

## A Multi-Layer Neural Network Approach to Predict The Success of Bank Telemarketing

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### Publication Information

#### Keywords :

- Bank telemarketing;
- Artificial intelligence;
- Multi-layer neural network.

Category : Full Research Article

Received : 04.04.2021

Accepted : 15.04.2021

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### ABSTRACT

In this study, an artificial neural network was constructed and trained with the dataset that created from anonymous data obtained from 45.211 people within the scope of a bank's marketing campaign. The dataset was obtained from an international database, UCI-Irvine Machine Learning Repository. The data set consists of 16 features and a result, the validity of which is based on expert opinion. For the marketing campaigns of the bank, the status of opening a time deposit account at the bank was examined based on the customers' personal characteristics. For this purpose, the results obtained by using the statistical methods used in the literature for the same data set and the multi-layered artificial neural network (MLNN) were compared. As a result, since the number of data is quite high, it is estimated with a 94.3% higher accuracy whether to open a time deposit account in the bank compared to statistical methods and other artificial neural network methods.

## 1. Introduction

Banks are financial intermediaries within the service sector. Banking is one of the business lines where public relations activities are most developed, and the banking branch, which instantly puts technological developments into practice, leads a change in this field [1, 2]. Thanks to the developing technology, the mass media, which are being used and increasing their impact, reach millions of people at the same time, convey their messages, direct the public opinion and cause radical changes in people's attitudes and behaviors. Investors' efforts to exist in an increasingly difficult competitive environment bring new searches and inventions together [3].

In this context, marketing campaign promotions carried out by a Portuguese bank's own call center were examined in order to examine the effect of telephone information, which is one of the mass media tools, on bank applications [4] and the data obtained were uploaded to the international database [5]. During the phone calls, some questions were asked to 45211 people, the campaign that was valid at that time was introduced and they were persuaded to open a deposit account at the bank. The study was organized for a

total of 17 campaigns over 30 months. Using the data obtained, they made examinations to estimate the probability of opening a deposit account at the bank or not, as a result of the interviews conducted [4].

Bahrammirzaee [6] used ANN in their study with different data and stated that PNN and MLP provided better performance than other models among ANN models used for credit measurement according to the results they obtained.

In their study, Moro et al [4] were applied data mining (DM) approach for the data used in this study and were ran the floating data mining (CRISP-DM) approach for three iterations to adjust the DM model results. Within the scope of the study, it is possible to compare two statistical approaches such as SVM (Support Vector Machine) and ROC (Receiver Operating Characteristic) used in classification. As a result, they explained that CRISP-DM gives better results at the end of each iteration and recorded the high predictive performance obtained with SVM as the best result. Findings obtained by applying these methods in the study, as seen in Table 1, the highest performance value for SVM according to the area under the lift curve (ALIFT) is 88.7% and according to the area under the ROC (AUC - Area Under Curve) is 93.8%.

ROC curve is one of the methods used in previous studies that is based on statistical decision theory [7]. The ROC curve allows the determination of the discriminatory power of the test, the comparison of the effectiveness of various tests, the determination of the appropriate positivity threshold, the monitoring of the quality of laboratory results, the monitoring of the progress of the practitioner and the comparison of the diagnostic efficiency of different practitioners [8]. The most commonly used measurement is the area under the ROC curve. If the AUC is the higher, the better of the outcome is predicted. Another method, Support Vector Machines (SVM), is a statistical method found by Weston and Watkins [9]. SVM is formulated around the structural risk minimization principle. Basically SVM deals with two-class problems.

**Table 1.** Performances obtained at the end of each iteration for DM and CRISP-DM algorithms [4].

CRISP-DM Iteration	Instances X Attributes (Nr. Possible Results)	Algorithm	Number of executions ( <i>runs</i> )	AUC (Area Under the ROC Curve)	ALIFT (Area Under the LIFT Curve)
1 <sup>st</sup>	79354 X 59(12)	NB	1	0.776	0.687
2 <sup>nd</sup>	55817 X	NB	20	0.823	0.790
	53 (2)	DT	20	0.764	0.591
3 <sup>rd</sup>	45211 X	NB	20	0.870	0.827
	29 (2)	DT	20	0.868	0.790
		SVM	20	<b>0.938</b>	<b>0.887</b>

ANN is widely used today in the field of bank loans as well as in many areas. While creating the data set used in this study, taking the reference from the international database [5], various characteristics of the individuals were taken into consideration and it was aimed to make an estimate as to whether they will open a deposit account at the bank within certain campaigns.

With the data set obtained within the scope of this study, it is aimed to make a preliminary estimation about whether customers will open a time deposit account at the bank by using the previously untested ANN model. No statistical method is included in this study.

