Prototype Early Warning System for Heart Disease Detection Using Android Application

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***Abstract*— Heart Disease affects approximately 70 million people worldwide where most people do not even know the symptoms. This research examines the prototype of early warning system for heart disease by android application. It aims to facilitate users to early detect heart disease which can be used independently. To build the application in android phone, variable centered intelligence rule system (VCIRS) as decision makers and pulse sensor - Arduino as heart rate detector were applied in this study. Moreover, in Arduino, the heart rate will become an input for symptoms in Android Application. The output of this system is the conclusion statement of users diagnosed with either coronary heart disease, hypertension heart disease, rheumatic heart disease or do not get any kind of heart disease. The result of diagnosis followed by analysis of the value of usage variable rate (VUR) rule usage rate (RUR) and node usage rate (NUR) that shows the value of the rule that will increase when the symptoms frequently appear. This application was compared with the medical analysis from 35 cases of heart disease and it showed concordance between diagnosis from android application and expert diagnosis of the doctors.**

I. Introduction

According to statistic of world health organization (WHO), Heart disease is the number one causes of deaths worldwide in 2011. Heart disease caused 7 million deaths in 2011 [1]. The projected increases in the importance of heart disease worldwide are related because bad life style and non periodic health check. Early warning systems to detect heart disease that support mobility of human is needed so that it can be used anywhere and anytime.

Expert systems are computer programs that imitate the reasoning an expert with expertise in a particular area of knowledge. Variable centered intelligent rule systems (VCIRS) is one method that the expert system has an advantage in data repair system. If an error occurs or data development, data updates can be done without having to create a system from scratch [2].

Previous studies discuss diagnosis a of acute coronary heart disease (ACHD) using experts' tacit knowledge into personal computer [4]. However, with the increasing mobility of people, the use of computers become inflexible.

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This research intends to develop an expert system that is connected to heart rate detector which is a combination of a pulse sensor- arduino ADK and android phones. In this research, a prototype of early warning system for heart disease using android mobile phone was successfully build. Furthermore, this prototype can facilitate users to detect heart disease early and independently.

II. Research Methodology

Focusing on developing android application to diagnosis heart disease, this research began with making questionnaire symptoms that arise from a disease that would be basic knowledge for diagnosing heart disease. These data obtained from existing literature and interviews to one doctor. After making the questionnaire we consulted cardiologist about their suggestion for further diagnostic indicators and the scale of the symptoms. The suggestion from cardiologist would be used as variables. Variable centered intelligent rule systems in this research used as main method to diagnosis analysis in android application.

A. Development of the questionnaire

Heart disease is divided into several parts, this research focused on 3 types of heart diseases as following:

- coronary heart disease
- hypertensive heart disease
- rheumatic heart disease

The determination of the symptoms of the disease was done by discussing with one doctors based on existing literature. The information from this discussion would be the basis for the information as the first draft of a comprehensive set of the diagnostic indicators to consider. We consulted to cardiologist about this draft questionnaire, asking their suggestion about the probability of each symptoms for each kind of heart disease.

B. Specification of variables

Based on the questionnaire that given to cardiologist, this system had 29 variables that taken from 29 symptoms of heart disease that can be seen in table 1. Every symptoms had certainty factors that would be used as a sequence in variable.

Table 1. The symptoms of heart diseases.

Id	Symptoms
1	Pain in the chest like a hot depressed, radiating to the left arm and then followed by a cold sweat
2	Obesity with characterized by abdominal circumference more than 80 cm for women and 90 cm for men and BMI (Body Mass Index) greater than 25
3	Having a low HDL, high LDL and high triglycerides.
4	heavy smokers (more than 20 cigarettes / day).
5	Have a history of diabetes mellitus.
6	has a history of Cholesterol

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Id	Symptoms
7	Always consumption of fatty foods
8	Rarely do sport
9	Have blood pressure over 140/70 mm Hg and in long time.
10	Swelling (edema) in the legs or abdomen
11	Feel palpitations (pounding), accompanied by a cold sweat.
12	Feeling dizzy
13	Feel fatigue when on the move, and stiffness in the head and neck.
14	Experiencing blurred vision suddenly that can not be overcome by the use of glasses, this issue is caused by bleeding in the retina
15	Experiencing shortness of breath while walking less than 100 meters
16	Experience shortness of breath when lying down and had to use a body buffer (pillow) to eliminate the shortness of breath
17	Unstable emotional
18	Fever with pharyngitis and streptococcal
19	Heart rate greater than 100 (tachycardia) but not febrile
20	Dilation of veins in the neck of patients that can be felt when palpated when the patient is lying with buffer (a pillow).
21	Erythema marginatum occurs that lasts for weeks or even months, no pain and no itch
22	Experienced polyarthritis and increased 12-24 hours followed inflammatory reaction
23	Got Chorea more than 2-6 month.
24	There are Subcutaneous nodules with a width of about 0.5-2 cm round and painless when in the press.
25	*Pulse Deficit*
26	Often experienced the symptoms of pain in the heart at about 4:00 a.m. to 10:00 a.m
27	More than 50 years old and a man
28	A woman and has entered into the postmenopausal stage
29	Aged less than 15 years

