Indonesian Journal of
Tropical and Infectious Disease
Vol. 3. No. 2 April–Juni 2012

Case Report

BRADYCARDIA AND TACHYCARDIA DETECTION SYSTEM WITH ARTIFICIAL NEURAL NETWORK METHOD

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ABSTRACT

Heart disease is one disease with high mortality rate in the world. Based on WHO records from 112 countries at 2004, the rate is 29% of all deaths each year. Medical devices are necessary to diagnose one's health as an indication of a disease. Nowadays, Indonesia still imports medical devices, for the diagnosis of heart failure, from abroad. This research aims to assist the monitoring of cardiac patients with bradycardia and tachycardia appearances of message condition patient's heart rate at the same time. The results were displayed with the output of bradycardia condition of the heart rate (heart rate less than 60 beats per minute) or tachycardia (heart rate over 100 beats per minute). The system displayed the data read from the heart to the PC embedded system to monitor the condition of the patients under decisions based on backpropagation neural network. Classification system could be performed quite well, training data and by testing the 10 pieces, the optimal weight gain was 1727 iteration, the learning rate was 0.1122, and the error was below 0.001 (0.0009997).

Keywords: *Heart Rate, Heart, tachycardia, bradycardia, Backpropagation*

ABSTRAK

Latar Belakang: *Penyakit jantung adalah salah satu penyakit yang memiliki angka kematian tinggi di dunia sebesar 29% kematian global setiap tahun, Perhitungan ini didasarkan pada catatan kematian dari 112 negara pada 2004 dari data WHO (World Health Organization) (Rusciano, 2004). Penggunaan alat medis sangat diperlukan untuk diagnosa kesehatan seseorang sebagai indikasi adanya penyakit. Saat ini Indonesia masih mengimpor alat-alat medis tersebut, termasuk untuk diagnosis gagal jantung.* ***Tujuan:*** *untuk membantu pasien penyakit jantung dalam pemantauan bradikardi dan takikardi dengan tampilan berupa pesan kondisi denyut jantung pasien saat itu.* ***Metode:*** *Hasil yang didapat akan ditampilkan dengan keluaran berupa kondisi denyut jantung yaitu bradikardi (denyut jantung kurang dari 60 kali per menit) atau takikardi (denyut jantung lebih dari 100 kali per menit). Sistem melakukan pembacaan data jantung dari sistem embedded ke PC untuk memonitoring kondisi penderita dengan keputusan berbasis jaringan saraf tiruan backpropagation.* ***Hasil:*** *Sistem dapat melakukan klasifikasi dengan cukup baik, dengan data pelatihan dan pengujian masing-masing 10 buah, memperoleh bobot yang optimal pada iterasi ke 1727, learning rate sebesar 0.1122 dan error di bawah 0.001 (0.0009997)*

Kata Kunci: *Heart Rate, Jantung, Takikardi, Bradikardi, Backpropagation*

INTRODUCTION

Heart is one of the most vital organs. The impaired cardiac function greatly influences other organs, especially kidneys and brains. The main function of heart as a single pump is to pump blood foward the entire body to provide nutrition for the metabolism of the survival cells. Internally, heart is separated into two parts, the right side of the heart functions as a blood pump to the lungs and the left side of the heart pumps blood foward the entire body. At each - there are two halves of the heart chambers of the heart. Blood from each atrium is sent to the ventricles. The blood from the right ventricle flous to the lungs at the pump - lung and blood from the left ventricle flous through the body in the pump. It is still considered normal that heart atrium contracts for approximately six seconds trillionth preceeding the ventricular contraction, allowing ventricular filling before the ventricles pump blood to the lungs and the entire body. The contraction of the heart works automatically and is generated by electrical currents in the form of action potentials or cardiac conduction and controllable cardiac rhythm. Heart has a special system generated in cardiac conduction to the rhythmic electrical impulses which causes a rhythmic contraction of the heart muscle called the heart rhythm. It sendsaction potentials through the heart muscles toword the heart[1]. As cardiac impulse flows the heart, the electrical current will spread into the tissues surrounding the heart and a small portion of the flow will be spreaded to the body surface. Heart is depicted in Figure 1.

