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Computational Intelligence Method for Early Diagnosis Dengue Haemorrhagic Fever Using Fuzzy on Mobile Device

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Abstract. Mortality from Dengue Haemorrhagic Fever (DHF) is still increasing in Indonesia particularly in Jakarta. Diagnosis of the dengue shall be made as early as possible so that first aid can be given in expectation of decreasing death risk. The Study will be conducted by developing expert system based on Computational Intelligence Method. On the first year, study will use the Fuzzy Inference System (FIS) Method to diagnose Dengue Haemorrhagic Fever particularly in Mobile Device consist of smart phone. Expert system application which particularly using fuzzy system can be applied in mobile device and it is useful to make early diagnosis of Dengue Haemorrhagic Fever that produce outcome faster than laboratory test. The evaluation of this application is conducted by performing accuracy test before and after validation using data of patient who has the Dengue Haemorrhagic Fever. This expert system application is easy, convenient, and practical to use, also capable of making the early diagnosis of Dengue Haemorraghic to avoid mortality in the first stage. Key Word: Dengue Haemorrhagic Fever, Diagnosis, Computational Intelligence, Fuzzy Inference System, Mobile Device.

1 Introduction

Health is a priceless treasure, so we are willing to do everything to maintain physical health. Anyone may face health problems, regardless of age, sex, and profession.

Deaths due to dengue hemorrhagic fever (DHF) in Jakarta are still high. Active surveillance of hospital reports Jakarta Health Agency of 2004, a 20 643 dengue cases with 91 deaths soul or case fatality rate (CFR) of 0.44%. Dengue deaths in Jakarta are quite high compared dengue deaths were reported in the world Organization World Health (WHO) 2000 CFR of 0.16%. Deaths due to many factors, among others, due to late diagnosis'[4].

Dengue Hemorrhagic Fever (DHF) is one of health problems that affect productivity of each person in fact possibly end in death. Dengue Haemorrhagic Fever symptoms have been identified by common people based on the general known physical characteristic without supported by other medical fact or medical consideration. (Unfortunately, some other disease has the symptoms that sometimes resemble those of Dengue Haemorrahagic Fever so that the patient possibly is misdiagnosed). Consequently, the patient is treated in the wrong way and do not recover. The laboratory test can be performed to get a better diagnosis but this way is relative expensive and take longer time to know the results, besides the adequate laboratory does not exist in every area in Indonesia.

A best way is to consult an expert or specialist doctor. Although at the present there are many experts or specialist doctor, the obstacles still there impede patient to get proper treatment, that are the limited visiting hour and the medical treatment centre is not easy or near to reach so that many patient waiting in queue whereas they have to be treated promptly. In this situation, the common people as users need an expert who can facilitate them to get early diagnosis to get promptly treatment in first stage. One way to solve the problem is make a tool that can take a role as an expert who is capable of making accurate diagnose and that can be run on mobile platforms.

Mobile technology development increase rapidly, both software and hardware. This condition facilitates the public, especially mobile or smart phone users to obtain any information at any time and any place with fast and practical way [1]. Expert system is one branch of artificial intelligence that studies how to adopt the way an expert thought and their logic in solving a problem, and make a decision or conclusion based on a number of facts. The basis of expert systems is how to transfer the knowledge possessed by an expert into a computer, and how to make decisions or draw conclusions based on that knowledge [5].

Method of expert systems such as the fuzzy logic system has advantages than other methods of expert system such as artificial neural networks. Fuzzy logic system can tolerate inaccurate data, able to model a very complex nonlinear function and can establish and apply the experiences of experts directly without having to go through the training process.

2 Methodologies

The following is scope of the study:

- Designing, manufacturing, and testing expert system applications that can help diagnose dengue fever through Android-based mobile devices with Sugeno fuzzy inference method based on four main symptoms, namely: fever, skin rush, spontaneous haemorraghing and tourniquet test.
- Design and manufacture of web-based administration system, as a means to exercise control and supervision of mobile-based applications.

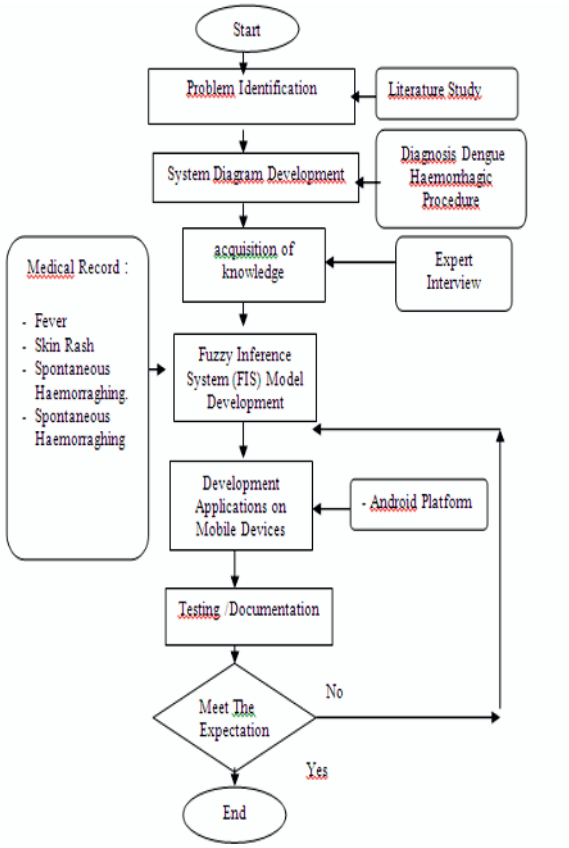

Fig.1. Methodologies

3 Design

Users run applications that have a diagnosis of dengue fever in the mobile phone Android operating system. Then the user has to answer some questions provided by the application to obtain data that will be processed. Once collected answers are entered then the application will proceed to diagnose whether the user is suffering from dengue fever or not. Users can also update the application in order to continue receiving the latest knowledge for further development. Users also perform data transmission diagnosis.

4 Input

The input is the answers given by the application user to the questions. Further answers will be treated to manage all of its value in accordance with the membership function so that the value becomes a fuzzy value. There are three membership functions contained in the application of each criterion. Then after getting the value of each fuzzy membership function of each category, the value is incorporated into the rules (rules) that exist [2].

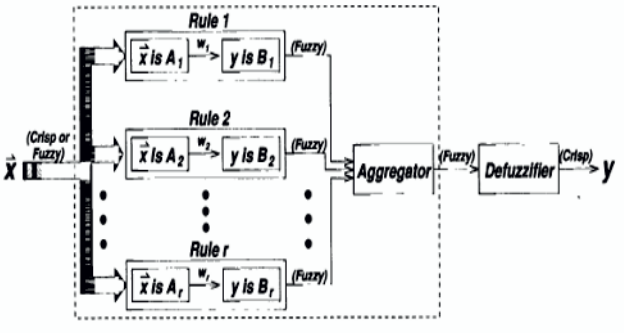

Fig.2. Fuzzy Inference System

5 Data Structure

Data structure is a fuzzy set. Data are differentiated based on the criteria and parameters [3]. Criteria were clinical symptoms of dengue fever including fever, skin rash, spontaneous bleeding, and tourniquet test. Clinical criteria identified as fuzzy data. Each criterion is represented in the membership reflects the membership function (mf). The employed membership function form S curve and Gauss curve. Membership function value of each clinical symptom is obtained based on interviews with experts.

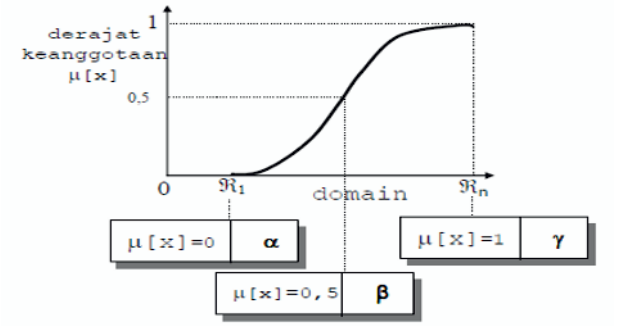

Fig.3. Membership function S Curve

$$S(x;\alpha,\beta,\gamma)=\begin{cases}0 & \rightarrow \quad x\le\alpha\\ 2((x-\alpha)/(\gamma-\alpha))^2 & \rightarrow \quad \alpha\le x\le\beta\\ 1-2((\gamma-x)/(\gamma-\alpha))^2 & \rightarrow \quad \beta\le x\le\gamma\\ 1 & \rightarrow \quad x\ge\gamma\end{cases} \tag{1}$$

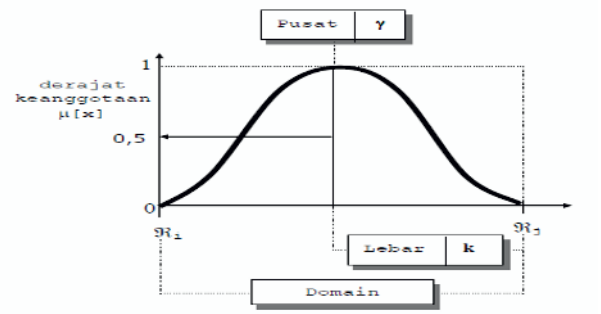

Fig.4. Membership function Gauss Curve

$$\mu[x] = e^{-\frac{(x-c)^2}{2s^2}} \quad (2)$$

Whereas:

μ = Membership Degree

5.1 Fever

There are three parameter of fever namely low, average, and high. The fever level is evaluated based on human body temperatur [5]. The temperature measurement is between 36°C-42°C. The body is considered suffering from fever if its temperature is 37°C or higher. The fever fuzzy score based on body temperature measurement shall be as follow:

Table 1. The Fever Fuzzy Score

Fever	Score	Measurement
Low	36,0 – 37,3	Body temperature between 36,0 – 37,3 ºC
Average	36,5 – 38,5	Body temperature between 36,5 – 38,5 ºC
High	38,0 – 42,0	Body temperature between 38,0 – 42,0 ºC

Membership function of Gaussian Fever type is ilustrated as follow:

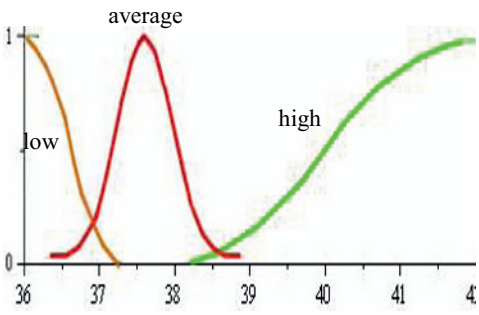

Fig.5. Membership Function Gaussian Fever

5.2 Skin Rash

There are three parameter of skin rash namely a few, moderate, and many. Evaluation of the skin rash is determined based on the amount of petekia (small skin rash) per circle with diameter 2.8 cm on the arm, chest or face [5]. The petekia measurement result will be scored between 0.00 – 1.00. The level of skin rash is determined based on score as follow:

Table 2. The Skin Rash Fuzzy Score

Skin Rash	Score	Measurement
A few	0,00 – 0,40	The amount of petekia < 3 per circle diameter 2,8 cm
Moderate	0,25 – 0,75	The amount of petekia 3-5 per circle diameter 2,8 cm
Many	0,60 – 1,00	The amount of petekia > 5 per cicle diameter 2,8 cm

The following is illustrated membership function of skin rash Gaussian type:

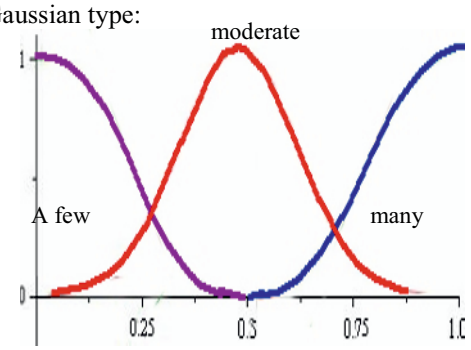

Fig.6. Membership Function of Skin Rash Gaussian

5.3 Spontaneous Haemorraghing

There Are three parameter of spontaneous haemorraghing namely indistinct, distinct, and very distinct. The evaluation of spontaneous haemorraghing level based on a haemorrhage occurred inside nose, gum, melena, and hematemesis [4]. The result of spontaneous haemorrhage will be score 0.00 – 1.00. The level of spontaneous haemorrhage is determined based on score as follow:

Table 3. The Haemorrhage *Fuzzy* Score

Haemorrhage	Score	Measurement
Indistinct	0,00 – 0,40	The patient have a slight haemorrhage (occur for less than 10 minutes) in the nose or gum.
Distinct	0,25 – 0,75	The patient have a lot of haemorrhage (occur for 10 minutes or longer).
Very Distinct	0,60 – 1,00	The patient undergo hematemesis (vomitting blood) or melena (passaging black tarry stool)

Haemorrhaging Membership Function Gaussian type is illustrated as follow :

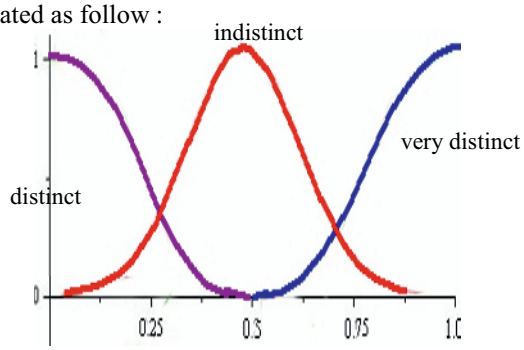

Fig.7. Haemorrhaging Membership Function Gaussian

5.4 Torniquet Test

There are three parameter of torniquet namely negative, indicisive, and positive. The evaluation of torniquet test level is determined by amount of petikia that observed per circle with diameter of on fossa cubiti [5]. The counting result of petekia will be scored between 0.00 – 1.00. The torniquet level will be determined based on score as follow :

Table 4. Fuzzy Score Of Torniquet Test

Torniquet	Score	Measurement
Negative	0,00 – 0,40	The amount of petekia per circle with diameter 2,8 on fossa cubiti < 3
Insicive	0,25 – 0,75	The amount of petekia per circle with diameter 2,8 on fossa cubiti : 3-5.
Positive	0,60 – 1,00	The amount of petekia per circle with diameter 2,8 on fossa cubiti > 5

The torniquet membership function Gausian type is illustrated as follow :

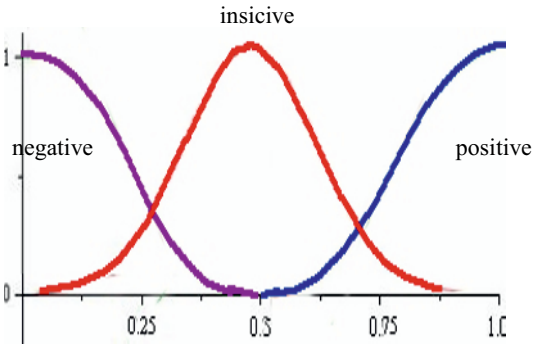

Fig.8. *Membership Function* Uji *Torniquet* Tipe *Gaussian*

6 Rule Base

Rule base employed in making this application used the rules of fuzzy IF THEN rules. Rules are made based on expert opinion and research. There are four criteria, each of which consists of three parameters so that the number of rules that will form as much as 81 rules.
Common form of rule base [3]:

If x is A then y is B (3)

7 Defuzzification Method

This research used the weighted average method as Defuzzification method. In weighted average method, each membership function is formed multiplied by the result of a rule that exists and everything added up, then the value is divided by the sum of all the membership function [3].
Sugeno defuzzification Weight Average *(WA)* :

$$WA = \frac{\alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \ldots + \alpha_n z_n}{\alpha_1 + \alpha_2 + \alpha_3 + \ldots + \alpha_n} \quad (4)$$

Whereas:

α = fire strength

8 Output

The result of diagnose is membership function from range 90 up to 91. The score included in this range will be evaluated and lead to the resume opstions namely infected by DHF or not infected. Range of score will be classified into three categories:

Table 5. Result of Diagnose

Output	Range of Score
You are not infected by DHF	90.0 - 90.4
There is slight possibility that you are infected by DHF. You need to visit your doctor to have medical examination.	More than 90.4 up to less than 90.6.
There is high possibility that you are infected by DHF.	90.6 – 91.0

9 Implementation

This program can be run with minimal configuration of mobile devices:

- Android operating system, version 2.2 (Froyo).

- CPU: 800 MHz ARM 11 processor, Adreno 200 GPU, Qualcomm MSM7227 chipset, 2G GSM Network 850 / 900 / 1800 / 1900, 3G HSDPA 900 / 2100, 320 x 480 pixels of resolution, and internal memory of 158 MB.

10 Evaluation

Testing program carried out by testing the accuracy using data of patients who contracted Dengue Hemorrhagic Fever (DHF). Data of patients who tested consisted of 28 data has not been validated and the data that has been validated 20. Check the accuracy of data validation is under special conditions. In this special condition is the rule (rule base) obtained from experts. Validation is done by examining the consistency of the data to the rule. According to expert opinion found that a sudden high fever accompanied by one of the manifestations of bleeding may be the conclusion of clinical diagnosis of DHF data results are compared with test results based on the system.
Testing 14 dengue cases according to medical records (numbers 1-14), concluded 13 cases of dengue fever by the system. 14 cases of dengue testing is not appropriate medical records (numbers 14-28), 9 cases are not concluded by the system DBD. Of the total 28 cases that tested the 22 cases (78.50%) just concluded by the model. Complete accuracy of conclusions can be seen in the following table.

Table. 6. Comparison Expert System Diagnosis With Prior Validation Data

Cases	Prior Validation Data	Expert System Diagnosis	Accuracy (%)
DBD	14	13	92.85
Non DBD	14	9	64.20
Total	28	28	78.50

Testing with data after the validation process has been done by performing data entry testing as many as 20 samples. Testing 10 dengue cases according to medical records (numbers 1-10), 10 dengue cases concluded by the system. 10 cases of dengue testing is not appropriate medical records (numbers 10-20), all concluded cases by the system rather than DBD. Of the total 20 cases that tested the 10 cases (100%) just concluded by the model. Complete accuracy of conclusions can be seen in the following table.

Table. 7. Comparison Expert System Diagnosis With After Validation Data

Cases	Prior Validation Data	Expert System Diagnosis	Accuracy (%)
DBD	10	10	100.00
Non DBD	10	10	100.00
Total	20	20	100.00

11 Application Display in Mobile Device

The application display is taken from screen shoot of system when the Android program is running in emulator.

Fig.9. Application Display in Emulator

12 Summary

Having completing the design and development of the system, as well as through the implementation and evaluation of the system, we obtain the following conclusion:

- The expert system application for diagnosing Dengue Hemorrhagic Fever (DHF) can be implemented on Android based mobile devices
- This expert system application could give early diagnosis of Dengue Hemorrhagic Fever (DHF) dengue fever so that medical treatment can be given promptly, this expert system application can be an alternative to the lab tests that take longer time to know the result.

Suggestion for model development will be as follow:

- The clinic criteria need to be further developed by adding other subjective symptoms such as headache, abdominal pain, nauseous and so on.
- It is necessary to develop other method such as ANFIS.

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