Classification of Customer Satisfaction Through Machine Learning: An Artificial Neural Network Approach

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Abstract:

This study aims to classify customer satisfaction data from Café Alvina using Machine Learning, specifically by implementing the Backpropagation Artificial Neural Network. The data used in this study consists of 70 training data and 30 testing data, with the Artificial Neural Network input layer having five neurons and the output layer having two neurons. The tested Artificial Neural Network models include the 5-5-2 Model, 5-10-8-8-2 Model, 5-5-10-2 Model, and 5-8-10-2 Model. Among the four models used in the testing process of the Backpropagation Artificial Neural Network system using Matlab, the 5-10-8-8-2 architecture model performed the best, achieving an MSE (Mean Squared Error) of 0.000999932 during training with 2920 epochs and a testing MSE of 0.000997829. After conducting the testing, the performance of the Artificial Neural Network models was as follows: the 5-5-2 Model achieved 81%, the 5-10-8-8-2 Model achieved 100%, the 5-5-10-2 Model achieved 98%, and the 5-8-10-2 Model achieved 96%. Through the implementation of a Backpropagation Artificial Neural Network, the classification of customer satisfaction can be effectively performed. The trained and tested data demonstrate that the Artificial Neural Network can accurately recognize the input data in the system.

Keywords: Artificial Neural Network, Backpropagation, Customer Satisfaction, MATLAB

1. INTRODUCTION

The advancement of technology has had a significant impact on human life, leading to the development of various innovative technologies that cater to human needs in different aspects of life [1]–[9], [10]–[13], [14]–[21]. One of the increasingly popular and rapidly developing technologies is artificial neural networks [22], [23], [24]–[28], which have shown great potential in solving complex problems, such as image and voice recognition, and big data analysis, in recent years. Artificial neural networks have been widely used in various industries, such as finance, medicine, and manufacturing. As the business world is constantly changing and becoming more competitive, companies must be able to predict various future possibilities. Companies carry out predictive activities to have a strategic decision-making basis for their sustainability.

Customer satisfaction is an essential issue for most businesses, as satisfied customers can consistently return and help the company to stand firm, overgrow, and become successful. Alvina Cafe is a business that operates in the restaurant or culinary field. The management and owners of Alvina Cafe consider customer satisfaction to be a crucial driving force for the sustainability of their business. Improvements in service quality, food, beverages, and facilities are regularly made to ensure that customers can obtain their respective satisfaction when they visit this cafe.

Assessing customer satisfaction is not an easy process. Alvina Cafe has traditionally assessed its customers' satisfaction by roughly calculating the number of customers who come in. This method has many drawbacks, particularly regarding objectivity and the absence of measurable criteria to determine customer satisfaction. Many assessment criteria are used in the evaluation process based on factors that can affect customer satisfaction. Given the above background, the satisfaction of Alvina Cafe's customers is determined using the backpropagation method of Artificial Neural Network (ANN). This neural network technology enables the process of determining customer satisfaction to be quick and easy.

2. METHOD

The steps for conducting the research activity can be seen in Figure 1. The Artificial Neural Network modeling is carried out by determining the neural network's architecture, such as the number of layers, number of neurons, and activation function. After modeling, the next step is to train the Artificial Neural Network using the backpropagation algorithm by determining the training parameters such as learning rate, momentum, and iteration. Subsequently, the results are evaluated using test data to test the performance of the Artificial Neural Network. After that, the evaluation results are interpreted to determine the effectiveness of the Artificial Neural Network in determining customer satisfaction.

Moreover, The data to be processed in this study consists of 100 customer satisfaction ratings. The results of normalizing the customer satisfaction data are presented in Table 1.
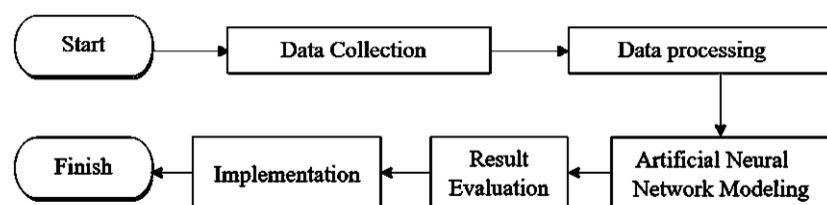

Figure 1. Research Framework

Table 1. Sample Results of Normalization of Customer Satisfaction Assessment Data

| No	X1	X2	X3	X4	X5	Y
1	0.9	0.1	0.9	0.5	0.7	10
2	0.7	0.3	0.7	0.7	0.7	10
3	0.7	0.3	0.7	0.9	0.7	10
4	0.9	0.3	0.7	0.9	0.7	01
5	0.7	0.1	0.7	0.9	0.7	10
6	0.9	0.1	0.7	0.9	0.9	01
7	0.9	0.1	0.7	0.9	0.9	01
44	0.9	0.9	0.9	0.9	0.9	11
50	0.7	0.5	0.7	0.5	0.9	10
51	0.9	0.9	0.9	0.9	0.9	11
52	0.7	0.5	0.7	0.5	0.9	10
53	0.9	0.9	0.9	0.9	0.9	11
54	0.5	0.9	0.9	0.9	0.9	01
55	0.5	0.9	0.9	0.9	0.9	01
…	…	…	…	…	…	…

The Artificial Neural Network architecture used in this study is a Backpropagation network consisting of an input layer of 5 nodes stored in variables X1 through X5. The system user determines the hidden layer through the best convergence trial and error until the best training convergence results are obtained (with the smallest number of epochs), and the output layer consists of 2 nodes. The Artificial Neural Network model with the Backpropagation method to be used in the design is 5-3-1, which uses five variables in the input layer, three hidden layers, and one variable in the output layer, the classification result.

3. RESULT AND ANALYZES

Furthermore, the steps of training and testing implementation are carried out to obtain the results. In this phase, the training and testing of the artificial neural network is implemented using Matlab software. All the data will be processed in the training and testing phases. Seventy data points are used as training data, while 30 are used for testing. Several network architecture models carried out in this study consist of:
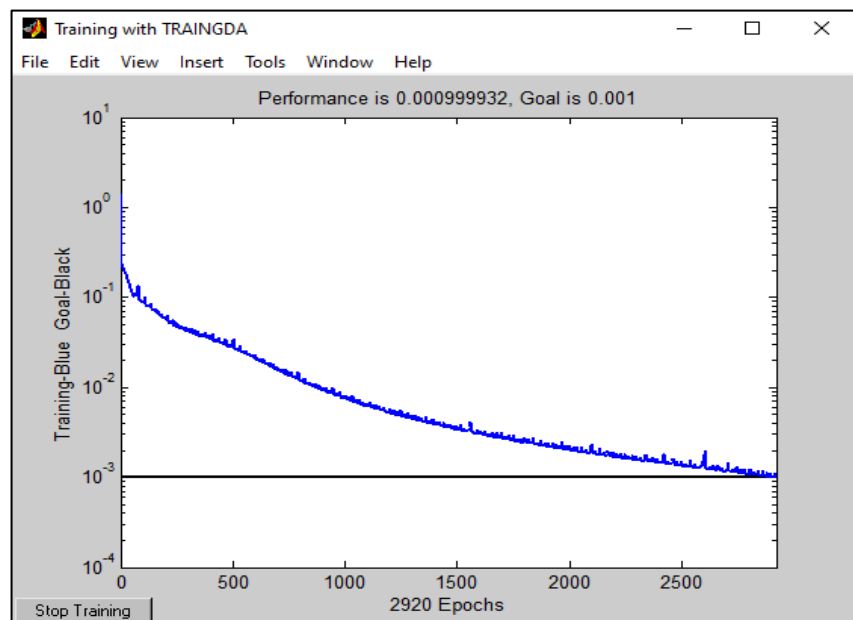
3.1 Training with 5-5-2 Model

At this stage, neural network training uses an input layer of 5 input nodes, a hidden layer of five nodes, and an output layer of 2 nodes. The training results achieved from backpropagation network training using the 5-5-2 architecture can be seen in Figure 2.
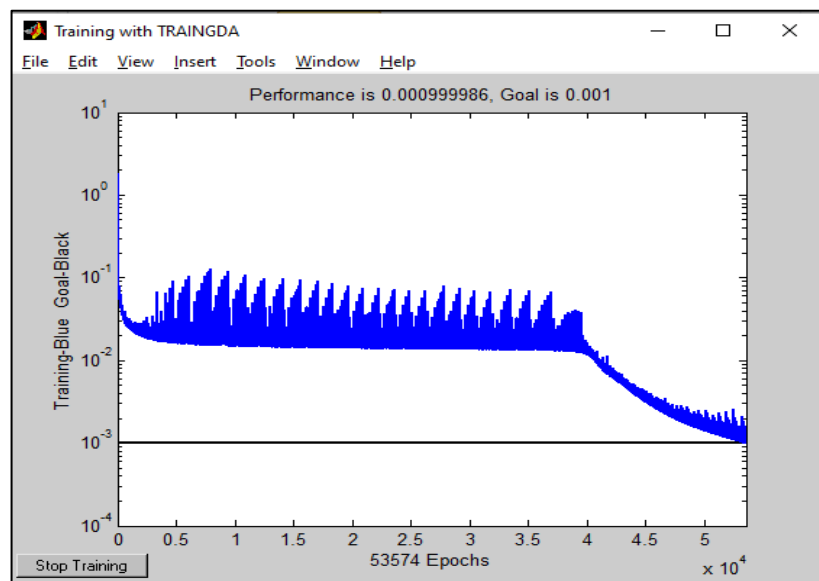
Figure 2. Training Goal with Pattern 5-5-2

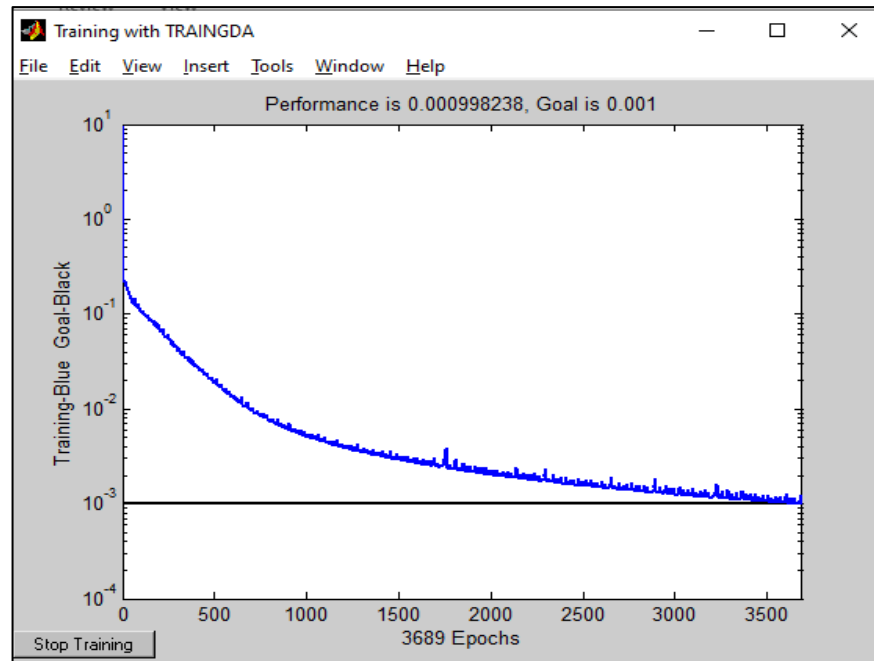### 3.2 Training with 5-10-8-8-2 Model

In this training, neural network training is carried out using an input layer consisting of 5 input nodes, three hidden layers with the number of nodes in the first hidden layer ten nodes, the 2nd and 3rd hidden layers each composed of 8 nodes, and the output layer, which consists of 2 nodes. The training results of the backpropagation network training using the 5-10-8-8-2 architecture are presented in Figure 3.

Figure 3. Training Goal with Pattern 5-10-8-8-2
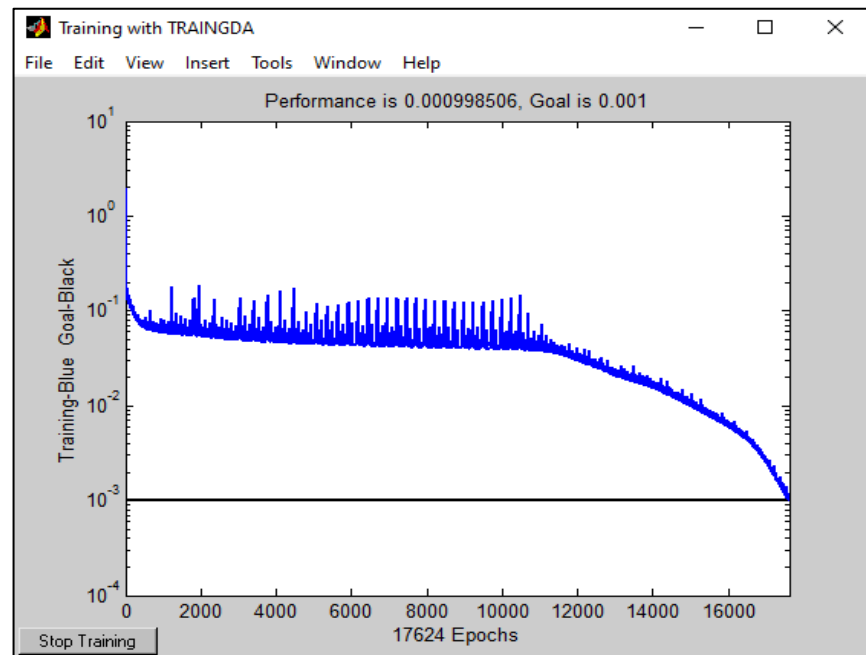
3.3 Training with 5-8-10-2 Model

In this training, neural network training is carried out using an input layer consisting of 5 input nodes and three hidden layers with the number of nodes. The first hidden layer is eight nodes, the second hidden layer is ten nodes, the third hidden layer is ten nodes, and the output layer consists of 2 nodes. The training results achieved from backpropagation network training using the 5-8-10-2 architecture are presented in Figure 4.

Figure 4. Training Goal with Pattern 5-8-10-2

3.4. Training with 5-5-10-2 Model

In this training, neural network training is carried out using an input layer consisting of 5 input nodes, two hidden layers with the number of nodes in the first hidden layer five nodes, the number of nodes in the second hidden layer ten nodes, and the number of nodes in the output layer is two fruit nodes. The training results achieved from backpropagation network training using the 5-5-10-2 architecture are presented in Figure 5.

Figure 5. Training Goal with Pattern 5-5-10-2

3.5. Testing Results

The testing process was conducted using the MATLAB software application. The Artificial Neural Network models tested include the 5-5-2 Model, 5-10-8-8-2 Model, 5-5-10-2 Model, and 5-8-10-2 Model. Among the four models used in the testing process of the Artificial Neural Network system with the Backpropagation algorithm using MATLAB, the 5-10-8-8-2 architecture model performed the best, achieving an MSE (Mean Squared Error) of 0.000999932 during training with 2920 epochs and a testing MSE of 0.000997829. The comparison of the results from each Model can be seen in Table 2.

After training and testing, an analysis of the output values resulting from all training and testing results is carried out to determine whether the output of the Artificial Neural Network is as expected. The analysis results include: the artificial neural network with the 5-5-2 architectural Model has the correct effects of 51 data from 70 data, which shows the accuracy of this neural network is 81%. Model 5-10-8-8-2 has the proper development of 70 data out of 70 data, which shows the accuracy of this neural network is 100%. Model 5-5-10-2 has the correct result of 68 data out of 70 data, which shows the accuracy of this neural network is 98%. Model 5-8-10-2 has the correct development of 66 out of 70 data, which shows the accuracy of this neural network is 96%.

Table 2. Comparison of Epoch and MSE

Model	5-5-2	5-10-8-8-2	5-5-10-2	5-8-10-2
Epoch	53574	2920	17624	3689
MSE Training	0.000999986	0.000999932	0.000998506	0.000998238
MSE Testing	0.000999493	0.000997829	0.000999656	0.000996867

5. CONCLUSION

Based on the conducted research, it can be concluded that Backpropagation Artificial Neural Network can effectively assess customer satisfaction. The trained and tested data demonstrated that the Artificial Neural Network could recognize the input data within the system accurately. The configuration of the Artificial Neural Network in this study involved 70 training data and 30 testing data, with five neurons in the input layer and two in the output layer. The best architecture of the Artificial Neural Network used was the 5-8-10-2 Model, with a training epoch of 2774. Training and testing with this 5-8-10-2 Model achieved a 100% recognition rate for the training and testing data, meeting the desired target.

AUTHOR CONTRIBUTIONS

All authors contribute to Conceptualization, Methodology, validation, formal analysis, investigation, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision project administration, funding acquisition, and have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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