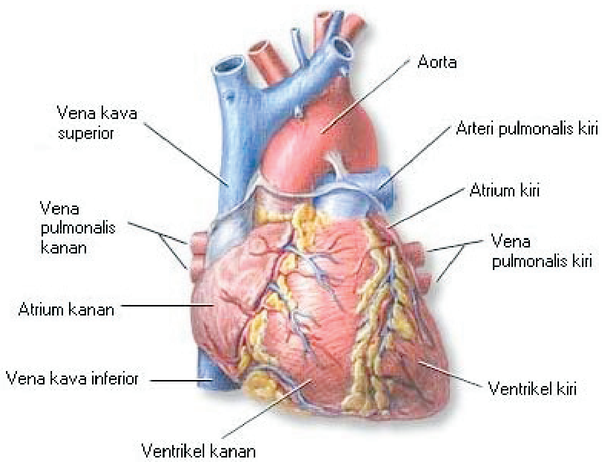

Figure 1. Heart[14]

The direction of the conduction of heart is Sinotrial (SA) node towards Atriventricular (AV) node, then to the bundle of his and branched into the left bundle and the right bundle branches. Left bundle branch's impulses are sent to the left the ventricle, and those of the right bundle branch are sent to the right ventricle. Impulses proceed to the Purkinje fibers and a network of fibers they spread rapidly to the ventricular wall[3]. Cardiac conduction is associated with the amount of heart rate (heart rate) per minute. Heart rate is used as an indication of any abnormalities in the heart. Normal heart rate ranges from 60 to 100 times/min.

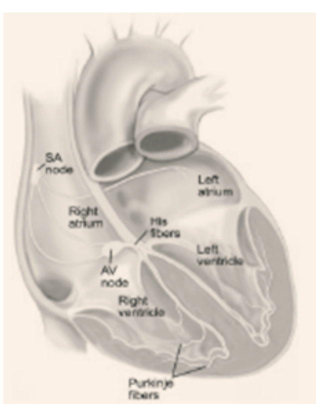

Figure 2. Cardiac Conduction Direction[3]

HEART ABNORMALITIES

Tachycardia

In normal circumstances, the electrical impulses are generated by a pacemaker called SA node. This electrical impulse is passed into the ventricle through an AV node, in which the node will be slowing down the flow of the impulses. The next impulse will spread throughout the ventricles.[2] Fast heart rate, called tachycardia, means that the heart rate exceeds 100 beats per minute. Tachycardia is divided into two main types: supraventricular and ventricular. The emergence of tachycardia is usually indicated by a shortness of breath or wheezing, rapid pulse, chest pain, cold sweat, and uncons ciousness. But in some people, tachycardia does not imply any symptoms.

Bradycardia

Bradycardia or bradyarrhythmias are terms used to indicate the presence of heart rhythm disorders and conduction that causes heart rate to be less than 60 beats/min. The onset of bradycardia is associated with a decrease or failure of impulse formation and of obstacles / interference electrical conductivity. Several causes of bradycardia are as follows:

a. **Barriers SA node**
   This condition is relatively common in the elderly due to the failure of the sinus node impulse to spread to the atrium.
b. **Barriers AV node**
   In this state atrial impulse is blocked in several places on its way into the ventricle.
c. **Bundle Branch Block**
   The disorder is more common nowadays with increasing age in both branches of the left and the right. When encountered individually, these disorders are not dangerous, join what? It could be bad.

