Fuzzy Expert System for Tropical Infectious Disease by Certainty Factor

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Abstrak

Komunikasi antara dokter dan pasien memegang peranan penting dalam melakukan diagnosis terhadap penyakit yang diderita oleh pasien. Keterbatasan waktu konsultasi menyebabkan tidak lengkapnya informasi yang diperoleh untuk melakukan diagnosis. Keterbatasan ini diatasi dengan mengembangkan sistem pakar menggunakan metode logika fuzzy untuk menangani kesamaran gejala yang dirasakan pasien dan metode faktor kepastian untuk menangani hubungan antara gejala dengan penyakit. Metode logika fuzzy diawali dengan akuisisi pengetahuan untuk menghasilkan fakta dan aturan, proses implikasi, komposisi, dan defuzifikasi. Hasil defuzifikasi digunakan dalam perhitungan faktor kepastian sekuensial dan gabungan yang menyatakan prosentase kepercayaan dari diagnosa penyakit yang diderita pasien. Hasil diagnosis antara pakar dengan sistem pakar terhadap kasus yang diberikan menunjukkan sistem memiliki kesamaan diagnosa dengan pakar sebesar 93.99%.

Kata kunci: *sistem pakar, berbasis web, logika fuzzy, faktor kepastian, infeksi tropis*

Abstract

Communication between doctor and patient play an important role in determining the diagnosis of the illness suffered by the patient. Consultation time constraints led to insufficient information obtained to produce a diagnosis. This limitation is overcome by developing an expert system using fuzzy logic to represent the vagueness of symptoms experienced by patients and the certainty factor represents a relationship between the symptoms and disease. Fuzzy logic method begins with the acquisition of knowledge to produce the facts and rules, implication process, composition and defuzzification. The result of defuzzification used in the calculation of sequential and combined certainty factor which represent the belief percentage of diseases diagnosis that suffered by the patient. The results of the expert diagnosis with expert system for the given cases indicates the system, has the similarity diagnosis with the expert at 93.99%.

Keywords*: expert system, web based, fuzzy logic, certainty factor, a tropical infection*

1. Introduction

Until now, the biggest health problems in Indonesia are still struggling to infectious diseases or tropical diseases. The action does indeed show that vaccination satisfactory results in certain diseases such as smallpox and polio. However, the disappearance of one type of illness does not necessarily ease the burden to overcome, because it appears a new types of diseases (emerging infectious diseases) and from whose disease has been eliminated, it can appear again (re-emerging infectious diseases). Indonesia has a part of a developing Asian country; it is yet to be released from other types of infectious diseases [1].

The problems of tropical infectious diseases require appropriate treatment where the active participation of doctor and patient play an important role in determining the diagnosis. In fact, in the process of diagnosis, the patient cannot complaint in detail because it is limited by the time of consultation. This causes the doctor did not obtain complete information about the

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patient. Doctor relies on medical record available and physical examination in determining the relationship between the symptoms experienced by the patient against possible illnesses.

Computer-based information technology develops to facilitate the process of consultation between doctor and patient in the form of expert system. Expert system is one outgrowth of technology developed with the aim to mimic the ability of an expert in a particular field [2]. Expert system enables patients as users of the system can communicate about a disease to the system as a doctor without being limited by distance and time can be done anywhere and anytime. Users will be directed by the system to deliver the complaint in detail and gradually. Expert system will provide solutions to the complaints submitted by users. In fact, expert systems capable of providing solutions to problems contain elements of uncertainty such as the similarity between the symptoms of a disease with other diseases.

Researches related to expert systems have been done with several research objects as follows. S. Zahan, R. Bogdan & R. Capalneanu develop fuzzy expert system for cardiovascular disease diagnosis-tests and performance evaluation to present the results of the tests performed in order to evaluate the performances of a fuzzy expert system developed for cardiovascular disease diagnosis. The tests were performed using clinical data that corresponds to 92 patients clinically investigated during 1998-1999 in order to establish the myocardial ischemia diagnosis. The system output was compared to three independent diagnoses given by physicians. For 85 patients, representing 92.39% of cases, the system diagnosis was correct [3].

M. Abdel-Salem Badeeh and M. El Bagoury Bassant develop model of an expert system for diagnosis of diseases thyroid cancer by combining the methods of neural network and certainty factor. The model is constructed consisting of three phases, each phase using a single network for the learning process. The model was tested against 820 cases of thyroid cancer patients from the National Cancer Institute of Egypt. Through cross-validation tests showed the diagnostic performance rate that reaches 99.47% [4].