C. Variable centered intelligent rules Systems

This research using expert system variable centered intelligent rule systems (VCIRS). Analysis of the value offered by VCIRS based on the data entered by the user and the information stored in the variable centered rule structure. There are three types of usage degree. First, variable usage rate (VUR) is used to measure the usefulness of a variable in the node that is being and has been used. Second, node usage rate (NUR) to measure the usefulness of a node in the execution. Third, rule usage rate (RUR), which measures the usefulness of a rule on execution. These are the formula:

$VUR_i = Credit_i x\ NS_i\ x\ (VO_i / TV)$ [2]

$NUR = \frac{\sum_{i=1}^{I} VUR_i}{N_j}$, $RUR = \frac{\sum_{i=1}^{I} VUR_i}{N_k}$ [2]

Where:

Crediti = occurrence of the variable i in the Node Structure

Nj = Number of nodes

Nk = number of rule

NSi = number of nodes (sharing) the variable i

VOI = sequence of variable i in a node

TV = total variable owned by a node

In VCIRS method there are two core parts are highly variable and determines that Rule. Variable derived from the data are significant in future decision making. While the rule is part of the highest combination of Node and this node is formed from a combination of several variables. In this research there are 29 variables were taken from the 29 symptoms of heart disease.

The process of formation of the rule as follows :

1. Determine the symptoms from the cardiologist by checking the symptom from questionnaire.
2. Determine the value of CF (Certainty Factor) of each symptom for each disease.
3. Compare the value of CF from each disease to determine the –highest order

D. Overview and diagram system

When the user activates the application of the detection system at the heart of the phone, then it will be activating pulse sensor, the sensor detects the heart rate of the user by placing a finger on the pulse sensors or in the ear, then the result of heart rate detection is read by the pulse sensor. Because pulse sensor read analog signal, arduino ADK translated the heart rate detection into digital signal and send the data to android phone. After this process, the user is required to insert the clinical symptoms that they felt. After inputting the symptoms the diagnosed of coronary heart disease or hypertension heart disease or rheumatic heart disease or do not get any kind of heart disease are showed. The result followed by analysis of the value of usage variable rate (VUR), rule usage rate (RUR) and node usage rate (NUR) that shows the value of the rule that will increase when the symptoms frequently used. At the other hand, the result of heart disease on the phone screen will be easy to understand and will not accompanied by VCIRS value analysis methods. The diagram system can be seen on figure 1 below.

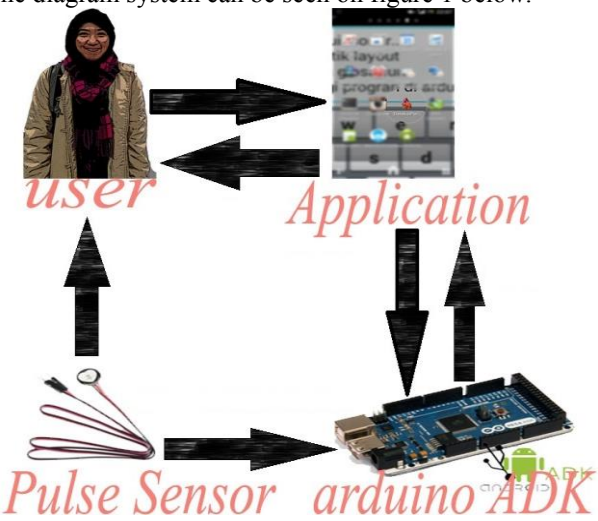

Figure 1. Diagram system of prototype early waning systems of heart disease using android phone.

This research integrated the variable centered intelligent rule system analysis and pulse sensor that used for detecting user heart rate by detecting the heart rate, user would be able to know that his/ her heart rate is either normal (60-100 BPM) or tachycardia (heart beats an average of greater than 100 BPM), or bradycardia (heart rate has averaged less than 60 BPM.

In android application there are the other menus that user can choose such as BMI menu. This menu can be used for detecting user body mass index. The other menu are glossary menu and tips menu. Glossary menu containt some difficult words in the form of symptoms and tips menu containt several tips to prevent heart disease. State diagram of the application in this research can be seen on figure 2.