DESIGNING THE HARDWARE AND THE SOFTWARE

Designing the Hardware

Hardware design utilizes Arduiono. Arduino is an open-source single-board micro-controller, derived from the wiring platform and designed to facilitate the use of electronics in a variety of fields. The hardware arduino has on Atmel AVR processor while the software arduino has its own programming language

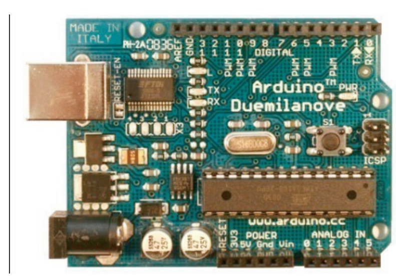

Figure 3. Arduino Board

This study made the hardware detect cardiac abnormalities "Tachycardia" and "bradycardia". These procedures were performed in several stages, namely, preparation of design diagramming tools, hardware design, and software design. The diagram tool is described in Figure 4.

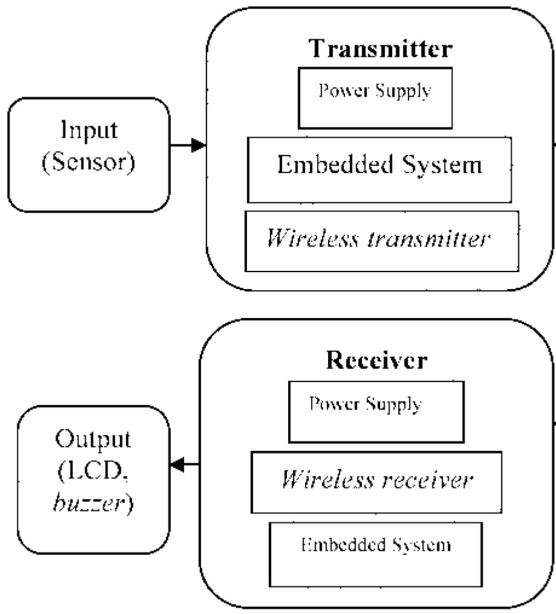

Figure 4. Hardware Diagrams

The explanation to Figure 4: in this study, the design of the sensor used is the Plethysmograph reflection mode as depicted in Figure 5 which depicts the installation of LED and LDR on the finger used as the heart rate detection sensors.

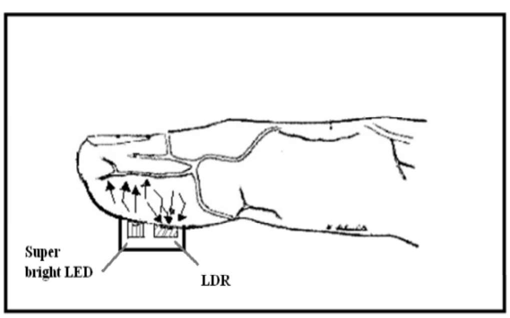

Figure 5. Sensor Plethsymograph.

In this study there are 2 microcontrollers as that functioned for the transmitter and the receiver. The transmitter circuit consisted of a sensor, a power supply, a wireless module and an Arduino Duemilanove. The first work of the transmitter was to detect the heart rate sensors on the fingers and to transmit the data to the wireless module which was enabled as the transmitter controlled by the microcontroller. Receiver circuit consisted of wireless modules that functioned as a receiver that received data from the transmitter and the data of which were processed by a microcontroller to be then displayed on the LCD with an output in the form of heart condition. The software design can be seen in Figure 6.

