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Recognition of a Human Behavior Pattern in Paper Rock Scissor Game Using Backpropagation Artificial Neural Network Method

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***Abstract*—Artificial neural network was a information processing paradigm that took a model from the works of biological neural network in processing information hence it would have an ability which seems like human brain. Artificial neural network was able to solve some problems which contain uncertainty inside, which usually only human who could solve it. It was pattern recognition for example.**

The objective of this research was to find the effectiveness of backpropagation artificial neural network method to recognize human behaviour pattern in paper rock scissor game. The result were: an application using artificial neural network to recognizing human behaviour pattern in paper rock scissor game (1), an effectiveness of backpropagation artificial neural network method to recognize human behaviour pattern in paper rock scissor game (2). *(Abstract)*

Keywords—Pattern Recognition; Human Behavior Pattern; Paper Rock Scissor Game; Artificial Neural Network; Backpropagation *(key words)*

I. INTRODUCTION

In computer science, especially in artificial intelligence, there is a method called artificial neural network. Artificial neural network (ANN) is an information processing paradigm which takes a model from the works of biological neural network in processing information. The background of the development of the ANN is the desire of human to make computer to be able to mimic human ability in processing information.

ANN has been proved to be able to solve any problems which contain uncertainty and usually can only be solved by human. Examples for those problems are forecasting, face recognition, hand-write recognition, and voice recognition. Those problems usually cannot be solved by a simple algorithm. It could be said that of the information processing paradigms, ANN is one of the most similar to the human ability in processing information.

The similarities of the ANN and human brain to process information have raised a question; that is how effective ANN can recognize behavior patterns which are generated from human brain.

However, a right media is needed to limit those patterns so they can be recognized well by computer; thus paper rock scissor game is chosen as the media. Paper rock scissor game is a perfect media to be used to limit human behavior pattern. Paper rock scissor game gives a limited number of patterns but able to show the tendency of the behavior of the human who play it. It makes much easier for ANN to recognize pattern which is generated by the research object.

The motivation behind this research is to make ANN understand how human think. Until now, the gaps between the way human and computer think is still quite far; thus makes computer still cannot do some task that considered must be done by human now. This research will take the first step to shorten those gaps.

If we can remove the gaps between the way human and computer think, we can hope that in the future we do not have to rely a lot to the human skill, as the cost to require a skilled human is quite high and takes a lot of time. We can just train the computer to do the task which is much cheaper and saves us a lot of time.

II. SCOPE OF THE RESEARCH

A. Problem Formulation

The problem which will be discussed in this research is the effectiveness of backpropagation ANN method in recognizing human behavior pattern in paper rock scissor game. It described as how the using of ANN that has been learning the behavior pattern of a human can give a correct response to the future match against that human; thus increase the computer winning percentage on the future paper rock scissor game against him.

B. Problem Limitation

The problem which will be discussed in this research takes basis on these limitations:

1) Human behavior pattern in paper rock scissor game which will be recognized by ANN is limited to:

a) The inputs are the choices the paper rock scissor game of both the human as research object and computer in two session of game back to back. The choices of the

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computer that will be used during recognizing process are generated randomly by the computer.

b) The output is the choice of the research object, which are used in the third game session right after two game sessions which were recognized before.

2) Research object is a human whose behavior pattern recognized by the computer.

3) The number of player per game is two; those are computer and research object.

4) The type of ANN which is used in this research is defined by these statement:

a) The type of ANN architecture is multi-layer feed-forward neural network.

b) The training algorithm which is used is backpropagation with variation which uses momentum.

5) The design of the ANN architecture which is used in this research is defined by these statement:

a) The number of neuron in input layer is four neuron

b) The number of neuron in hidden layer is defined dynamically while application is running.

c) The number of neuron in output layer is one neuron

6) The ANN parameters which is used in this research are defined by these statement:

a) The error is calculated using mean square error function with limitation at value 0.0001.

b) Transfer function for connection between input layer and hidden layer is sigmoid bipolar.

c) Transfer function for connection between hidden layer and output layer is sigmoid bipolar

d) Maximum number of epoch is defined dynamically while application is running.

e) Momentum parameter is defined dynamically while application is running.

f) Learning rate is defined dynamically while application is running.