## 2. Materials and Method

The anonymous data set that used in this study was obtained from the international database [5]. While preparing this data set, 45211 people were introduced to the marketing campaigns of a Portuguese bank by phone calls made by the call center of the bank. The parameters used as features in the application are the results of the persons' age, occupation, marital status, education status, credit history, average annual income level (in euro), whether there is a home and consumer loan, contact information, last meeting date, number of meetings, information about the campaign. In addition, within the scope of another campaign, the day of the interview and the results of the previous marketing campaign were also used. The validity of these features is based on expert opinion. The total data used belongs to 45211 people, 31648 (approximately 70% of all data) were used as training data and 13563 (approximately 30% of all data) were used as test data. All data were used in the training of an artificial neural network with 16 inputs, 2 hidden layers and 1 output layer (multi-layer). And based on the features that mentioned above it was tried to predict the possibility of opening a time deposit account in the bank for marketing campaigns.

In the most general sense, artificial neural networks could be considered in two main groups as feed forward and feedback networks. In feed-forward networks, the information is moved from the input layer to the output layer. This is also called the activation direction. An example of this type of artificial neural network is a single and multilayer perceptron. Such networks were trained with supervised learning techniques [10]. Figure 1 shows the mathematical model of a neuron [11]:

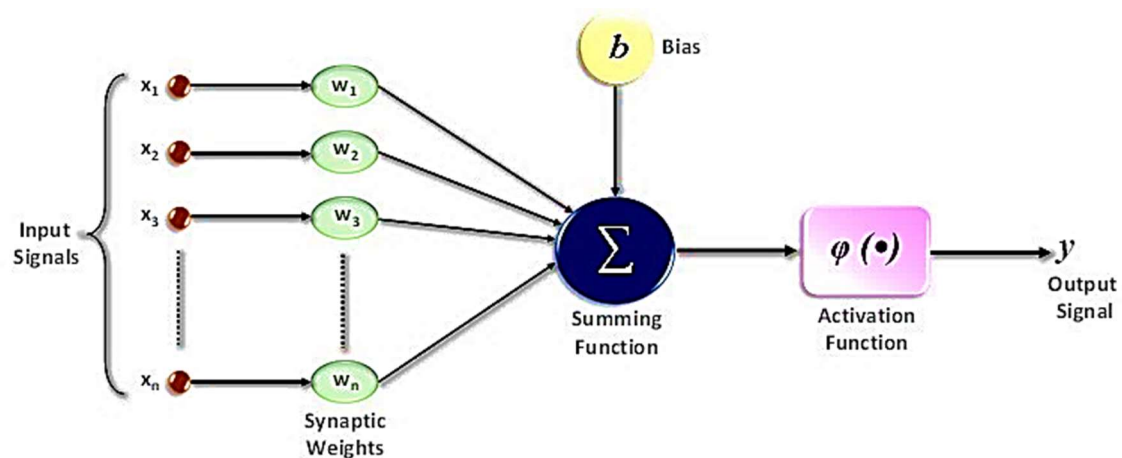


Figure 1. Mathematical Model of Neuron [12].

Eq. 1 gives the formation of the weighted sum and Eq. 2 gives the calculation of the neuron output [11].

$$S_1 = u_1W_1 + u_2W_2 + \dots \dots u_nW_n - \theta = \sum_{i=1} u_iW_i - \theta \tag{1}$$

$$\varphi = \Psi(S) \tag{2}$$

In Eq. 1 and 2 above,  $S$  is the sum function,  $u_i$  is the input function,  $w_i$  is the weighting factor,  $\varphi$  is the output function,  $\Psi(S)$  is the activation function and  $\theta$  is the threshold value.

In this study, a multi-layer perceptron model that works with a feedback network is preferred. While a simple perceptron can be used successfully in system definition, simple perceptron models may be inadequate because many real applications contain non-linear features. While simple perceptron are insufficient to perform functions that cannot be investigated linearly, this is not the case with multilayer perceptron (MLP) [13]. MLP networks are a network structure that formed by the combination of detector units. There are three basic layers in MLP as well. These are the input layer, hidden layer, and output layer. All layers except the input and output layers are called hidden layers and may exist in one or more. This structure is listed as seen in Figure 2.

