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Implementation of Artificial Neural Networks In Predicting Students 'English Understanding Level Using The Backpropagation Method

Kristin D R Sianipar[1], Septri Wanti Siahaan[2], Iin Parlina[3]
[1,2,3]Department of Informatics Engineering, STIKOM Tunas Bangsa Pematangsiantar, Indonesia

ABSTRACT

English is a language that unites humans in communicating with others. The existence of language differences can make it difficult for people to understand each other in dialogue. Therefore, the role of English is very useful to unite human communication. In this case, researchers make research to predict the level of understanding of students in English. Predicting the level of understanding of students in English is needed to determine the level of ability or understanding of students in English so that students can further enhance student abilities. English is very necessary for students to support a bright future. In this study implements the Artificial Neural Network in conducting research and applying the bacpropagation method in it. To complete this study, researchers used several criteria, namely: Reading References, Hearing from the Environment, Practicing, Utilizing Technology. Of the four criteria using the backpropagation method is useful for training in predicting the level of understanding of students in English. The results of this research test get that the level of understanding of students in English is with the level of accuracy and architecture

Keyword : Artificial Neural Network; **Prediction**; **English; Level of Understanding; Backpropagation**.

Corresponding Author:
Septri Wanti Siahaan,
Department of Informatics Engineering
STIKOM Tunas Bangsa Pematangsiantar
Jl. Jend. Sudirman, Blok. A, No. 1, 2, dan 3, Pematangsiantar, 21143, Sumatera Utara, Indonesia.
Email : septriwanti26@gmail.com

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1. INTRODUCTION

Artificial Neural Network is a network in which modeling applies the human neural network. Artificial neural network is an information processing paradigm inspired by the bilogin nervous cell system as well as the brain that processes information (Yani & Sukarno, 2005). An artificial neural network consists of several groups of small processing units.

The implementation of artificial neural networks is the same as humans who carry out learning from an example in solving a problem that has a pattern of rules similar to the example given. Artificial Neural Networks (ANN) are an information processing system that has characteristics similar to biological neural networks (JSB). Artificial Neural Networks are created as a generalization of the mathematical model of human understanding (human cognition) (Maharani, 2015).

English is the language used globally by humans to communicate with people who have different languages. English has been studied since elementary school. Many people find it difficult to understand English because there is a lot of grammar that has to be learned. Teachers are indispensable in helping students improve their understanding of English.

English is one of the guidelines for getting a job in the future. In carrying out the KBM (Teaching and Learning Activities) process in the classroom, there must be a two-way relationship between students and lecturers so that students can understand the material being studied. Many factors can be used to improve students' understanding in English. In this case, the researcher conducted research to predict how well students understood English. This aims to motivate students to improve their ability in English. To predict the level of understanding of students in English, the researcher applies Artificial Neural Networks in the test. The method used in this research is the Backpropagation method.

2. RESEARCH METHOD

A. Artificial Neural Network

Artificial Neural Networks (ANN) is one of the applications in Artificial Intelligence which has achieved great success in recent years in multifactor process modeling and opens up new dimensions in optimizing complex systems for scientific research and business applications (Saxena, 2015). Artificial neural network is an information processing paradigm inspired by the bilogin nervous cell system as well as the brain that processes information. Artificial neural networks are inspired by neural networks in humans. The modeling used by artificial neural networks is through the learning process and adjustment to an object (Yanto, 2017). In Artificial Neural Networks basically is adopting the workings of the human brain which has the characteristics of parallel processing, processing large amounts of elements and fault tolerance (Setiabudi, 2015). Artificial Neural Network mentions 3 things (Pratama & Anifah, 2015):

1. The pattern of relationships between neurons (called network architecture).
2. Methods for determining attributed weights (called training / learning / algorithm methods).
3. Activation function.

The framework of the Artificial Neural Network can be seen from the number of layers and the number of neurons. These neurons are collected in layers called neuron layers (Matondang, 2013). Artificial Neural Networks have several unique characteristics, including (Windarto, 2017):

1. Ability to learn
2. Ability to generalize
3. The ability to solve problems that do not or are not good enough when modeled as a linear system, which is a requirement for several other forecasting methods, such as time series data models.