M. Ragab Abdul Hamid, Khalid Abdullah and Mohamed Ismail Fakeeh Roushdy develop expert systems for diagnosis of heart disease with certainty factor method. Heart disease is classified into 25 types of disease that is left heart failure and right heart failure in the form of semantic networks. Data is divided into patient demographic data (age and sex) and clinical data such as laboratory results and clinical examination. Knowledge representation is done by using production rules [5].

Lina Handayani and Tole Sutikna develop the design and use of expert system shell e2gLite for the diagnosis of the ear, mouth and throat diseases. The shell e2gLite must be made 2 pieces of the files containing the applet of web pages and knowledge base. The system can identify 23 types of the ear, mouth and throat diseases based on variations of 38 symptoms [6].

Emmanuil Marakakis, Kostas Vassilakis, Emmanuil Kalivianakis and Sifis Micheloyiannis develop expert systems for disease diagnosis of epilepsy with certainty factor method. Data used are 50 types of epilepsy, in which each type of epilepsy is expressed in the form of 28 diagnostic criteria. The knowledge obtained by physical examination and laboratory results. The system was tested against 42 cases in children with the test results are successfully entered correctly diagnosed 35 cases (83.3%) [7].

Sefindra Purnama, Kartika Firdausy and Anton Yudhana develop expert system to detect damage on the motor enginee by forward chaining inference method. The program has been tested using Black Box test and Alpha test.The black box test results that system is made worthy of publication.The alpha test results that system can assist and facilitate in detecting damage on the enginee [8].

M. Neshat, M. Yaghobi, M.B. Naghibi and A. Esmaelzadeh develop a fuzzy system for learning, analysis and diagnosis of liver disorders. Required data has been chosen from trusty database (UCI) that has 345 records and 6 fields as the entrance parameters and rate of liver disorder risks is used as the system resulting. On time diagnosis of disease and appointing the rate of liver disorders improvement has been experienced and its Verification 91% [9].

Honggowibowo develops expert system to diagnosis rice plants disease. This research designs a web-based expert system using rule-based reasoning. The rules are modified from the method of forward chaining inference and backward chaining in order to help farmers in the rice plant disease diagnosis [10].

Ali and Mehdi Adeli Neshat develop expert systems for diagnosis of heart disease by the method of Fuzzy Logic. The system uses 11 variables attributes input and one output variable attributes. Inference method used is the Mamdani and the defuzzification method used is centroid. Test results on 303 patients from V.A. Medical Center, Long Each and Cleveland Clinic Foundation showed that success rates of 94% of these systems [11].

Mirza M, GholamHosseini H and Harrison M.J. develop a clinically useful diagnostic alarm system for detecting critical events during anesthesia administration. The performance of the system was validated through a series of off-line tests. When detecting hypovolaemia a substantial level of agreement was observed between FLMS and the human expert (the anesthetist) during surgical procedures [12].

Fazel Zarandi, Zolnori, Moin, and Heidarnejad develop expert systems for diagnosis of asthma disease by the method of Fuzzy Logic. The knowledge acquisition process is done by using a semantic network. Knowledge representation is done with the production rules. Fuzzy inference method used is the Mamdani method and the method used is defuzzification centroid method. Testing method used is a method of verification and validation. Test results on 53 patients with asthma and 53 non-asthmatic patients of Imam Khomeini Hospital and Masih Daneshvari in Tehran, Iran, with a cut-off value of 0.7 indicates the level of accuracy of 100% and 94% response rate [13].

A.A. Abdullah, Z. Sakaria and N.F. Mohamad design a Fuzzy Expert System (FES) for diagnosis of hypertension risk for patients aged between 20's, 30's and 40's years and is divided into male and female gender. The input data is collected from a total of 10 people which consists of male and female with different working background. The parameters used as input for this fuzzy expert system were age, Body Mass Index (BMI), blood pressure and heart rate [14].

Chang-Shing Lee and Mei-Hui Wang present a novel fuzzy expert system for diabetes decision support application. A five-layer fuzzy ontology, including a fuzzy knowledge layer, fuzzy group relation layer, fuzzy group domain layer, fuzzy personal relation layer, and fuzzy personal domain layer, is developed in the fuzzy expert system to describe knowledge with uncertainty [15].

O. Geman delineates a model of a fuzzy expert system, dedicated to Parkinson's disease diagnosis. The input parameters of the system are represented by amplitude, frequency, the spectral character and trembling localization. The last one signifies the main symptom that occurs in Parkinson's disease, but others can also be mentioned: small handwriting, loss of smell, trouble sleeping, soft or low voice [16].

Researches have been done on the field of medicine was developed only using one method only to deal with uncertainty in the problems faced by user, both certainty factor method or fuzzy logic method. There is no research related to combining the two methods above in developing expert system in medicine, when in fact the symptoms experienced by patient are not certain of a particular disease, so it requires a process of diagnosis that can determine the relationship between the symptoms of the disease.