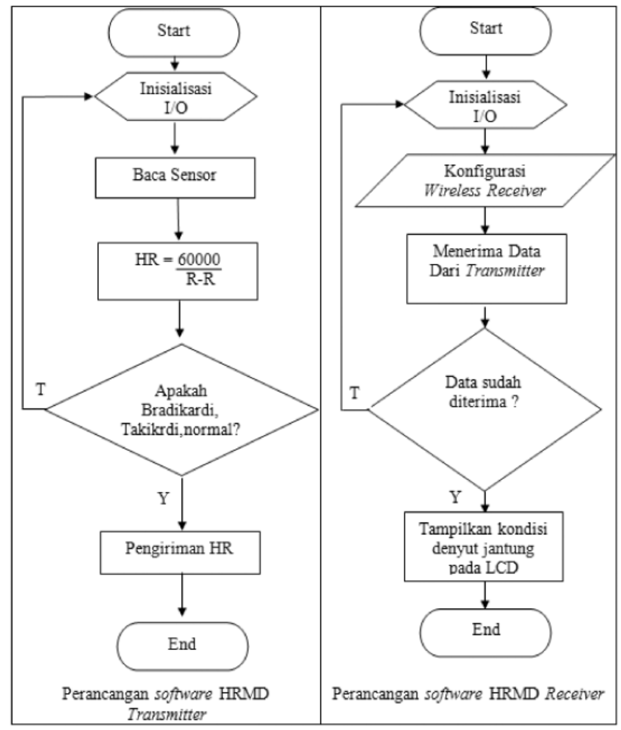

Figure 6. Software Diagrams

Design of Intelligent Network Backpropagation

Artificial neural networks is a system in which the computing architecture and its operation can be inspired from the knowledge of biological nerve cells in the human brain. Neural network is one of the artificial representation of the human brain. To find out more about the origin and how the structure of the neural network is created and can be used as a counter, these will be reviewed briefly by the terms that have generally been used. The structure in Figure 7 is the standard form of the basic units of the human brain tissue that has been simplified. The structure of this standard will change in the future if scientists can find a better standard form or improve the standard form used today. Human brain tissue is composed of 1013 pieces, each neuron is connected by about 1015 pieces of dendrites. The function of dendrites is to transmit signals from neuron to other neurons connected to it. As the output channel, each neuron has axons, while the signal receiver is called synapses.

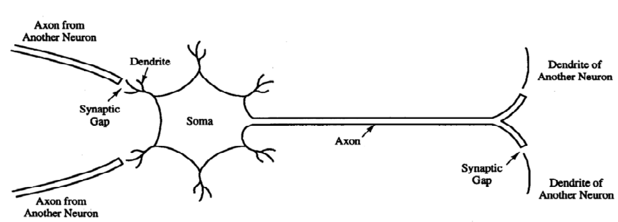

Figure 7. Simple structure a neuron.

In general, neural network is composed of one trillion (even more) neurons that are interconnected and integrated with each other by a trillion synapses so that they can carry out activities to store (memorize) knowledge regularly and continuously as needed.[6] Backpropagation is one of the unsupervised training methods (supervised learning) and is usually designed for operations on multi-layer neural network. According to Rumelhart's backpropagation method that has been applied widely, approximately 90% of backpropagation has been successfully applied in various fields, such as finance, pattern recognition handwriting,