B. Artificial intelligence

Artificial intelligence or also called Artificial Intelligence (AI) is one part of computer science that studies how to make machines (computers) do work as well as what humans do, even better than humans do (Revi, Ramadan & Solikhun, 2018). Artificial Intelligence (AI) is to identify and model human thought processes and design machines so that they can mimic human behavior. Intelligent, means having knowledge and experience, reasoning, how to make decisions and take good moral actions (McCarthy & Dahria, 2012).

C. Neuron Model

It also explains that there are three basic elements of the neural model, namely (Cao et al., 2012):

1. A set of synapses, or bridges each classified by weight or strength.
2. An adder to add up input signals. Weighted from the synaptic strength of each neuron.
3. An activation function to limit the output amplitude of the neuron. This function aims to limit the amplitude range allowed by the output signal to a limited number.

D. Backpropagation Algorithm

The Backpropagation Neural Network (BP) uses the initial connection weight between the backpropagation neural network layer and the initial threshold to optimize the search for a solution [12]. Backpropagation is one of the ANN models that has the ability to strike a balance between the network's ability to recognize patterns used during training and the network's ability to respond correctly to input patterns that are similar (but not the same) as the patterns used during training (Kusmaryanto, 2018).

Backpropagation is one of the ANN models that has the ability to strike a balance between the network's ability to recognize patterns used during training and the network's ability to respond correctly to input patterns that are similar (but not the same) to the patterns used during training (Revi, 2016).

The steps in the backpropagation algorithm are as follows (Fausett, 1994):

Step 0: Initialize the weights (set weights to small random values).

Step 1: When the stop condition is wrong, do steps 2 - 9.

Step 2: For each training pair, do steps 3 - 8.

Feedforward

Step 3: Each input unit (X_i, i =1,. . . , n) receives the input signal Xi and transmits this signal to all units in the layer above it (hidden unit).

Step 4: Each hidden unit (Z_j, ,j=1,. . . ,p) adds up the weight of the input signal.

$$z\_in_j = v_{0j} + \sum_{i=1}^{n} X_i V_{ij} \quad (1)$$

applies the activation function to calculate the output signal

$$z_j = f(z\_in_j) \quad (2)$$

and sends signals to all units in the layer above it (output unit).

Step 5: Each unit of output (Y_k, k = 1, . . . , m) adds up the weight of the input signal.

$$y\_in_k = W_{0k} + \sum_{j=1}^{p} Z_j W_{jk} \quad (3)$$

and applies its activation function to calculate the output signal.

$$y_k = f(y\_in_k) \quad (4)$$

Backpropagation

Step 6: Each unit of output (Y_k, k = 1, . .. , m) receives the target pattern according to the input training pattern, calculating the error information.

$$\delta_k = (t_k - y_k) f'(y\_in_k) \quad (5)$$

calculates its weight correction (used to update w_{jk})

$$\Delta w_{jk} = \alpha \delta_k z_j \quad (6)$$

calculating bias correction (used to update w_{0k})

$$\Delta w_{0k} = \alpha \delta_k \quad (7)$$

send to the layer unit beneath it

Step 7: Each hidden unit (Z_j , j = 1, . . . , p) adds up the input delta (from the units in the upper layer).

$$\delta\_in_j = \sum_{k=1}^{m} \delta_k W_{jk} \quad (8)$$

multiplied by the derivative of the activation function to calculate the error information.

$$\delta_j = \delta\_in_j f'(z\_in_j) \quad (9)$$

calculating weight corrections (used to update v_{ij})

$$\Delta v_{ij} = \alpha \delta_j x_i \quad (10)$$

and calculates the bias correction (used to update v_{0j})

$$\Delta v_{0j} = \alpha \delta_j \quad (11)$$

Update weights and biases

Step 8: Each unit of output (Y_k, k = 1, . .. , m) updates the bias and weights (j = 0,..., P)

$$w_{jk}(new) = w_{jk}(old) + \Delta w_{jk} \quad (12)$$

Each hidden unit (Z_j, j = 1, . . . , p) updates the weights and biases (i = 0,...., N)

$$V_{ij}(new) = w_{ij}(old) + \Delta v_{ij} \quad (13)$$

Step 9: Test the stop condition.

Application algorithm

After training, the backpropagation neural network was applied using only the feedforward phase of the training algorithm. The steps are as follows [15]:

Step 0: Initialize the weights (from the training algorithm).

Step 1: For each input vector perform steps 2-4. Step 2: For i = 1,. . . , n activation set for the input unit xi.

Feedforward

Step 3: For every j = 1,. . . , p

$$z\_in_j = v_{0j} + \sum_{i=1}^{n} X_i V_{ij} \quad (14)$$

$$z_j = f(z\_in_j) \quad (15)$$

Step 4: For every k = 1,. . . , m

$$y\_in_k = W_{0k} + \sum_{j=1}^{p} Z_j W_{jk} \quad (16)$$

$$y_k = f(y\_in_k) \quad (17)$$

3. RESULTS AND DISCUSSION

A. System planning

1. Defining Inputs and Targets

The student data that has been obtained will then be processed with an Artificial Neural Network, namely the backpropagation method. To make it easier for the Artificial Neural Network to recognize data, the data is initialized into a numeric form, which is between 0 and 1, where each criterion or content is input data to students as recognition of patterns and what is the output is a prediction of student understanding in English from the best architectural model when determining the best pattern.

2. Defining Input

The variables in determining the level of understanding of students in English are criteria that are useful as a reference when making decisions using Artificial Neural Networks. The variables that are determined are done by looking at the dependence on data on the research being carried out. The list of variables to determine understanding of English in English is as follows:

Table 1. List of Variables in Students' Understanding of English

No.	Criteria	Variable	Rank Average Value	Information	Weight
1	Reference Reading	A	5	Strongly agree	1
			4 - 4.99	Agree	0.8
			3 - 3.99	Simply Agree	0.6
			2 - 2.99	Disagree less	0.4
			0 - 1.99	Very Disagree	0.2
2	Hearing from the Environment	B	5	Strongly agree	1
			4 - 4.99	Agree	0.8
			3 - 3.99	Simply Agree	0.6
			2 - 2.99	Disagree less	0.4
			0 - 1.99	Very Disagree	0.2
3	Demonstrate	C	5	Strongly agree	1
			4 - 4.99	Agree	0.8
			3 - 3.99	Simply Agree	0.6
			2 - 2.99	Disagree less	0.4
			0 - 1.99	Very Disagree	0.2
4	Utilizing Technology	D	5	Strongly agree	1
			4 - 4.99	Agree	0.8
			3 - 3.99	Simply Agree	0.6
			2 - 2.99	Disagree less	0.4
			0 - 1.99	Very Disagree	0.2

The data was obtained by researchers by conducting questionnaires to students who were learning from home. The student sample data used consisted of 20 data. The data has 4 variables and 1 target. The data obtained will be transformed into a data that is between 0 and 1. This is done prior to training and testing using the backpropagation method found in Artificial Neural Networks.

3. Defining Targets

In this study, the target data is equal to 1, namely students understand English.

B. Data processing

The data sample used is 20 students and will be divided into two parts, namely the training section and the data testing section. Data that is still raw will be converted into a table of criteria that has been specified in Table 1.

Table 2. Sample Data from Changed Data

No	Student Name	Variable				Target
		A	B	C	D	
		X_1	X_2	X_3	X_4	
1	Ira	0,8	0,6	0,6	0,8	1
2	Wulan Samosir	0,8	1	0,8	0,8	1
3	Fran Sihombing	0,8	0,6	0,4	0,4	1
4	Ulina Sinaga	0,8	0,8	0,8	1	1
5	Miranda Siadari	0,6	0,6	0,8	0,6	1
6	Kristin Sianipar	0,8	0,8	0,8	0,8	1
7	Jhordi Samosir	0,6	0,8	0,6	0,8	1
8	Intan Liana	0,8	0,6	0,6	0,8	1
9	Niya Panggabean	0,8	0,8	0,6	0,8	1
10	Santo Lubis	0,6	0,8	0,6	0,6	1
11	Septri Siahaan	0,8	0,8	0,6	0,8	1
12	Lasma Situmorang	0,6	0,4	0,6	0,8	1
13	Lony Simanjuntak	0,8	0,8	1	1	1
14	Anang Bagus	0,6	0,6	0,8	0,6	1
15	Nendi Maulica	0,8	1	0,8	0,8	1
16	Tri Nona Damanik	0,8	0,8	0,8	0,8	1
17	Dico Peranginangin	0,8	0,8	0,6	0,8	1
18	Wanson Silalahi	0,8	0,6	0,8	1	1
19	Juandri Turnip	0,8	0,8	0,8	0,8	1
20	Jojo	0,8	0,6	0,8	0,6	1
21	Jeje	0,8	0,8	0,6	0,8	1
22	Irene Sinaga	0,6	0,6	0,8	0,6	1
23	Dormauli Simanjuntak	0,6	0,4	0,6	0,8	1
24	Andryan Situmorang	0,6	0,8	0,8	0,8	1
25	Friska Manik	0,6	0,6	0,8	0,8	1
26	Jesica Situmorang	0,6	0,8	0,8	0,8	1
27	Cristine Simanjuntak	0,6	0,4	0,6	1	1
28	Devi Sihombing	0,8	0,6	0,8	1	1
29	Marina	0,6	0,6	0,6	0,8	1
30	Jojor Damanik	0,6	0,6	0,4	0,6	1
31	Christine	0,8	0,6	0,6	0,8	1
32	Sasa Sri	0,6	0,6	1	1	1
33	Fauza	0,8	0,8	0,6	1	1
34	Ahmad Fauzril	0,8	0,8	0,6	1	1
35	Debora	0,6	0,6	0,6	1	1
36	Jonathan S	0,4	0,4	0,4	0,6	1
37	Priska	0,8	0,6	0,6	0,8	1
38	Denny	0,8	0,8	0,8	0,6	1
39	Srilan	0,8	0,8	1	0,8	1
40	Juwita	1	0,4	1	1	1

C. Artificial Neural Network Architecture Design

In knowing the level of understanding of English, students can use a network, namely the backpropagation method of Neural Networks and using feedforward learning. Artificial Neural Networks have several layers, namely, the input layer, the output layer and the hidden layer. The hidden layer allows the network to be able to mark more input forms compared to networks that do not have a hidden layer. The standards in forming the backpropagation method network using 4 variables as input, 1 hidden layer with 2 and 1 output layer are as follows:

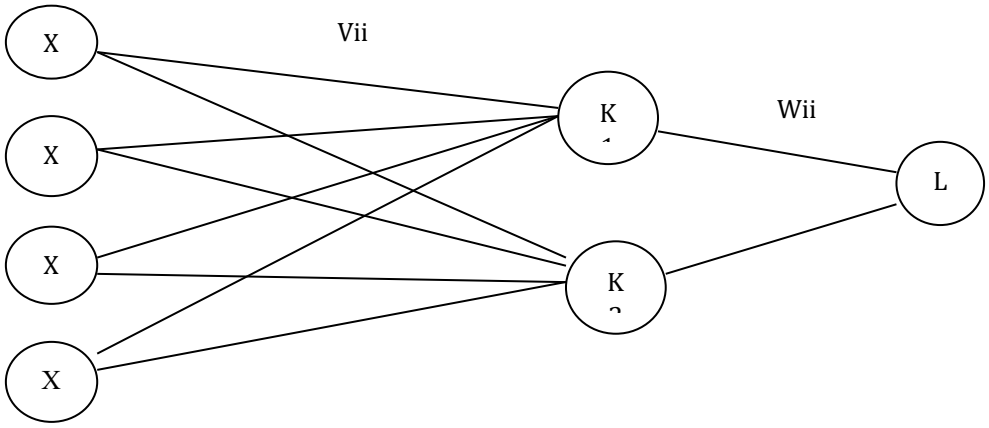

Figure 1. Artificial Neural Network Architecture Predicts Students' Level of Understanding of English

The neural network to be designed is a backpropagation algorithm using the Sigmoid activation function. To perform calculations on the actual output value in the hidden layer and calculate the actual output value at the output layer using the activation function found on the Artificial Neural Network.

D. Defining Output

In this research phase, it is expected to be able to produce a pattern detection to determine the best criteria for improving students' English skills. The testing phase is as follows:

a. In knowing the level of understanding of students in English, it is tested based on the factors that influence students to improve their understanding of English. The output of the level of understanding of English in this student is whether the student understands English by using a weight of 1.
b. The "understand" categorization

The category for "understand" is determined based on the minimum error rate of the target "understand" 1. The categorization is as follows:

Table 3. Categorization of "understand"

No.	Information	*Minimum Error*
1	Very Understand	0.0000 - 0.0010
2	Understand	0.0011 - 0.0100
3	Enough understand	0.101 - 0.1000

E. 4-2-1 Architectural Design Using Neural Networks

In designing the data that is owned, it uses an Artificial Neural Network which functions as training and testing data and uses 4 variables or criteria as input, namely:

X1 = Reading Reference
X2 = Hearing from the Environment
X3 = Practicing
X4 = Utilizing Technology

In carrying out the manual calculation process, data is given as a sample and there are 4 input variables, namely X1, X2, X3, X4.

The steps that will be useful for users of the backpropagation algorithm using the sigmoid activation function can be done by doing the following steps:

1. Initialization is the first step that serves to define or regulate the criteria / value variables, for example: the value of the input data, the weight, the desired output value, the learning rate and other data values.
2. Activation is a step in calculating the actual output value in the hidden layer and the process of calculating the actual output value in the output layer.
3. *Weight Training* is a step in the process of calculating the error gradient value in the output layer and the process of calculating the error gradient value in the hidden layer.
4. *Iteration* (Iteration) is the last step in the testing process, where if there is still the desired minimum error has not been obtained. Hence, go back to the activation step.

At the training stage or the process of forming an Artificial Neural Network that must be done, the first thing to do is to initialize the initial weights. The initial weight will connect the nodes between the input layer and the hidden layer. The initial weight in the backpropagation algorithm above is V = (V11, V12, V21, V22, V31, V32, V41, V42), and the bias weights are obtained randomly in the nodes between the hidden layer and the output layer (W11, W12) obtained by random.

The backpropagation algorithm at the training stage uses 4 input layers, 2 hidden layers, and 1 output layer and also the binary sigmoid activation function as follows:

1. Initialization stage:

Write down the input value given

X1 = 0.8
X2 = 0.6
X3 = 0.6
X4 = 0.8

Target = 1 *Learning rate*(α) = 0.1

Give the weight value (V) from the input to the hidden layer using a random value.

Table 4. Weight Value of Input to Hidden Layer

	K1	K2
V1	0.2	-0.3
V2	0.4	0.1
V3	0.3	-0.5
V4	0.5	-0.4

Give the weight value (W) from the hidden layer to the output using a random value.

Table 5. Weight Value of Hidden Layer to Output

	L
W1	-0.3
W2	-0.2

2. Activation stage
   a. Calculate the output value of each node (hidden node and output node)

K1 = X1. V11 + X2. V21 + X3. V31 + X4. V41
= (0.8) (0.2) + (0.6) (0.4) + (0.6) (0.3) + (0.8) (0.5)
= 0.98

= Sigmoid {0.98} = $\frac{1}{\left(1+e^{0,84}\right)}$ = 0.301

K2 = X1. V12 + X2. V22 + X3. V32 + X4. V42
= (0.8) (- 0.3) + (0.6) (0.1) + (0.6) (- 0.5) + (0.8) (- 0.4)
= - 0.8

= Sigmoid {-0,8} = $\frac{1}{\left(1+e^{-0,16}\right)}$ = 0.539

L = K1.W11 + K2. W21
= (0.301) (- 0.3) + (0.539) (- 0.2)

= -0.1981

= Sigmoid {-0,1981} = $\frac{1}{\left(1+e^{-0,1984}\right)}$ = 0.82

b. Calculate output error values and hidden layers
By using the formula, then:
Err L = L. (α- L). (T - L)
= 0.82 (0.1 - 0.82) (1 - 0.82)
= - 0.106272
Err K1 = K1. (A - K1). (Err L - W11)
= 0.301 (0.1 - 0.301) (- 0.106272 - (-0.3))
= - 0.01172
Err K2 = K2. (A - K2). (Err L - W21)
= 0.539 (0.1 - 0.539) (- 0.106272 - (-0.2))
= - 0.022178

c. Modify / Calculate new weights
By using the formula, then:
ΔW11 = W11 + α. Err L. K1
= (-0.3 + 0.1) (-0.106272) (0.301)
= 0.006397
ΔW21 = W21 + α. Err L. K2
= (-0,2 + 0,1) (-0.106272) (0.539)
= 0.005728
ΔV11 = V11 + α. Err K1.X1
= (0.2 + 0.1) (- 0.01172) (0.8)
= -0.0028128
ΔV12 = V12 + α. Err K2.X1
= (-0.3 + 0.1) (-0.022178) (0.8)
= 0.003548
ΔV21 = V21 + α. Err K1.X2
= (0.4 + 0.1) (- 0.01172) (0.6)
= -0.003516
ΔV22 = V22 + α. Err K2.X2
= (0.1 + 0.1) (-0.022178) (0.6)
= -0.00266
ΔV31 = V31 + α. Err K1.X3
= (0.3 + 0.1) (- 0.01172) (0.6)
= -0.0028128
ΔV32 = V32 + α. Err K2.X3
= (-0.5 + 0.1) (-0.022178) (0.6)
= 0.005322
ΔV41 = V41 + α. Err K1.X4
= (0.5 + 0.1) (- 0.01172) (0.8)
= -0.0056256
ΔV42 = V42 + α. Err K2.X4
= (-0.4 + 0.1) (-0.022178) (0.8)
= 0.00532272

F. Prediction of Level of Understanding of English in Students

The final stage of this research is the process of predicting the level of understanding of English in students. This stage is used by making a comparison of the minimum error value from the results obtained. By using the 4-2-1 architectural model, the data will be predicted to find out how accurate or precise the 4-2-1 model is to recognize the data. The data that will be carried out for prediction in knowing the level of accuracy are as follows:

Table 6. Prediction Results Using Model 4-2-1

Prediction Model 4-2-1		Prediction		Information
No.	Student name	*Database*	Artificial Neural Network	Result
1	Jeje	Simply Understand	0.0116	Right
2	Irene Sinaga	Simply Understand	0.0232	Right
3	Dormauli Simanjuntak	Simply Understand	0.0502	Right
4	Andryan Situmorang	Simply Understand	0.0122	Right
5	Friska Manik	Simply Understand	0.0136	Right
6	Jesica Situmorang	Simply Understand	0.0122	Right
7	Cristine Simanjuntak	Simply Understand	0.0442	Right
8	Devi Sihombing	Simply Understand	0.0111	Right
9	Marina	Simply Understand	0.0255	Right
10	Jojor Damanik	Simply Understand	0.1308	Wrong
11	Christine	Simply Understand	0.0126	Right
12	Sasa Sri	Simply Understand	0.0112	Right
13	Fauza	Simply Understand	0.0114	Right
14	Ahmad Fauzril	Simply Understand	0.0114	Right
15	Deborah	Simply Understand	0.0232	Right
16	Jonathan S	Simply Understand	0.4181	Wrong
17	Priska	Simply Understand	0.0126	Right
18	Denny	Simply Understand	0.0134	Right
19	Srilan	Simply Understand	0.0112	Right
20	Juwita	Simply Understand	0.0108	Right

At the prediction stage, the results obtained that the Artificial Neural Network can carry out predictions above 90% of the accuracy level.

4. CONCLUSION

The conclusions that can be obtained by the author after writing this research are as follows:

1. By making more hidden screens during the training and testing stages, it doesn't get the maximum output. In the type of architecture designed, the model that has the highest MSE level at the training stage is the 4-2-1 model with a value of 0.0108.
2. The 4-2-1 architectural model can carry out predictions at the level of students' understanding of English, namely with a performance result above 90%.
3. In predicting the level of understanding of students' English, the appropriate method is to use the backpropagation method.

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BIOGRAPHIES OF AUTHORS

	Name : Kristin Daya Rohani Sianipar Semester : 7 Department Of Informatics Engineering in STIKOM Tunas Bangsa Pematangsiantar
	Name : Kristin Daya Rohani Sianipar Semester : 7 Department Of Informatics Engineering in STIKOM Tunas Bangsa Pematangsiantar
	Name : Iin Parlina Lecturer in Amik and STIKOM Tunas Bangsa Pematangsiantar