This research will develop an expert system combines the method of Fuzzy Logic and Certainty Factors with the object of research is a disease of tropical infectious diseases include Dengue Fever, Typhoid Fever and Chikungunya. Fuzzy logic methods will be used to handle the uncertainty experienced the patient’s symptoms and the certainty factor method will be used to handle the inability of an expert in defining the relationship between the symptoms of the disease with certainty. Expert system developed on web based platform, provide improve of knowledge, where expert can add new knowledge to a disease or alter the existing knowledge on the disease, so the system will remain accurate and up to date.

In the expert system to be developed, each of fuzzy variables has a whole range of a fuzzy set value and the system can handle the weight of each phase of tropical infectious diseases which affected the diagnosis. The consultation process carried out by day consultation because there are a phase of fever and a phase of critical on fever dengue disease that occurs over a range of different days. This expert system is expected to increase the percentage of similarity between the result obtained from a doctor diagnosis and system diagnosis.

2. Research Method

Types of diseases that were made as the object of research are disease of Dengue Fever, Dengue Hemorrhagic Fever I, Dengue Hemorrhagic Fever II, Dengue Hemorrhagic Fever III, Dengue Hemorrhagic Fever IV, Chikungunya and Typhoid Fever. Expert knowledge used as a source such as library books and internist doctor. Basic knowledge based on the results of clinical examination and routine hematology tests in the laboratory. The system does not handle the presence of complications among the symptoms suffered by patient. Knowledge representation is done using fuzzy rules. Fuzzy inference method used is Sugeno method. Patient data are used as test data are limited to adult patients. Tests carried out by internist doctor. System is developed by web-based that easily accessed by the user and easy to facilitate the repairing process. The output generated by this system is the belief of the illness.

2.1. Knowledge Acquisition

The knowledge acquired from the literature and single expert, including the gender of the patient, the day when the symptoms experienced by patient, clinical symptoms, syndrome symptoms and symptoms of routine hematology. Clinical examination consists of 22 symptoms, syndrome consists of 6 symptoms and routine hematology consists of 6 symptoms. Clinical symptoms consist of 17 symptoms of crisp value and 5 symptoms of fuzzy value. All of routine hematology symptoms and syndrome symptoms are fuzzy value [17]-[19].

2.2. Knowledge Representation

Knowledge of clinical symptoms and results of routine hematology from the patient require a representation of the facts in question are accompanied by an explanation of the question. The symptoms are represented in the form of common question, so it can be used to represent all the symptoms of seven diseases. The relationship between the symptoms represented in the form of syndrome of symptom.

A crisp symptom are modeled in the form of 2 sets, are ‘Yes’ and ‘No’. The answer of a crisp symptom from the patient is given in the form of multiple choices, such as ‘No’, ‘A bit of’, ‘Enough’ and ‘Very’, with a weight value of each. Syndrome symptom are modeled in the form of 2 sets, are ‘Yes’ and ‘No’. A fuzzy symptom will be represented by a fuzzy set with membership function [20]-[22]. From 11 symptoms of fuzzy value, some of fuzzy sets model are shown below.