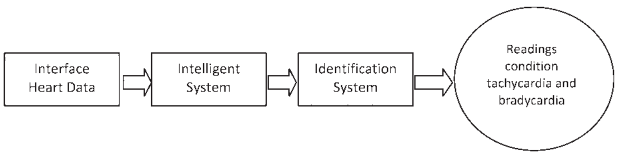

Figure 8. Diagram System

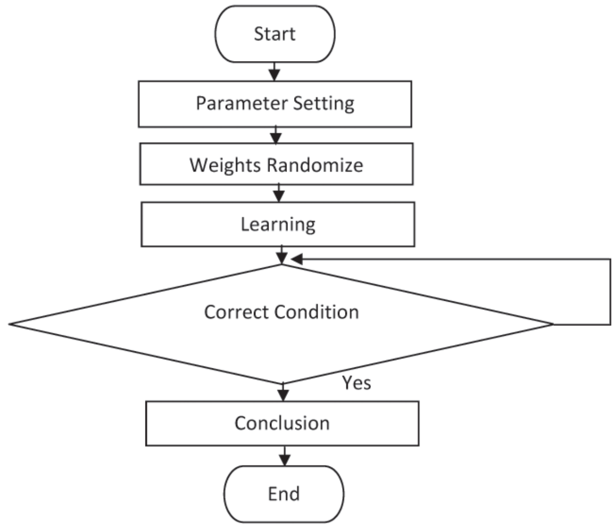

Figure 9. Software Flowchart

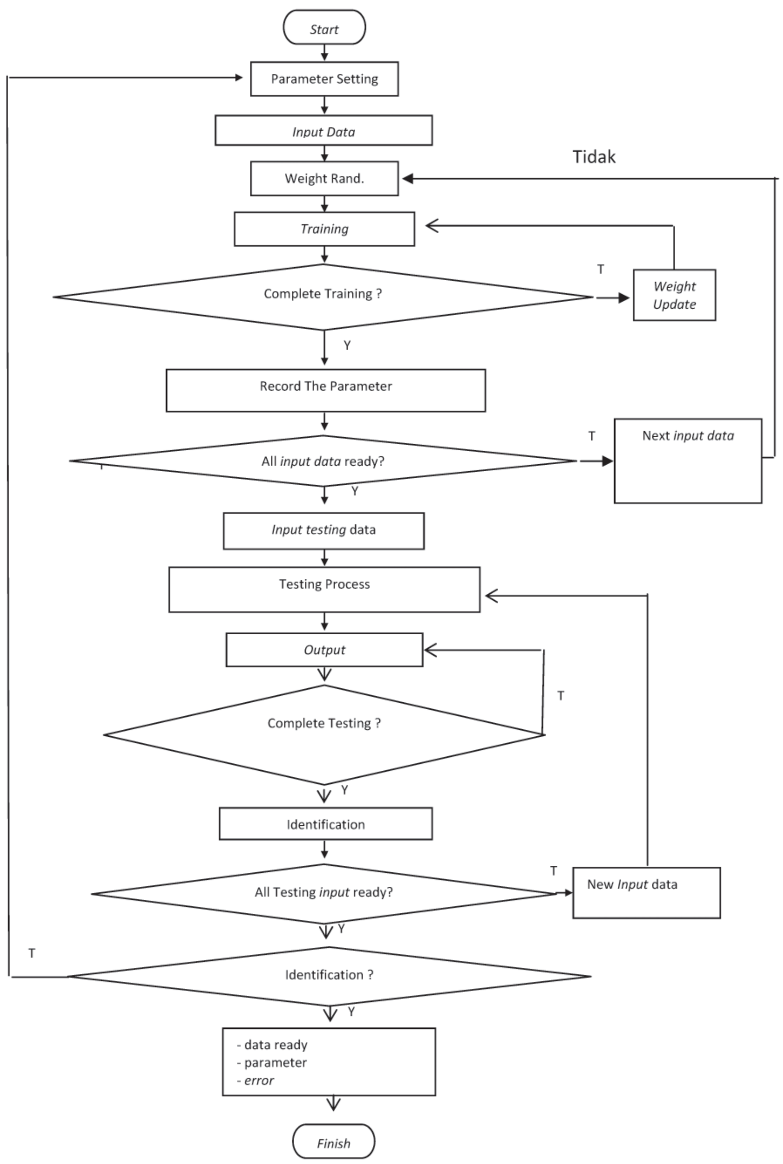

Figure 10. Neural Network Flowchart

voice pattern recognition and medical image processing. This algorithm has a training process that is based on a simple interconnection, for example, if the output gives the wrong result, it will be corrected so that the weight can be reduced and subsequent neural network response could be expected to detect the correct value better. Backpropagation is also capable of transforming and improving the weight of the hidden layer. The system was created as a diagram (Figure 8), the sensor started reading to determine the decision to backpropagation.

Software design cardiac abnormality detection system (bradycardia and tachycardia with a method of Backpropagation Neural Networks). Neural Networks were prepared using 3 pieces of object layers (one input layer, one hidden layer and one output layer). Input layer in a dynamic array was arranged according to the image

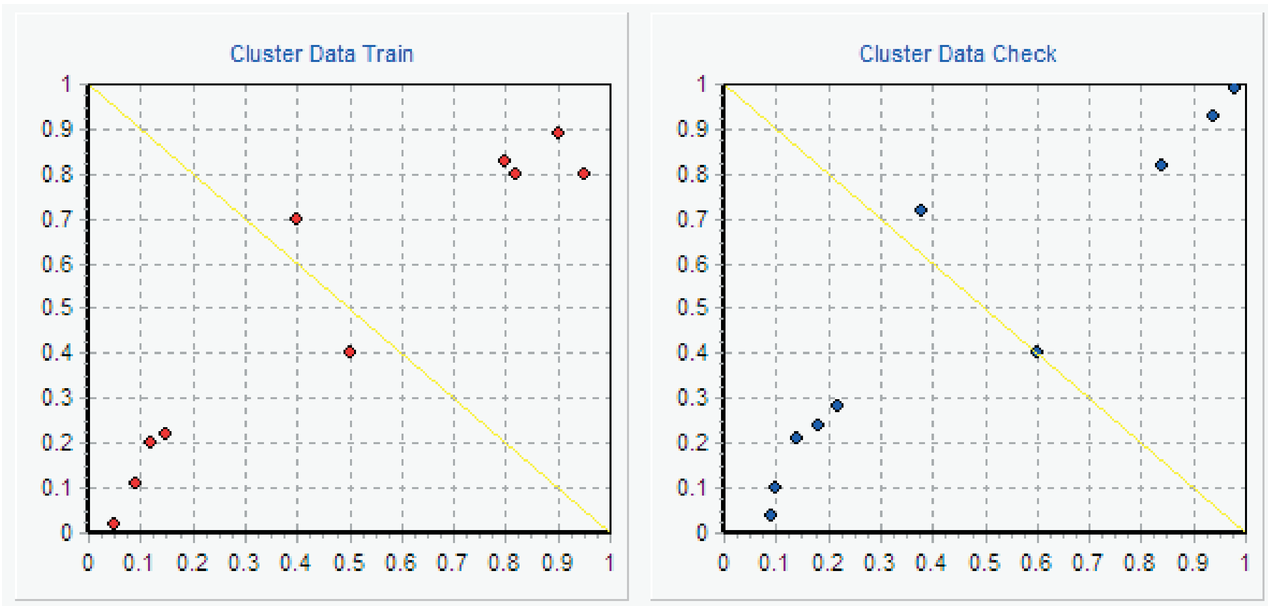

Figure 11. Data Training and Testing
Source: Intelligent System Theory[13]

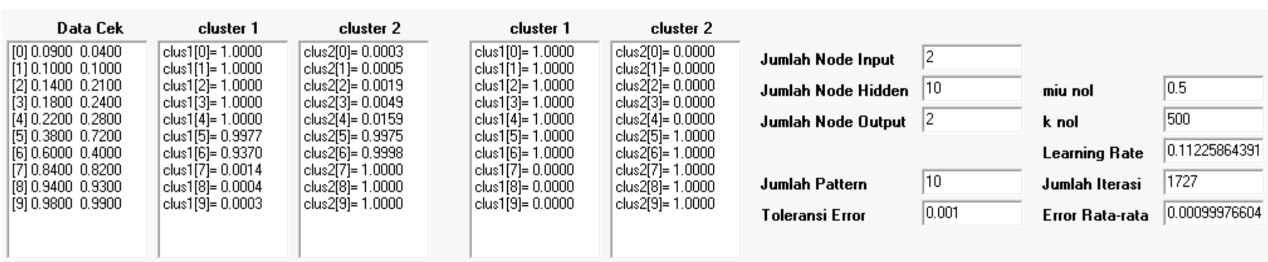

Figure 12. Results Classification of Heart Disease
Source: Intelligent System Theory[13]