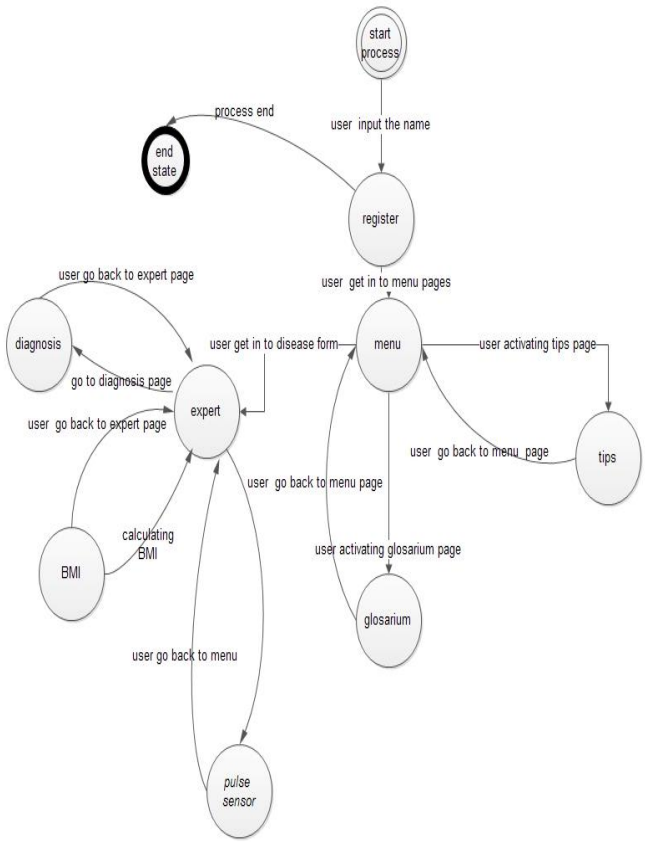

Figure 2. State diagram of system.

III. RESULT AND DISCUSSION

A. Comparison of application with manual checking

Testing was done by selecting the question of disease symptoms on diagnosis menu by the user. By way of giving a check in the checkbox of each question and then application compare the results with the design of an expert system rule. In the example for this research, user chose some symptoms that user felt. In this case, the user enter the id of the eight symptoms with symptoms with a value of 1, 2, 3, 4, 5, 6, 7, and 8, Id symptoms do not appear because the user does not need to know it at the time of diagnosis. Selected symptoms will add the value of the credit to the database table option. Credit value which shows the rule increases the symptoms most often felt by people with heart. In addition, many symptoms that can be clicked to accumulate the total value of selected symptoms, so that when the user completes the form filling symptoms characterized by emphasizing the "results" will exit with the value of disease diagnosis VUR, RUR and its NUR which are characteristic of the method VCIRS. If we draft rule for this system are expressed in the form of if-then as below:

if
Pain in the chest feel like heat depressed, radiating to the left arm and then followed by a cold sweat
yes
if
Obesity is characterized by abdominal circumference more than 80 cm for women and 90 cm for men and BMI (Body Mass Index) greater than 25
yes
if
Having a low HDL, high LDL and high triglycerides.
yes
If
Heavy smokers (more than 20 cigarettes / day)
yes
If
Having a history of diabetes mellitus
yes
If
Having a history of Cholesterol disease
yes
If
Frequent consumption of fatty foods
yes
If
Rarely doing sports.
yes
then
Coronary Heart Disease

We can conclude that the diagnosis is made the user with the system complies with the design rule manual. Based on the statement that the data obtained in the form of a variable number of rules of Coronary Heart.

B. Analysis to get value from VUR (variable usage rate), NUR (node usage rate) and RUR (rule usage rate)

The sequence of each variable according to the value of the Certainty Factor symptoms such symptoms . Overall the data from the rule of coronary heart disease in the form of tables can be seen in the table below.

Table 2. Rule Data of Coronary Heart Disease .