III. BASE THEORIES AND METHODS

A. Artificial Neural Network

Artificial neural network (ANN) is information processing system which characteristics similar to biological neural network [1]. ANN is created as mathematical model generalization of biological neural network with these assumptions:

1. Information processing happens in several simple elements called neuron.
2. Signals are sent within neurons through connections.
3. Connection between neurons has weight which will strengthen or weaken the signals.
4. To decide output, each neuron uses transfer function to which the sum of received inputs is exposed. The value of this output then compared to error limitation.

B. Backpropagation Training Algorithm

Backpropagation training algorithm is an algorithm used to train the ANN and make it recognize the pattern given to it. Backpropagation developed from perceptron training algorithm with the use of multi-layer network architecture [1]. Backpropagation is able to perform pattern recognition which could not be performed by previous algorithm.

Transfer function which is used by backpropagation must fulfill several conditions; those are continuing, differentiated easily, and not a descending function. The functions which fulfill those three condition and quite popular to be used are sigmoid binary and sigmoid bipolar.

Training with backpropagation algorithm follow these steps:

1) Initialize all neuron's weight with random small number.
2) If stopping condition (maximum epoch or minimum error value) is not fulfilled repeat step 3 to 9.
3) For each training data set, do step 4 to 9.
4) Each input layer's neuron receives the inputs and pass it to the connected hidden layer's neuron .
5) Count all output values from hidden layer using equation (1) and (2).

$$z\_net_j = v_{j0} + \sum_{i=1}^{n} x_i v_{ji} \quad (1)$$

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

6) Count all output values from output layer using equation (3) and (4) .

$$y\_net_k = w_{k0} + \sum_{j=1}^{p} z_j w_{kj} \quad (3)$$

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

7) Count the output layer's error factor based on the error in each of the output layer's neuron using equation (5) and (6).

$$\delta\_y_k = (t_k - y_k) f'(y\_net_k) \quad (5)$$

$$\Delta w_{kj} = \alpha \delta\_y_k z_j \quad (6)$$

8) Count the hidden layer's error factor based on the error in each of the hidden layer's neuron using equation (7), (8), and (9).

$$\delta\_znet_j = \sum_{k=1}^{m} \delta\_y_k w_{kj} \quad (7)$$

$$\delta\_z_j = \delta\_znet_j f'(z\_net_k) \quad (8)$$

$$\Delta v_{ji} = \alpha \delta\_z_j x_i \quad (9)$$

9) Count all changes of the weight of the neurons.

$$w_{kj}(t+1) = w_{kj}(t) + \Delta w_{kj} \quad (10)$$

$$v_{ji}(t+1) = v_{ji}(t) + \Delta v_{ji} \quad (11)$$

Description:

1) z_net_j = the output value of hidden layer's neuron j^{th} before it is exposed to transfer function.
2) v_{j0} = connection line weight from bias neuron of input layer to j^{th} hidden layer's neuron.
3) $x_i = i^{th}$ input value.
4) v_{ji} = connection line weight from i^{th} input layer's neuron to j^{th} hidden layer's neuron.
5) z_j = output value of j^{th} hidden layer's neuron.
6) $f()$ = transfer function
7) y_net_k = the output value of output layer's neuron k^{th} before it is exposed to transfer function.
8) w_{k0} = connection line weight from bias neuron of hidden layer to k^{th} output layer's neuron.
9) w_{kj} = connection line weight from j^{th} hidden layer's neuron to k^{th} output layer's neuron.
10) y_k = output value of k^{th} output layer's neuron.
11) $t_k = k^{th}$ output layer's neuron target output.
12) α = learning rate.
13) δ_y_k = error factor of k^{th} output layer's neuron.
14) Δw_{kj} = the change of the connection line weight from j^{th} hidden layer's neuron to k^{th} output layer's neuron.
15) δ_znet_j = error factor of j^{th} hidden layer's neuron before it is exposed to transfer function.
16) δ_z_j = error factor of j^{th} hidden layer's neuron.
17) Δv_{ji} = the change of the connection line weight from i^{th} input layer's neuron to j^{th} hidden layer's neuron.
18) $w_{kj}(t+1)$ = new connection line weight from j^{th} hidden layer's neuron to k^{th} output layer's neuron.
19) $w_{kj}(t)$ = current connection line weight from j^{th} hidden layer's neuron to k^{th} output layer's neuron.
20) $w_{kj}(t-1)$ = old connection line weight from j^{th} hidden layer's neuron to k^{th} output layer's neuron.
21) $v_{ji}(t+1)$ = new connection line weight from i^{th} input layer's neuron to j^{th} hidden layer's neuron.
22) $v_{ji}(t)$ = current connection line weight from i^{th} input layer's neuron to j^{th} hidden layer's neuron.
23) $v_{ji}(t-1)$ = old connection line weight from i^{th} input layer's neuron to j^{th} hidden layer's neuron.

IV. SYSTEM DESIGN

A. Artificial Neural Network Architecture Design

Input layer consists of four neurons to take four choice pattern inputs, which are the choices made by the computer and the research object in two consecutive matches. Output layer consists of one neuron which produces output as the predicted choice which will be made by the research object in the match right after those two matches. Minimum error value in the form of mean square error (MSE) value which is used is 0.0001. The number of maximum epochs which is used is 100 epochs. The number of hidden layer which are used is one layer. The number of neuron in the hidden layer, learning rate value, and momentum parameter value are decided based on this result of research:

Training data set:

1) First Input = 0,3
2) Second Input = 0,6
3) Third Input = 0,9
4) Forth Input = 0,3
5) Output = 0,75

TABLE 1. RESULT OF NUMBER OF HIDDEN LAYER'S NEURON PARAMETER RESEARCH

Number of Hidden Layer's Neuron	5			7			9		
Learning Rate	0.01			0.01			0.01		
Momentum Parameter	0.9			0.9			0.9		
Number of Research	1	2	3	1	2	3	1	2	3
Number of Epochs Passed	95	58	31	35	31	30	45	45	100
Training Result	v	v	v	v	v	v	v	v	x
Number of epochs average	61,333			32			63,333		

TABLE 2. RESULT OF LEARNING RATE PARAMETER RESEARCH

Number of Hidden Layer's Neuron	7			7			7		
Learning Rate	0.01			0.001			0.1		
Momentum Parameter	0.9			0.9			0.9		
Number of Research	1	2	3	1	2	3	1	2	3
Number of Epochs Passed	35	31	30	100	100	100	100	9	100
Training Result	v	v	v	x	x	x	x	v	x
Number of epochs average	32			100			69,667		

TABLE 3. RESULT OF MOMENTUM PARAMETER RESEARCH

Number of Hidden Layer's Neuron	7			7			7		
Learning Rate	0.01			0.01			0.01		
Momentum Parameter	0.9			0.8			0.7		
Number of Research	1	2	3	1	2	3	1	2	3
Number of Epochs Passed	35	31	30	100	100	100	100	100	100
Training Result	v	v	v	x	x	x	x	x	x
Number of epochs average	32			100			100		

Explanation:

1) v = Training succeed
2) x = Training failed

Based on the research result which can be viewed in table 1, table 2, and, table 3, it can be concluded that the number of hidden layer's neuron = 7, learning rate = 0.01, and momentum parameter value = 0.9 give the optimum result.

B. Learning System Design

In order to have the ANN understand the behavior pattern of the research object, a learning system that supports it in learning the pattern is needed. The modeling system describes

how ANN learns so it will understand the behavior pattern well.

The first phase in the learning system is to make the ANN learn the general pattern of the research object's behavior. This is performed by doing forty paper rock scissor matches between the computer and the research object. At this phase, the choices of the computer are generated randomly. The ANN takes four inputs, which are the choices made by the computer and the research object in two consecutive matches. The target output of the ANN is the choices made by the research object in the match right after those two matches. The learning progress is started from the third match, as it need the first and the second match as the inputs. Then the ANN continue its learning progress by learning the pattern given by the second and third match as inputs and the forth match as the target output. This learning progress continues until fortieth match.

After the ANN learns the general pattern, it is ready for the real paper rock scissor game against the research object. The real game means that in this game, the computer will count and record its winning percentage. This winning percentage will be used to measure the effectiveness of the ANN to recognize the behavior pattern of the research object. In the real game, in the first and the second match, the computer still use random choices as there are not any matches before those matches can be used as inputs of the ANN. In the third match, the computer use the choices made in the first and second match as inputs of the ANN and made it produce the prediction of the choices that will be made by the research object. The computer then chooses the choice that beat the prediction. In this real game, the ANN still do its learning progress. It still takes inputs from the choices made by the computer and the research object in two consecutive matches and takes the choices made by the research object in the match right after those two matches as the target output. The purpose in designing the learning progress to still progress even in the real game is to adapt the changes in behavior pattern of the object research during the real game.

The visualization of the learning system is showed on the flowchart in figure 1.

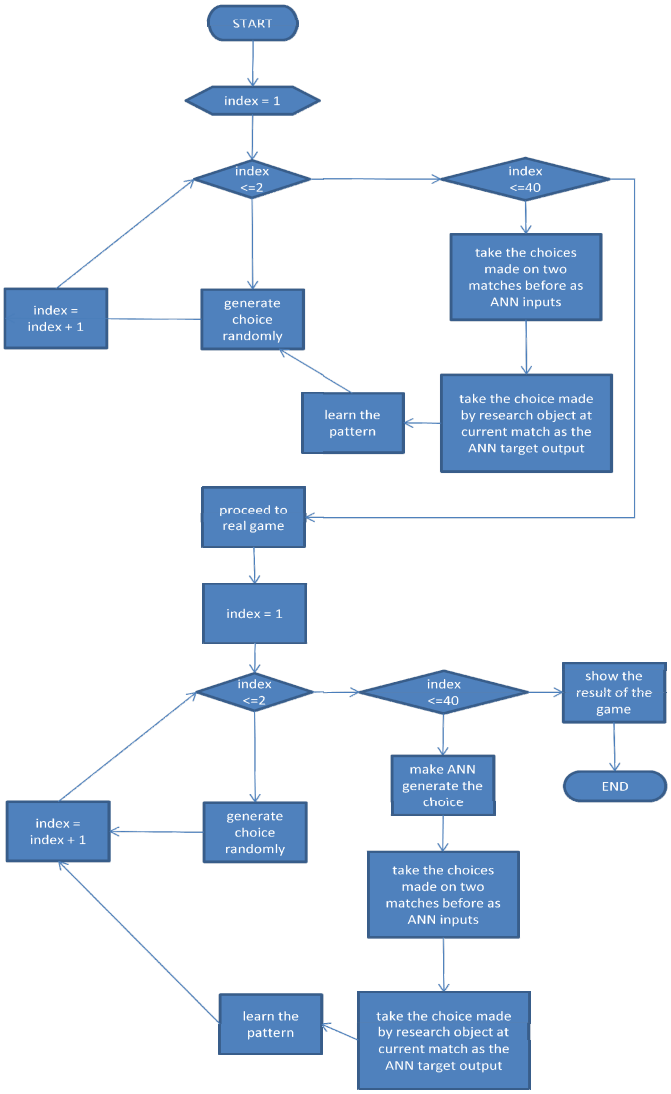

Figure 1. Flowchart of the Learning System

V. IMPLEMENTATION

Before the learning of the ANN is started, the parameters have to be set so that the ANN will perform an optimum result. The parameter will be set with the result of the research done in designing ANN architecture. The parameters will be set in the form which is shown by figure 2.

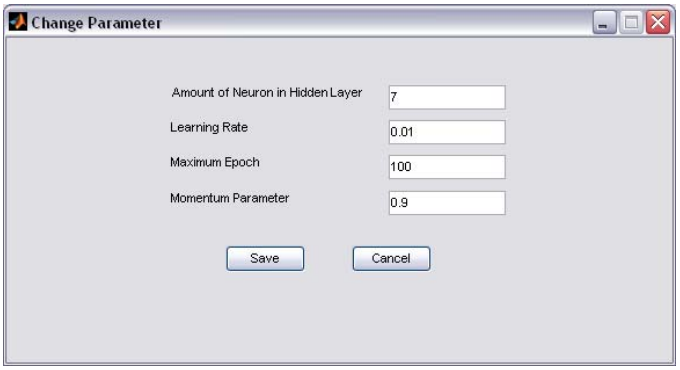

Figure 2. Change Parameter Form

As what has been written before, the first phase in the learning system is to make the ANN learn the general pattern of the research object's behavior. It will be conducted in the form which is shown by figure 3.

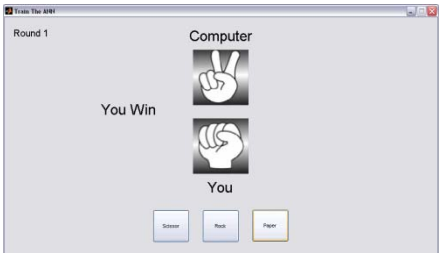

Figure 3. Train The ANN Form

The training of the ANN is done by doing forty round of the paper rock scissor game between research object versus computer. Afterwards, the pattern which is happening during the game is recognized by ANN.

The second phase is to make the computer using the trained ANN to have a real paper rock scissor game. It will be conducted in the form which is shown in figure 4.

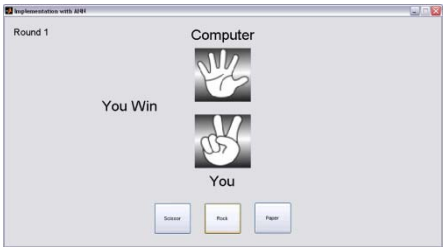

Figure 4. Implementation with ANN Form

For comparison to the winning percentage which is produced during the real game, another game which the computer use random choice for all of the matches in the game is conducted. It will be conducted in the form which is shown in figure 5. The produced winning statistics will then be compared to the winning percentage in the game which uses the ANN to generate choices. The comparison will then be used for drawing conclusion of the research.

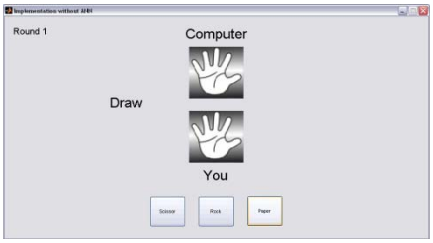

Figure 5. Implementation without ANN Form

The produced winning statistics will then be compared to the winning percentage in the game which uses the ANN to generate choices. The comparison will then be used for drawing conclusion of the research. the comparison can be viewed in the form which is shown in the figure 6.

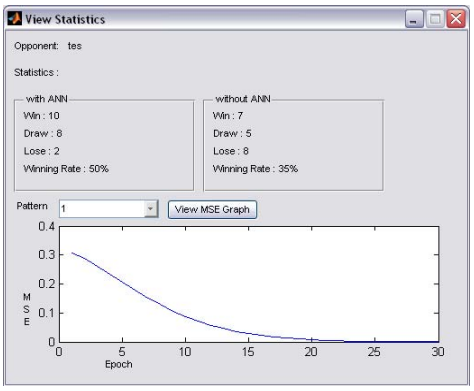

Figure 6. View Statistics Form

The effectiveness of the system to recognize the human behavior pattern is the result of this research. It is calculated from computer winning rate which is obtained from the research. First, the difference between winning rate of the computer which has recognized the behavior pattern of the research object and winning rate of the computer which is not recognize the behavior pattern of the research object is calculated for each user. Afterwards, average value of those differences for all users is calculated. This average value is used as the measure of the effectiveness of the ANN to recognize human behavior in paper rock scissor game in this research.

The winning rates of each user are shown on table 11.

TABLE 4. RESEARCH RESULT

Name	Ages	Sex	Computer Winning Percentage	
			with ANN	without ANN
Hartopo Cenggoro	44	Male	35%	35%
Lisawati Suciatmaja	43	Female	55%	20%
Tjeng Yogi Cenggoro	20	Male	30%	10%

The formula to calculate the average value to measure effectiveness of ANN to recognize human behavior pattern in paper rock scissor game in this research is shown in equation 1:

$$\bar{P} = \frac{\sum P_{ann} - P}{n} \quad (12)$$

Where:

1) $\bar{P}$ = average value of the difference between winning rate of the computer which has recognized the behavior pattern of all research objects and winning rate of the computer which is not recognize the behavior pattern of all research objects.

2) P_{ann} = winning rate of the computer which has recognized the behavior pattern of a certain research object.

3) P = winning rate of the computer which is not recognize the behavior pattern of a certain research object.

4) n = number of the research object.

Then, the average value is:

$$\bar{P} = \frac{(35\% - 35\%) + (55\% - 25\%) + (30\% - 10\%)}{3}$$

$$= 18{,}33\%$$

VI. CONCLUSION

1) Multi-layer feed-forward neural network with backpropagation training algorithm with the architecture of four neurons in input layer, seven neurons in hidden layer, and one neuron in output layer is able to recognize human behavior pattern in paper rock scissor game.

2) In the game between computer versus research object, an increased winning rate of the computer which was using ANN compared with the computer which was not using ANN has been observed. The average of this increased winning rate for all of the research subjects is 18.33%.

VII. SUGGESTION

1) The research following this research should try to use another type of ANN architecture to find whether the change of architecture can improve the effectiveness or not.

2) The research following this research should try to use another variation of backpropagation training algorithm to find whether the change of training algorithm can improve the effectiveness or not.

3) The research following this research should try to use another artificial intelligence method which has learning ability to find if another method can improve the effectiveness.

4) The research following this research should try to use another game with more complex rule to extend the meaning of human behavior pattern which is described in this research.

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