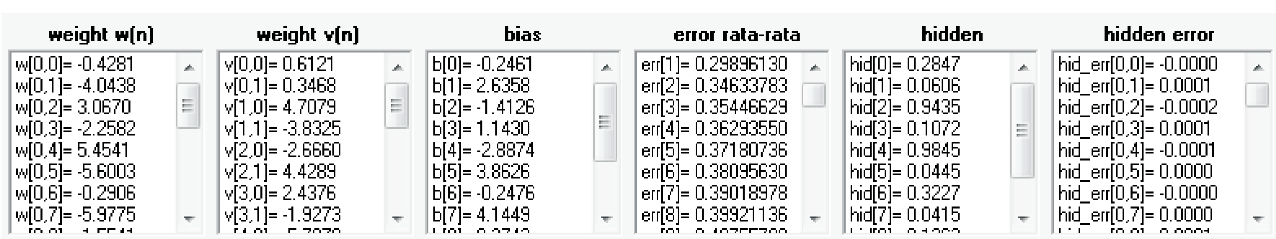

Figure 13. Weight Training Results
Source: Intelligent System Theory[13]

Table 1. Training Data Heart Disease

No	Condition Data		Clasification		Disease
1	0.05	0.02	1	0	Tachycardia
2	0.09	0.11	1	0	Tachycardia
3	0.12	0.2	1	0	Tachycardia
4	0.15	0.22	1	0	Tachycardia
5	0.4	0.7	1	1	Normal
6	0.5	0.4	1	1	Normal
7	0.8	0.83	0	1	Bradycardia
8	0.82	0.8	0	1	Bradycardia
9	0.9	0.89	0	1	Bradycardia
10	0.95	0.8	0	1	Bradycardia

Table 2. Test Data

No	Condition Data		Clasification		Disease
1	0.09	0.04	1	0	Tachycardia
2	0.1	0.1	1	0	Tachycardia
3	0.14	0.21	1	0	Tachycardia
4	0.18	0.24	1	0	Tachycardia
5	0.22	0.28	1	0	Tachycardia
6	0.38	0.72	1	1	Normal
7	0.6	0.4	1	1	Normal
8	0.84	0.82	0	1	Bradycardia
9	0.94	0.93	0	1	Bradycardia
10	0.98	0.99	0	1	Bradycardia

size of the object which roled as an input to the first layer. A number of output nodes were determined based on the number of characters that were supposed to be recognized. The number of nodes in the hidden layer was determined based on the experimental results. The diagram design procedure of Artificial Neural Network method is shown in Figure 9.

Software testing was performed using the type of feedforward Artificial Neural Networks. Artificial Neural Network weights that was going to be used was the value of the weight at the time of learning. Data from the heart to the PC embedded system were compared with the data of the patients who had identified cardiac abnormalities. When the error detection results compared with the data value was less than five percent, the detection result would succeed. The diagram learning procedure and the test methods of Artificial Neural Network are depicted in Figure 10.

RESULTS AND DISCUSSION

Testing of Backpropagation Neural Network

Tests were performed on intelligent systems by observing the system's ability to perform the data clustering. Training data and test data were observed as depicted in Figure 11.

Classification system could perform quite well as depicted in Figure 12, with data such as the training the testing of table 1 and table 2. The system obtained optimal weight by the number of iterations of 1727 patterns 10 pieces of data, learning rate of 0.1122 and the error below 0.001 (0.0009997)

Weight training results were stored in the memory and then were used during testing with different data. Table 1 shows the training data and Table 2 shows the test data.

Discussion

The testing of the data above indicated that the system could work as expected that it could classify patients into normal or diseased conditions by the type of tachycardia or bradycardia.

CONCLUSION

Classification system could be performed quite well as depicted in Figure 13, with data such as the training and the testing of table 1 and table 2. The system obtained optimal weight by the number of iterations of 1727 patterns 10 pieces of data, learning rate of 0.1122 and the error below 0.001 (0.0009997).

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