Variable ID	Variable	Variable Order	Credit	NumOfNodeID	Total Variable
1	Pain in the chest	1	1	1	8
2	Obesity	2	1	1	8
3	High fat-profile	3	1	1	8
4	Smokers	4	1	1	8
5	Diabetes mellitus	5	1	1	8
6	Cholesterol Disease	6	1	1	8
7	Consumption fatty food	7	1	1	8
8	Rarely doing sport	8	1	1	8

The analysis value of VUR (Variable Usage Rate of 8 symptoms) for coronary heart disease can be seen below :

$$VUR = credit_i \; x \; Weight_i$$

$$VUR = Credit \; x \; (NumofNodeId \; x \frac{Variabel \; Order}{Total \; Variabel})$$

The first time use:

VUR of variable chest pain

$$VUR = Credit \; x \; (NumofNodeId \; x \frac{Variabel \; Order}{Total \; Variabel})$$

$$VUR = 1\ x\ (1x\frac{1}{8})$$
= 0.125
*one example to get VUR for coronary heart Disease
NUR (Node Usage Rate) of Coronary Heart Disease
$$NUR = \frac{\sum VUR}{Nj}$$
$$= \frac{\sum 0.125+0.25+0.375+0.5+0625+0.75+0.875+1}{8}$$
$$= \frac{4.5}{8} = 0.5625$$
RUR (Rule Usage Rate) of the system Heart Disease
$$RUR = \frac{\sum NUR}{Nk}$$
$$= \frac{\sum 0.5625}{1}$$
=0.5625

C. Comparison result diagnosis android application with doctor

This Experiment compared the diagnosis of the disease by using an VCIRS expert system and diagnosis by 14 expert physicians. The combinations of symptoms were 35 cases based on the patient's medical record. The meaning of number on table 3 symptoms refered to symptoms that taken on table 1.

Table 3. Comparison diagnosis doctor and system.

id	Symptoms	Doctor 's Diagnosis	System's Diagnosis	Conclusions
1	1,2,3,4,5,6,78	Coronary HD	Coronary HD	Right
2	18,19,20,21,22,23, 24,29	Rheumatic HD	Rheumatic HD	Right
3	1,2,3,4,5,6,7,8,27	Coronary HD	Coronary HD	Right
4	1,8,22,24,29	Rheumatic HD	Rheumatic HD	Right
5	17,18,21,22,23,24, 29	Rheumatic HD	Rheumatic HD	Right
6	7,8,18,21,22,24,29	Rheumatic HD	Rheumatic HD	Right
7	1,2,3,4,5,6,7,8,9,2 7	Coronary HD	Coronary HD	Right
8	1,2,3,6,7,8,9,11,28	Coronary HD	Coronary HD	Right
9	1,2,3,5,6,78,28	Coronary HD	Coronary HD	Right
10	9,10,11,12,13,14,1 5,16,20,27	Hypertension HD	Hypertension HD	Right
11	9,10,13,27	Hypertension HD	Hypertension HD	Right
12	9,10,13,27	Hypertension HD	Hypertension HD	Right
13	9,11,12,13,14,28	Hypertension HD	Hypertension HD	Right
14	1,3,6,7,8	Coronary HD	Coronary HD	Right
15	1,3,4,6,7,8,27	Coronary HD	Coronary HD	Right
16	1,4,6	Coronary HD	Coronary HD	Right
17	18,21,22,24	Rheumatic HD	Rheumatic HD	Right
18	1,3,5,6,8,28	Coronary HD	Coronary HD	Right
19	19,22,24,29	Rheumatic HD	Rheumatic HD	Right
20	2,4,8,9,11,13	Hypertension HD	Hypertension HD	Right
21	1,3,6,7,8,27	Coronary HD	Coronary HD	Right
22	9,10,11,12,13,15,1 6,20,26	Hypertension HD	Hypertension HD	Right
23	5,8,9,14,15,16,20, 27	Hypertension HD	Hypertension HD	Right
24	1,3,4,5,8,9	Coronary HD	Coronary HD	Right
25	1,3,5,8,9,19,25,27	Coronary HD	Coronary HD	Right
27	8,913,14	Hypertension HD	Hypertension HD	Right
28	2,3,4,7,9,15	Coronary HD	Coronary HD	Right
29	1,2,3,4,6,9,27	Coronary HD	Coronary HD	Right
30	18,23,29	Rheumatic HD	Rheumatic HD	Right
31	2,3,8	No	No	Did not get heart Disease
32	3,15,17,27	No	No	Did not get heart Disease
33	8,9,19,26,	No	No	Did not get heart Disease
34	8,13,28	No	No	Did not get heart Disease
35	2,3,8,20	No	No	Did not get heart Disease

From 35 cases were tested and compared, all diagnosis have concordance between diagnosis this research system and doctor diagnosis. This shows that the expert system has been successfully made in diagnosing diseases.

IV. CONCLUSION

Based on the results of testing and analysis that has been done on this research it can be concluded that the result by application and manual checking have same result. The value analysis of VUR, RUR, NUR shows the amount of the value of each node, and the rule variable that will continue to grow if selected by the user. However the value of VUR, RUR, NUR does not affect the outcome of diagnosis. The expert system is designed by using the method of diagnosis VCRIS able to provide the same results with the results of the doctor's diagnosis.

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