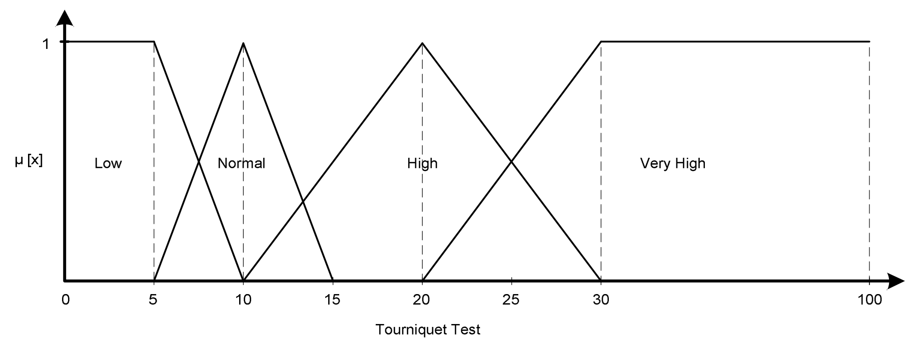

Figure 1. Membership Curve of Tourniquet Test

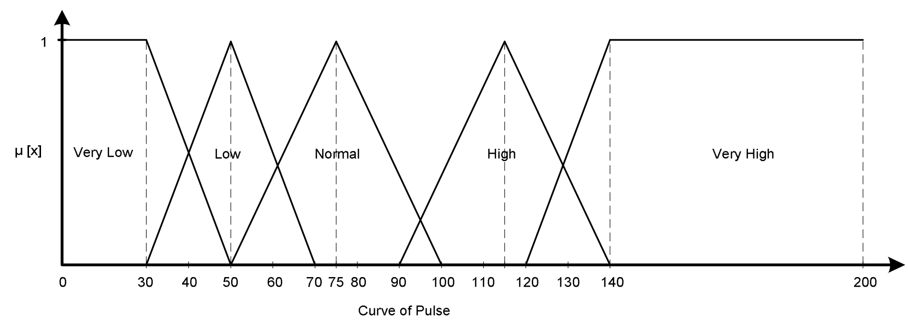

Figure 2. Membership Curve of Pulse

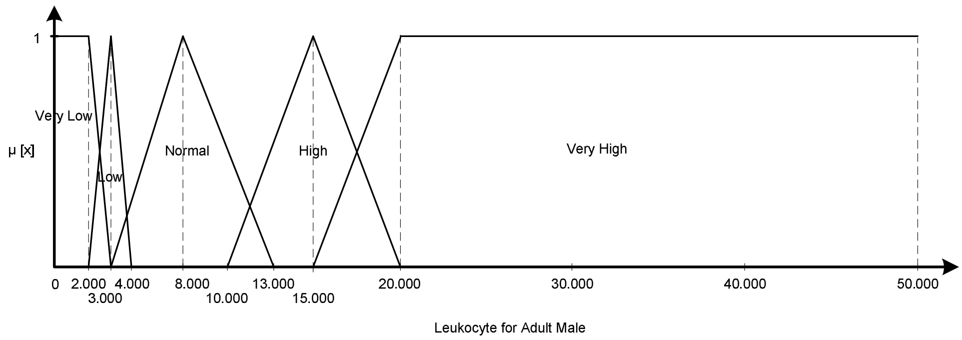

Figure 3. Membership Curves of Leukocyte for Adult Male

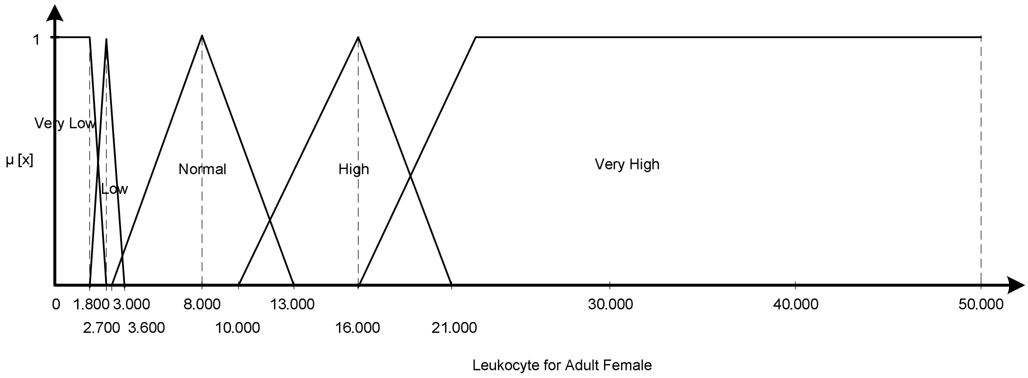

Figure 4. Membership Curves of Leukocyte for Adult Female

Membership functions of tourniquet test:

$$\mu_{Low}(x) = \begin{cases} \frac{10-x}{5}, & 5 \le x \le 10 \\ 1, & x \le 5 \end{cases}$$

$$\mu_{Normal}(x) = \begin{cases} \frac{x-5}{5}, & 5 \le x \le 10 \\ 1, & x = 10 \\ \frac{15-x}{5}, & 10 \le x \le 15 \end{cases}$$

$$\mu_{High}(x) = \begin{cases} \frac{x-10}{10}, & 10 \le x \le 20 \\ 1, & x = 20 \\ \frac{30-x}{10}, & 20 \le x \le 30 \end{cases}$$

$$\mu_{VeryHigh}(x) = \begin{cases} \frac{x-20}{10}, & 20 \le x \le 30 \\ 1, & x \ge 30 \end{cases}$$

Membership functions of pulse:

$$\mu_{VeryLow}(x) = \begin{cases} \frac{50-x}{20}, & 30 \le x \le 50 \\ 1, & x \le 30 \end{cases}$$

$$\mu_{Low}(x) = \begin{cases} \frac{x-30}{20}, & 30 \le x \le 50 \\ 1, & x = 50 \\ \frac{70-x}{20}, & 50 \le x \le 70 \end{cases}$$

$$\mu_{Normal}(x) = \begin{cases} \frac{x-50}{25}, & 50 \le x \le 75 \\ 1, & x = 75 \\ \frac{100-x}{25}, & 75 \le x \le 100 \end{cases}$$

$$\mu_{High}(x) = \begin{cases} \frac{x-90}{25}, & 90 \le x \le 115 \\ 1, & x = 115 \\ \frac{115-x}{25}, & 115 \le x \le 140 \end{cases}$$

$$\mu_{VeryHigh}(x) = \begin{cases} \frac{x-120}{20}, & 120 \le x \le 140 \\ 1, & x \ge 140 \end{cases}$$

Membership functions of leukocyte for adult male:

$$\mu_{VeryLow}(x) = \begin{cases} 1, & x \le 2000 \\ \frac{3000-x}{1000}, & 2000 \le x \le 3000 \end{cases} \qquad \mu_{Low}(x) = \begin{cases} \frac{x-2000}{1000}, & 2000 \le x \le 3000 \\ 1, & x = 3000 \\ \frac{4000-x}{1000}, & 3000 \le x \le 4000 \end{cases}$$

$$\mu_{Normal}(x) = \begin{cases} \frac{x-3000}{5000}, & 3000 \le x \le 8000 \\ 1, & x = 8000 \\ \frac{13000-x}{5000}, & 8000 \le x \le 13000 \end{cases}$$

$$\mu_{High}(x) = \begin{cases} \frac{x-10000}{5000}, & 10000 \le x \le 15000 \\ 1, & x = 15000 \\ \frac{20000-x}{5000}, & 15000 \le x \le 20000 \end{cases} \quad \mu_{VeryHigh}(x) = \begin{cases} \frac{x-15000}{5000}, & 15000 \le x \le 20000 \\ 1, & x \ge 20000 \end{cases}$$

Membership functions of leukocyte for adult female:

$$\mu_{VeryLow}(x) = \begin{cases} 1, & x \le 1800 \\ \frac{2700-x}{900}, & 1800 \le x \le 2700 \end{cases} \qquad \mu_{Low}(x) = \begin{cases} \frac{x-1800}{900}, & 1800 \le x \le 2700 \\ 1, & x = 2700 \\ \frac{3600-x}{900}, & 2700 \le x \le 3600 \end{cases}$$

$$\mu_{Normal}(x) = \begin{cases} \frac{x-3000}{5000}, & 3000 \le x \le 8000 \\ 1, & x = 8000 \\ \frac{13000-x}{5000}, & 8000 \le x \le 13000 \end{cases} \quad \mu_{High}(x) = \begin{cases} \frac{x-11000}{5000}, & 11000 \le x \le 16000 \\ 1, & x = 16000 \\ \frac{21000-x}{5000}, & 16000 \le x \le 21000 \end{cases}$$

$$\mu_{VeryHigh}(x) = \begin{cases} \frac{x-16000}{5000}, & 16000 \le x \le 21000 \\ 1, & x \ge 21000 \end{cases}$$

2.3. Fuzzy Inference

2.3.1. Fuzzification

Rules are made for the expert system developed as much as 1524 rules, which consists of 92 rules for Dengue Fever, 168 rules for Dengue Hemorrhagic Fever I, 188 rules for Dengue Hemorrhagic Fever II, 260 rules for Dengue Hemorrhagic Fever III, 260 rules for the Dengue Hemorrhagic Fever IV, 162 rule for Chikungunya and 394 rules for Typhoid Fever. The conclusions contained in any rule requiring the certainty value of expert (Expert CF) to determine how much the belief that the symptoms included in the rules affecting the diagnosis occurred at the conclusion.

Some of the rules produced are shown in Table 1.

2.3.2. Implication and Composition

Calculation of the degree of fuzzy membership for each symptom is determined by the value assigned by the user. For example, if user types the body temperature is 39.8^{0}C.

$$\mu_{BodyTemperature=High}(39.8) = \frac{39.8-39}{1.0} = \frac{0.8}{1.0} = 0.80$$

$$\mu_{BodyTemperature=VeryHigh}(39.8) = \frac{39.8-38.5}{1.0} = \frac{0.3}{1.0} = 0.30$$

Table 1. Fuzzy Rule

Rule Number	Rules
A00000005	**IF**(actual body temperature is HIGH) **THEN CF: 0.70**
A00000006	**IF**(actual body temperature is VERY HIGH) **THEN CF: 0.90**
A00000007	**IF**(typical fever syndrome is YES) **AND** (pain in spine is YES) **AND** (pain in head is YES) **THEN CF: 0.70**
A00000008	**IF**(typical fever syndrome is YES) **AND** (pain in spine is YES) **AND** (pain in head is NO) **THEN CF: 0.60**
A00000009	**IF**(typical fever syndrome is YES) **AND** (pain in spine is NO) **AND** (pain in head is YES) **THEN CF: 0.60**
A00000010	**IF**(typical fever syndrome is YES) **AND** (pain in spine is NO) **AND** (pain in head is NO) **THEN CF: 0.50**
A00000068	**IF**(typical specific syndrome is YES) **AND** (platelet is VERY LOW) **THEN CF: 0.90**
A00000069	**IF**(typical specific syndrome is YES) **AND** (platelet is LOW) **THEN CF: 0.80**
A00000070	**IF**(typical specific syndrome is YES) **AND** (platelet is NORMAL) **THEN CF: 0.60**
A00000071	**IF**(typical specific syndrome is YES) **AND** (platelet is HIGH) **THEN CF: 0.50**

Based on the degree of membership, calculate the implication function with MIN function [20]-[22]. $\mu(x)$ is the degree of membership for x and w_i is the result of implication.

$$wi = Min\big(\mu(x), \mu(y)\big)$$

For the example above, the implication result is shown below.

w_1 = min($\mu_{BodyTemperature=High}$[39.8]) = min(0.80) = 0.80
w_2 = min($\mu_{BodyTemperature=VeryHigh}$[39.8]) = min(0.30) = 0.30

The process of composition is made to obtain the value z_i of each rule. The certainty value from expert of each rule is value of z_i. The rules of body temperature for both fuzzy sets are shown below.

IF (Actual_Body_Temperature is HIGH) THEN A00000005, CF: 0.70
IF (Actual_Body_Temperature is VERY HIGH) THEN A00000006, CF: 0.90

2.3.4. Defuzzification

Defuzzification process is done using weighted average method defuzzification by calculating the average value of z_i [20]-[22].

$$z = \frac{\sum_{i=1}^{N} w_i z_i}{\sum_{i=1}^{N} w_i}$$

w_i is the result of implication and z_i is the result of composition. The results of defuzzification demonstrate the value of the belief for the syndrome experienced by patients. For the example above, the defuzzification result is shown below.

$$z = \frac{(0.8 * 0.7) + (0.3 * 0.9)}{0.7 + 0.9} = \frac{0.83}{1.6} = 0.52$$

2.4. Certainty Factor Calculation

The result of defuzzification process will be used to calculate the value of belief for the diagnosis. Firstly, will be calculated certainty factor (CF) sequential as follows [21].

$$CF(x, y) = CF(x) * CF(y)$$

CF(x,y) is result of certainty factor sequential, *CF(x)* is result of defuzzification and *CF(y)* is the expert certainty value of each rule. In this study, CF sequential multiplies with the weight value of each phase of disease. CF sequential from several rules generated combined using the following calculation of the combined CF as follows [21].

$$CF(x,y) = CF(x) + CF(y) - \big(CF(x) * CF(y)\big)$$

For the example above, the calculation result is shown below.

$$CF(x,y)\ A00000005 = 0.52 * 0.70 * 0.50 = 0.18$$
$$CF(x,y)\ A00000006 = 0.52 * 0.90 * 0.50 = 0.23$$

The results of combined CF suggest the diagnosis of the disease to the symptoms experienced by patients.

$$CF(x,y)\ A00000005\&A00000006 = 0.18 + 0.23 - (0.18 * 0.23) = 0.37$$

3. Results and Discussion

3.1. System Platform

Expert system developed on web based platform using some software such as SQLyog Community Edition to build knowledge base, Macromedia Dreamweaver 8 with PHP and Java Script to build the application, and CSS to design the interface.

3.2. System Structure

3.2.1. Knowledge Acquisition

The acquisition of knowledge is the development environment used by the knowledge engineer to acquire the knowledge of single expert as the source. In this expert system development, knowledge acquisition is done through interviews with internist doctor, and supported by literature studies.

3.2.2. Knowledge Base

Knowledge base is a development environment used by the knowledge engineer to represent the knowledge that gained from the acquisition of knowledge. The fact are the disease, the symptoms, the phase of disease, the fuzzy symptoms, the curve, the fuzzy sets, the symptoms of diseases and user response options. The rules are made by combining the facts above. Knowledge base built in the form of 13 tables, such as table of status, table of sets, table of curves, table of diseases, table of symptoms, table of fuzzy symptoms, table of disease symptoms, table of response options, table of syndrome, table of detailed syndromes, table of rules and table of detailed rules.

3.2.3. User Interface

The interface is an environmental consultancy that is intended for users to do the questions and answers with the expert system. The answer to the symptom of crisp value is given in several options (‘No’, ‘A bit of’, ‘Enough’, ‘Very’), and the answer to the symptom of fuzzy value is given in a numeric value.

3.2.4. Inference Engine

The inference engine uses IF-THEN production rules, the reasoning method of Forward Chaining. Reasoning based on rules that have been established on the basis of knowledge above.

3.2.5. Workplace

Workplace represented in the form of five tables such as table of diagnosis, table of consultation, table of detailed consultation, table of membership and table of implication.

