is clear from Figure 2 application of Kohonen maps have already managed to find a satisfactory way to group individual respondents' answers to the corresponding age categories were logically grouped. Figure 3 showing the results according to education is less satisfactory (small color difference shows smaller significant impact of education on customer behavior).

4 Conclusion
The performed simulation experiments over the mentioned data it is clear that for a given application is crucial to use a suitable type of artificial neural networks. Classification results obtained by means of Multi-Layer Perceptron neural network are unsuitable for this type of data well as using other learning algorithms [9, 4].

In contrast, using self-organizing (Kohonen's) maps brought relatively satisfactory results, especially in the age characteristics. The characteristics according to education, where the results are less satisfactory, heterogeneity may be due to such independence of educational attainment on shopping behavior.

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References:


