Analysis of Satisfaction Level with Servqual method using Artificial Neural Networks

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Abstract. This research aims to analyze the level of student satisfaction at a college in pattern recognition using an artificial neural network with feedforward backpropagation algorithms. Input on the network consists of 5 variables, namely Tangibles (X1), Reliability (X2), Responsiveness (X3), Assurance (X4) and Empathy (X5) which are the dimensions of the Servqual method. Data processing in the Servqual method will become target data on the network. Data is obtained through multi-item questions given to students. After some training trials, the best configuration architecture consists of 5 neurons in the input layer, one hidden layer with seven neurons and one neuron in the output layer. The activation function used by a Sigmoid Binary that has a range of 0 to 1. This architecture can recognize the pattern well in the 14th iteration with MSE of 0.000192. Data testing results obtained an accuracy rate of 91.07% with an error rate of 8.93%. So that it can be concluded that the Artificial Neural Network with feedforward backpropagation algorithm in the case of analyzing the level of student satisfaction on college services can recognize the pattern well.

1. Introduction

The application of information technology today has been widely used in various fields of science. The use of information technology produces effectiveness in obtaining information that will also affect the development of the lifestyle of technology users (users). Information obtained by utilizing technology must be of high quality, meaning that having meaning for the recipient of the information will then be reprocessed to produce new and sustainable information. Information accuracy can create the right decision for those in need.

Universities that are one of the educational organizations must do services to their customers. Providing quality service and satisfaction is the most important thing because based on the measurement of service quality and satisfaction, an organization can find out whether the operation of operations has proceeded as desired. So to measure service quality and satisfaction, the Servqual (Service of Quality) method is used.

The Servqual method is a method used to measure the level of customer satisfaction for services provided by the organization. The services referred to in this study are actions given by universities to students as internal customers.
Artificial Neural Networks is a computerized system that is inspired by biological nerve cells, just like the brain that processes information. The application of artificial neural networks has been widely used in solving scientific problems, one of which can be classified in pattern recognition.

In its application, it will analyze the service quality and the level of satisfaction with the Servqual method and test the results of the analysis to obtain the level of accuracy using Artificial Neural Networks with feedforward backpropagation algorithm.

2. Theoretical basis
In this stage, the theory is presented in analyzing data so that it is relevant to the research that will be conducted.

2.1. Servqual (Service of Quality)
One approach to favorite service quality that is used as a reference in marketing research is the Servqual model developed by Parasuraman, Zeithaml and Berry in 1988. Servqual is built on the comparison of two main factors, namely customer perception of the real service they receive (Perceived Service) with actual expected/desired services (Octy, 2014). If the reality is more than expected, then the service can be said to be quality, whereas if the reality is less than expected, then the service is said to be not qualified. If the reality is the same as hope, the service is satisfying.

The measurement of service quality in the servqual model is based on a multi-item scale designed to measure customer expectations and perceptions, as well as a gap between the two in the five dimensions of service quality. According to research conducted by Parasuraman, et al. there are five servqual dimensions (Kaihatu, 2008), as follows:

1. Tangibles, or physical evidence, namely the ability of a company to show its existence to external parties. This includes physical facilities (buildings, warehouses, etc), technology (equipment and equipment used), and the appearance of employees. Briefly can be interpreted as the appearance of physical facilities, equipment, personnel, and communication material.
2. Reliability, namely the company's ability to provide services as promised accurately and reliably. In short, it can be interpreted as the ability to provide promised services accurately, on time, and can be trusted.
3. Responsiveness, which is a willingness to help and provide services that are fast (responsive) and appropriate to the customer, with the delivery of precise information. In short, it can be interpreted as a willingness to help customers by providing excellent and fast services.
4. Assurance, or guarantee and certainty, namely knowledge, courtesy of compensation, and the ability of company employees to foster a sense of customer trust in the company. In short, it can be interpreted as the knowledge and hospitality of personnel and the ability of personnel to be trusted and believed.
5. Empathy, which is giving sincere and individual or personal attention given to customers by trying to understand the desires of consumers. In short, it can be interpreted as an effort to find out and understand customer needs individually.

To get a gap score, obtained by the formula: Servqual Gap = Perception Score - Hope Score

2.2. Artificial Neural Network
Artificial Neural Network (ANN) is one of the artificial representations of the human brain that always tries to simulate the learning process in the human brain. The term artificial here is used because this neural network is implemented using a computer program that can complete some calculation processes during the learning process.
2.2.1. Basic concept of Artificial Neural Networks

Each pattern of input and output information given into artificial neural networks is processed in neurons. These neurons accumulate in layers called neuron layers. The layers composing the neural network can be divided into three, namely (Lesnussa et. Al., 2015):

1. Input Layer. The units inside the input layer are called input units. These input units receive input patterns from outside the data that describe a problem.
2. Hidden Layer. The units inside the hidden layer are called hidden units. Where the output cannot be directly observed.
3. Output Layer. The units in the output layer are called output units. The output of this layer is an artificial neural network solution to a problem.

2.2.2. Feedforward Backpropagation algorithm

Feedforward backpropagation artificial neural network was first introduced by Rumelhart, Hinton, and Wiliam in 1986, then Rumelhart and Mc Clelland developed it in 1988. Feedforward backpropagation algorithm is a supervised learning algorithm and is usually used by perceptron with many layers to change the weights which is connected to the neurons in the hidden layer. Feedforward backpropagation uses an error output to change its weight values in backward direction. To get this error, the forward propagation stage must be done first. At the time of forward propagation, neurons are activated using an activation function that can be differentiated.

The performance function used in this study is the mean square error (mse), where this function takes the average squared error that occurs between the network output and the target.

2.2.3. Feedforward Backpropagation Activation Function

In feedforward backpropagation, the activation function used must fulfill several conditions, namely: continuous, differentiable easily and is a function that does not go down. The activation function that will be used in this research is Binary Sigmoid. This function is a function that meets these three conditions, and this function is also usually used for Artificial Neural Networks that are trained using feedforward backpropagation algorithms.

The reason the researcher used the binary sigmoid activation function is because in this study will produce output satisfaction level in the form of range values (0, 1). Where this function is often used for artificial neural networks that require an output value located in the range (0.1) or it can also be output value 0 or 1.

2.2.4. Feedforward Backpropagation Training

Backpropagation training includes three phases. The first phase is the advanced phase. Input patterns are calculated forward from the input layer to the output layer using the specified activation function. The second phase is the backward phase. The difference between the network output and the desired target is the error that occurred. The error is propagated backwards, starting from the line directly related to the units in the output layer. The third phase is modification of weights to reduce errors that occur (Siang, 2005).

a. Phase I: Progressive propagation, the input signal (Xi) is propagated to the hidden layer using the specified activation function. The output of each hidden layer unit (Zj) is then propagated forward again to the hidden layer above it using the specified activation function. So on to produce network output (Y).

b. Phase II: Propagation retreats

Based on the t-y error, the factor δ is used to distribute errors in unit Y to all hidden units directly connected to Y. δ is also used to change the line weights that are directly related to the output unit.
c. Phase III: Change in weight
   After all the $\delta$ factors are calculated, the weight of all lines is modified together. Changing the weight of a line is based on factors $\delta$ neurons on the top screen. For example, changes in the weight of the line leading to the output screen are based on $\delta$ in the output unit.

3. Research Methodology
   At this stage will be explained the stages to solve the problems that have been formulated.

3.1. Research design
   To get results, the stages are divided into 2 discussions:
   1. Analysis of service quality measurement and satisfaction using the servqual method.
   2. Testing analysis of servqual method using Artificial Neural Network with feedforward backpropagation algorithm.

3.2. Population and Research Sample
   The study population was students active in the 2017/2018 academic year in Odd semester totaling 512 people at AMIK Medan Business Polytechnic. They are college customers who will analyze their level of satisfaction by comparing the reality of the service to students' expectations of service from universities. While the sample studied amounted to 225 people, obtained based on the Slovin formula (Wirdha, 2015):
   $$ n = \frac{N}{1+Ne^2} $$
   Where :
   - $n$ = Minimum number of samples
   - $N$ = Population
   - $e$ = Error Margin (5%)

3.3. Data collection technique
   In data collection is done through interviews, questionnaires and documentation.

3.4. Data Collection Tool
   The data collection tool in this study is a questionnaire consisting of 25 questions and deducted to students as respondents. Determination of the level of satisfaction of students will service each question using a level scale (likert) as shown in Table 1.

| No. | Expectations   | Score | Perceptions  | Score |
|-----|----------------|-------|--------------|-------|
| 1.  | Very Unimportant | 1     | Strongly Disagree | 1     |
| 2.  | Unimportant     | 2     | Disagree     | 2     |
| 3.  | Quite Important | 3     | Quite Agree  | 3     |
| 4.  | Important       | 4     | Agree        | 4     |
| 5.  | Very Important  | 5     | Strongly Agree | 5     |

Table 1. level scale (likert)

3.5. Research variable
   The variables of this study amounted to 6 pieces consisting of 5 independent variables and 1 dependent variable.
   - Independent variables consist of: Tangibles as X1, Reliability as X2, Responsiveness as X3, Assurance as X4 and Empathy as X5,
   - Dependent variable consists of: Satisfaction as Y

4. Results and Discussion
   At this stage, it will be explained about problem solving until the problem formulation can be answered properly.
4.1. Results
To get the results of the level of satisfaction from students, the results of the questionnaire data obtained from respondents were analyzed first using the servqual method. Furthermore, the results of the analysis of the servqual method will become Target Neural Network Data.

Target Data is divided into 2 parts, Training Data is 75% or 169 and Test Data is 25% or 56. The application used in servqual method analysis is Microsoft Office Excel 2016 and Artificial Neural Network analysis with feedforward backpropagation algorithm using MathWorks Matlab 2017a.

Training Data aims to make the system run accurately and consistently and be able to exploit the advantages of Artificial Neural Networks. Training Data is done repeatedly to get the best network with the smallest MSE value and stop when the MSE value has increased. This condition shows that the generalization of data has decreased so that Training Data can be stopped immediately.

| Training Data | 5   | 6   | 7   | 8   | 9   |
|---------------|-----|-----|-----|-----|-----|
| Hidden Layer  | 1   | 1   | 1   | 1   | 1   |
| Neuron        | 5   | 6   | 7   | 8   | 9   |
| Time          | 265 | 83  | 14  | 49  | 92  |
| Performance   | 0:00:01 | 0:00:00 | 0:00:00 | 0:00:00 | 0:00:00 |
| Gradien       | 1.22e-05 | 1.25e-06 | 0.000192 | 5.14e-05 | 9.60e-06 |
| Validation Checks | 1.59e-05 | 0.000691 | 0.000311 | 0.000594 | 9.03e-05 |
| Best Validation Performance | 4.7179e-06 | 1.1763e-05 | 0.0058951 | 0.0014667 | 0.00016522 |
| At Epoch      | 259 | 77  | 8   | 43  | 86  |

Table 2. Data Training

In the Training Data Table 2, Data Training was conducted 9 times. Jarigan is best at the 7th Data Training. The MSE (Performance) value obtained is 0.000192. The architecture used is 5-7-1 which means 5 neurons in the Input Layer, 7 neurons in the Hidden Layer and 1 neuron in the Output Layer.

With the same architecture, Data Testing is done to be analyzed again from the Output from the Network. Data Testing Results can be seen in the following figure.

The Figure 1 shows the comparison between the target desired by the output of the data testing results. The target to be achieved is identified by an asterisk (*) and the Output Data Test results are identified by a circle (o). The best result is if all Target and Output data are in the same position.
4.2. Discussion
From the results of testing the data as many as 56 samples, then it will be compared with the target data from the analysis of Servqual method to get the accuracy of data testing using artificial neural networks with feedforward backpropagation algorithm. Some of the desired patterns are "Unsatisfied" < 0 and "Satisfied" >= 0.

| No. | Servqual | ANN | Actual Conditions | Prediction Conditions | Network Accuracy |
|-----|----------|-----|-------------------|-----------------------|------------------|
| 1   | -0.08    | Unsatisfied | Unsatisfied | Correct                |                  |
| 2   | -0.32    | Unsatisfied | Unsatisfied | Correct                |                  |
| 3   | 0        | Satisfied    | Unsatisfied | Not Correct            |                  |
| 4   | -0.72    | Unsatisfied | Unsatisfied | Correct                |                  |
| 5   | -0.12    | Unsatisfied | Unsatisfied | Correct                |                  |
| 6   | -2.28    | Unsatisfied | Unsatisfied | Correct                |                  |
| 7   | -1       | Unsatisfied | Unsatisfied | Correct                |                  |
| 8   | 0.12     | Satisfied    | Satisfied    | Correct                |                  |
| 9   | 0.08     | Satisfied    | Satisfied    | Correct                |                  |
| 10  | -0.88    | Unsatisfied | Unsatisfied | Correct                |                  |
| 11  | 0.32     | Satisfied    | Satisfied    | Correct                |                  |
| 12  | -0.04    | Unsatisfied | Unsatisfied | Correct                |                  |
| 13  | -2.68    | Unsatisfied | Unsatisfied | Correct                |                  |
| 14  | 0        | Satisfied    | Unsatisfied | Correct                |                  |
| 15  | -1.28    | Unsatisfied | Unsatisfied | Correct                |                  |
| 16  | -3      | Unsatisfied | Unsatisfied | Correct                |                  |
| 17  | -3      | Unsatisfied | Unsatisfied | Correct                |                  |
| 18  | 0        | Unsatisfied | Unsatisfied | Correct                |                  |
| 19  | -0.4     | Unsatisfied | Unsatisfied | Correct                |                  |
| 20  | -2.12    | Unsatisfied | Unsatisfied | Correct                |                  |
| 21  | -1.36    | Unsatisfied | Unsatisfied | Correct                |                  |
| 22  | -3.48    | Unsatisfied | Unsatisfied | Correct                |                  |
| 23  | -0.16    | Unsatisfied | Unsatisfied | Correct                |                  |
| 24  | -1.44    | Unsatisfied | Unsatisfied | Correct                |                  |
| 25  | -2.4     | Unsatisfied | Unsatisfied | Correct                |                  |
| 26  | 0.16     | Satisfied    | Satisfied    | Correct                |                  |
| 27  | -1.32    | Unsatisfied | Unsatisfied | Correct                |                  |
| 28  | 0        | Unsatisfied | Unsatisfied | Correct                |                  |
| 29  | -2.24    | Unsatisfied | Unsatisfied | Correct                |                  |
| 30  | -1.16    | Unsatisfied | Unsatisfied | Correct                |                  |
| 31  | -1       | Unsatisfied | Unsatisfied | Correct                |                  |
| 32  | -1.16    | Unsatisfied | Unsatisfied | Correct                |                  |
| 33  | -1.76    | Unsatisfied | Unsatisfied | Correct                |                  |
| 34  | -1.36    | Unsatisfied | Unsatisfied | Correct                |                  |
| 35  | -2.2     | Unsatisfied | Unsatisfied | Correct                |                  |
| 36  | -0.16    | Unsatisfied | Unsatisfied | Correct                |                  |
| 37  | -0.88    | Unsatisfied | Unsatisfied | Correct                |                  |
| 38  | -1.12    | Unsatisfied | Unsatisfied | Correct                |                  |
| 39  | -2.32    | Unsatisfied | Unsatisfied | Correct                |                  |
| 40  | -2.08    | Unsatisfied | Unsatisfied | Correct                |                  |
| 41  | -1.44    | Unsatisfied | Unsatisfied | Correct                |                  |
| 42  | -0.08    | Unsatisfied | Unsatisfied | Correct                |                  |
| 43  | -0.24    | Unsatisfied | Unsatisfied | Correct                |                  |
| 44  | -2.64    | Unsatisfied | Unsatisfied | Correct                |                  |
| 45  | -1.96    | Unsatisfied | Unsatisfied | Correct                |                  |
| 46  | -1.2     | Unsatisfied | Unsatisfied | Correct                |                  |
| 47  | -1.24    | Unsatisfied | Unsatisfied | Correct                |                  |
| 48  | 0.28     | Satisfied    | Satisfied    | Correct                |                  |
| 49  | -1.6     | Unsatisfied | Unsatisfied | Correct                |                  |
| 50  | -2.04    | Unsatisfied | Unsatisfied | Correct                |                  |
| 51  | -0.16    | Unsatisfied | Unsatisfied | Correct                |                  |
| 52  | -1.64    | Unsatisfied | Unsatisfied | Correct                |                  |
| 53  | -1.64    | Unsatisfied | Unsatisfied | Correct                |                  |
Based on the Table 3, it can be seen that 51 data or 91.07% Target Data with Data Testing Output is appropriate, while 5 data or 8.93% are not suitable between Target Data and Data Testing Output. In this case, the level of accuracy of the analysis of service quality and student satisfaction for the 2017/2018 academic year of the Odd semester is 91.07%.

5. Conclusion and Recommendation

From the results obtained through the stages of design, analysis, data training and data testing, conclusions are obtained and given recommendations.

5.1. Conclusion

The conclusions obtained from this study are as follows:

Artificial Neural Networks with feedforward backpropagation algorithm are considered good in testing the accuracy of student satisfaction with work accuracy of 91.07%.

5.2. Recommendation

The suggestions that can be given are:

This research is to be developed again using a more complex network architecture.

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