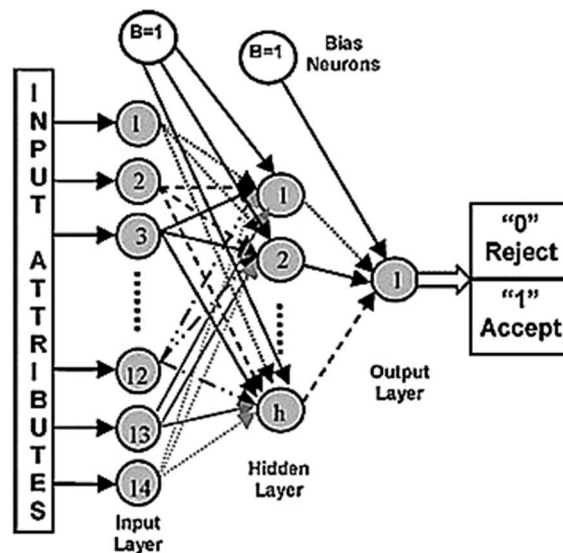


Figure 2. Multi Layer Neural Network [14].

In general, the most common method used in training MLP networks is back propagation algorithm [15]. Today, this algorithm is used successfully in many areas where solutions are produced with artificial neural networks, from speech recognition problems to nonlinear system problems [16]. In applications, the sigmoid type activation function is used in cases where the neuron response must be a continuous function of the inputs. The back-propagation model requires a ubiquitously differential activation function [17]. In Figure 3, the sigmoid-type activation function, whose derivative can be taken, is used in the solution of continuous problems.

The equation of the sigmoid type activation function is as follows Eq. 3 [11]:

$$\Psi(S) = \frac{1}{1 + e^{-S}} \quad (3)$$

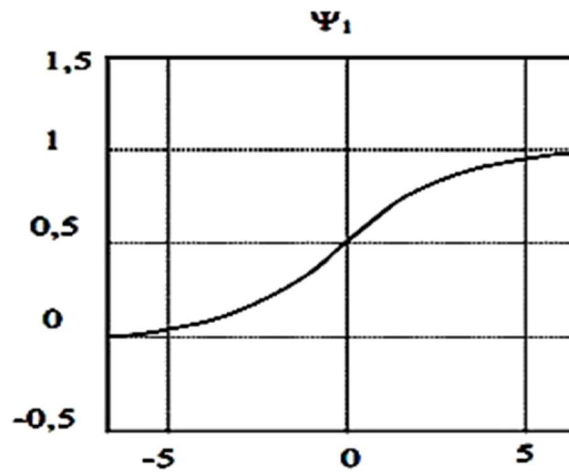


Figure 3. Sigmoid Activation Function [11].

The artificial neural network structure used in this study is the MLNN network with two hidden layers (1 input layer, two hidden layers, one output layer), realized by using the back-propagation algorithm of weights. The nonlinear sigmoid activation function was used for the hidden layer neurons (10 for the first layer, 5 for the second layer) and the output layer. These criteria have been obtained by trial and error method to produce the best result. This system includes 16 features (the number of cases that make up the input vector) and 2 status classifications (whether to open a deposit account or not).

### 3. Results and Discussions

Although it is seen that PNN network frequently produces more successful results in studies conducted for classification in the literature [18, 19], the number of data used in this study was too high, and so the PNN network was not show success in the expected performance. However, the study was tested with MLNN network and successful results were obtained.

In order to improve the results obtained by using the data set, artificial neural network models that have not been applied in the literature have been tried to the data obtained from the international database have been processed for this purpose. In addition, the accuracy rates obtained by using MLNN networks to predict the probability of people opening a time deposit account in the bank thanks to marketing campaigns and the results of the study [4] in the literature are given comparatively in Table 2.

In this study anonymous data is used. Totally 45211 data were used in this study, approximately 70% of all data was used as training data and approximately 30% of all as test data were used in the creation of the artificial neural network and for the marketing campaigns of the bank, it is estimated that individuals open a time deposit account in the bank or not, with an accuracy of 94.3 %.

**Table 2.** Comparison of the accuracy rates obtained in this study with previous studies in the literature.

Studies	ANN Models	Classification Accuracy (%)
(Moro et al, 2011)	ROC-AUC	93.8
(Moro et al, 2011)	SVM-ALIFT	88.7
This study	MLNN with two hidden layers	94.3

#### 4. Conclusion and Evaluation

When the obtained results are compared with the literature studies, although the results are very close to each other, it is an undeniable fact that the use of the MLNN network has a positive effect on the accuracy of the result.

As a result, it has been observed that the artificial neural networks provide more successful results compared to statistical methods. In addition, artificial neural networks are preferred because of their ease of application, clarity and widespread use. It is thought that this method can be actively used by banks and also any institution that has marketing activities.

In future studies, in cases where significant results cannot be obtained in ANN methods due to the large number of data, the sources of these problems can be determined and studies can be carried out to improve the method or to create new methods.

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