3.2.6. Explanation Facility

The explanation facility provided in the form, first, at each symptom in question, the system provides information about symptoms, and choice for users who want to know why the system asks the symptoms are; second, at the end of the consultation, in addition to displaying the results of the diagnosis, the system provides the option for users who want to know how to diagnose the system results. The examples for this facility are shown at Figure 5 and Figure 6.

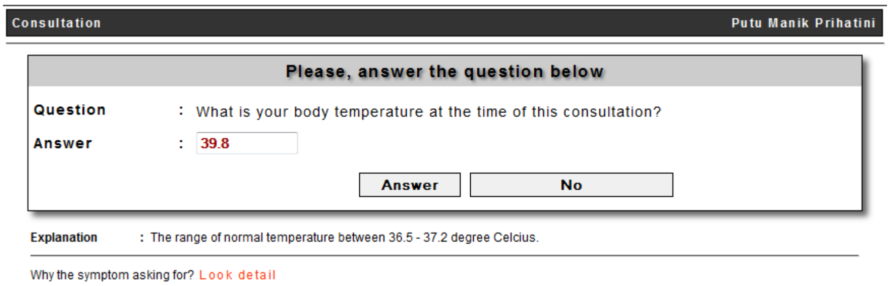

Figure 5. Consultation User Interface

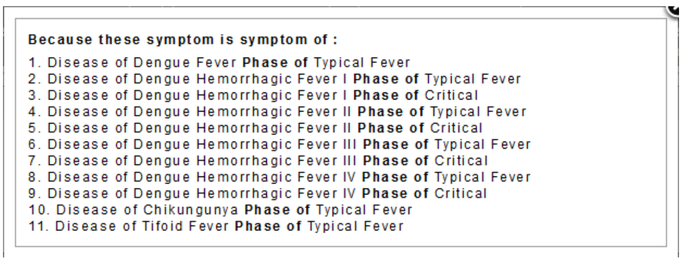

Figure 6. Explanation Facility Interface

3.2.7. Knowledge Improvement

Improvement of knowledge can be done if there are additions or changes to the new symptoms to a disease, the addition or change in symptom status, the addition or change of a fuzzy set and the addition or change the curve on a fuzzy set. Based on any additions or changes, the system will do the creation of new rules of the syndrome and the diseases that generate automatically.

3.3. Consultation Case and Analysis

Based on the structure of the above system, the expert system was tested on 20 different cases. One example of consultation and the diagnosis of the system are given at Table 2 and Tabel 3. The consultation occurred on the fourth day.

The diagnosis of the system gives the value of the different belief of the disease that suffered by patient. Dengue Fever has the value of belief at 87%, because the actual body temperature given by patient is set on Very High which has the certainty value of expert is 0.9. Patient feel very pain in the head and in the spine which has the certainty value of expert is 0.7. Patient has much rash on the skin, and the tourniquet test result is 40 which set on Very High, with the certainty value of expert is 0.7. The results of routine hematology tests in the laboratory show that the patient decreased platelet at 75000 which set on Low and Very Low, with the certainty value of expert is 0.8 and 0.9, and decreased leukocyte at 2500 which set on Low and Very Low with the certainty value of expert is 0.6 and 0.7.

Dengue Hemorrhagic Fever Type I have the value of belief at 60%, because the different of the actual body temperature and the body temperature on the day before given by patient indicates an increase of temperature at the fourth day of consultation, so it does not indicate a critical phase, which is the characteristic of the disease.

Dengue Hemorrhagic Fever Type II, III and IV have the value of belief at 35%, because the different of the actual body temperature and the body temperature on the day before given by patient indicates an increase of temperature at the fourth day of consultation, so it does not indicate a critical phase. Moreover, the patient does not experience a spontaneous bleeding which is the characteristic of the disease.

Chikungunya has the value of beliefe at 34%, because the patient does not feel pain in joint in the morning, there is no feel joint pain feels inclined to move or do not settle on a particular limb, and there is no feel joint pain in the ankle/wrist/in the joints of the hands, which are the characteristics of the disease. The results of routine hematology tests in the laboratory show that the lymphocytes and erythrocyte sedimentation rate are Normal.

Dengue Fever has the value of beliefe at 14%, because the patient does not feel headache, there is no feel vomiting and nausea, there is no loss of appetite, the patient does not experincing an increase in body temperature from normal temperature, especially in the afternoon until the evening and stomach does not feel uncomfortable or bloated which are the characteristics of the disease. The results of routine hematology tests in the laboratory show that the hemoglobin, lymphocytes and erythrocyte sedimentation rate are Normal.

The result of diagnosis shows that the fuzzy logic method is able to handle the vagueness of symptoms experienced by patient. System is able to put any fuzzy value given by the patient into the appropriate fuzzy set. System looks for rules that match the combination of symptoms experienced by patient, both crips symptom, fuzzy symptom, or the combination. The rules give the certainty value of the expert which show the relationship between the symptoms that suffered by patient with the disease. The certainty value used in the implication process, decomposition, defuzzification and the calculation of sequential and combined certainty factor to result the percentage of disease that suffered by patient.

3.4. System Performance

Developed an expert system testing performed by comparing the results of diagnosis made by a real expert with the diagnosis given by the expert system. Table 4 shows that system performance as the result of the comparison.

Table 2. Consultation Case

No	Questions	Answer
1	What is your body temperature at the time of this consultation?	40
2	Do you feel headache? Choose one answer in the box following options.	No
3	Do you feel pain in the head? Choose one answer in the box following options.	Very
4	Do you feel pain in the spine? Choose one answer in the box following options.	Very
5	What is your body temperature on the day before the consultation is done?	40.3
6	Do you feel pain in the muscle? Choose one answer in the box following options.	Very
7	Do you feel pain in joints? Choose one answer in the box following options.	Very
8	Do you feel pain in the back of the eye? Choose one answer in the box following options.	Very
9	Do you have vomiting?	No
10	Do you have nausea?	No
11	Are you experiencing loss of appetite?	No
12	Do you have a rash on the skin? Choose one answer in the box following options.	Very
13	Have you done a tourniquet test? If so, type the value of your result test below	40
14	Do you experience spontaneous bleeding in the skin in the form of red spots or vomiting blood or black color stools or bleeding of the gums? Choose one answer in the box following options.	No
15	What is your pulse?	100
16	What is your systolic blood pressure value?	70
17	Do you feel joint pain tends to occur in the morning? Choose one answer in the box following options.	No
18	Do you feel joint pain feels inclined to move or do not settle on a particular limb? Choose one answer in the box following options.Do you feel pain in the spine? Choose one answer in the box following options.	No
19	Do you feel joint pain in the ankle/wrist/in the joints of the hands? Choose one answer in the box following options.	No
20	Are you experincing an increase in body temperature from normal temperature, especially in the afternoon until the evening? Choose one anwers in the box following options.	No
21	Does your stomach feel uncomfortable and bloated?	No
22	Are you having difficulty in bowel movements or diarrhea?	No
23	Have you done a complete examination of blood test in the lab? Give the result of your platelet below	75000
24	Have you done a complete examination of blood test in the lab? Give the result of your hematocrit below	40
25	Have you done a complete examination of blood test in the lab? Give the result of your lymphocytes below	30
26	Have you done a complete examination of blood test in the lab? Give the result of your hemoglobin below	13
27	Have you done a complete examination of blood test in the lab? Give the result of your leukocyte below	2500
28	Have you done a complete examination of blood test in the lab? Give the result of your erythrocyte sedimentation rate below	10

The difference result between expert diagnosis and system diagnosis for the case is 6.01%, indicates that the expert system have similarity with the real expert at 93.99%. This is because the expert system developed using a fuzzy set to some of the symptoms so that can handle the vagueness of existing symptoms, as well as the believe value of an expert on the relationship of symptoms to be able to handle the uncertainty of the diagnosis is given.

Table 3. Result of Diagnosis for Consultation Case

No	Name of Disease	Procentage
1	Dengue Fever	87%
2	Dengue Hemorrhagic I	60%
3	Dengue Hemorrhagic II	35%
4	Dengue Hemorrhagic III	35%
5	Dengue Hemorrhagic IV	35%
6	Chikungunya	34%
7	Tifoid Fever	14%

Table 4. System Performance

Case	Expert Diagnosis (%)	System Diagnosis (%)	The difference result between Expert and System Diagnosis (%)
1	36	33	8.40
2	36	40	11.60
3	57	55	4.01
4	47	43	8.21
5	43	38	10.37
6	67	70	4.48
7	66	65	2.37
8	70	74	5.73
9	70	74	5.73
10	68	69	1.90
11	63	59	7.21
12	68	69	1.46
13	64	60	7.13
14	68	69	1.46
15	68	60	12.53
16	43	41	5.00
17	66	68	3.70
18	33	30	9.57
19	50	55	9.46
20	10	10	0.00
Average of the difference result			6.01

4. Conclusion

Expert system for diagnosing tropical infectious diseases has been developed on web based platform to receive input in the form of clinical symptoms and routine hematology tests in the laboratory. The inputs are crisp and fuzzy value to handle the vagueness of symptoms. Fuzzy rules represent the relationship of symptoms of each disease using the certainty factor of the expert. The system provides output from the diagnosis of the seven diseases expressed as a percentage of certainty of the user experience of the disease. System testing results show that the system developed has the similarity with the real expert at 93.99%.

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