Journal of Theoretical and Applied Information Technology
10th August 2015. Vol.78. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

EXPERT SYSTEM DIAGNOSIS CHRONIC KIDNEY DISEASE BASED ON MAMDANI FUZZY INFERENCE SYSTEM

[1]MUCH AZIZ MUSLIM, [2]IIN KURNIAWATI, [3]ENDANG SUGIHARTI,
[1,3]Department of Computer Science, Semarang State University, Semarang, Indonesia
[2]Department of Mathematics, Semarang State University, Semarang, Indonesia

E-mail: [1]a212muslim@yahoo.com, [2]iin.kurniawati45@gmail.com, [3]endanghs02@yahoo.com

ABSTRACT

Expert systems are computer-based system that uses knowledge, facts and reasoning techniques in solving problems that usually can only be solved by an expert in a particular field. In this research, expert systems are used for the diagnosis of Chronic Kidney Disease. The purpose of this research is to develop an expert system diagnosis of Chronic Kidney Disease based on Mamdani Fuzzy Inference System and determine the level of system accuracy in diagnosis of Chronic Kidney Disease. There are four processes in this method, namely fuzzification, implications, composition of the rules and defuzzification. Agile Method was used for software development in a systematic way. In this research, A simulation of expert system was built using Matlab R2009a. The accuracy expert system of diagnosis Chronic Kidney Disease is calculated using the Confusion Matrix. Based on results of the research, showed that bisector method generate the highest level of accuracy.

Keywords: *Expert System, MFIS, Diagnosis, Chronic Kidney Disease, Software Matlab R2009*

1. INTRODUCTION

A long with the time, developed a technology which is able to adopt the process and a way of thinking human. The development of computerized device based on artificial intelligence human, in the end bring up one a new branch of computer science, namely artificial intelligence. One branch of artificial intelligence are expert system. According to [1], expert system is a computer-based system that uses knowledge, facts and reasoning techniques in solving a problem that usually can be solved by an expert in a particular field. Expert system is computer systems that emulate the decision-making ability of a human expert[2]. The purpose of expert system is not to replace the human roles, but to presented human knowledge in forms of a system, so it can be used by many people. Expert systems are made in the area of knowledge for a particular expertise approaching human capabilities in one specific field. expert systems and they have the tendency to be developed to the direction of on one side directed also specialized knowledge (expertise orientation) and on the other hand in the development of applications in specialized problems problem - oriented)[3].

Mamdani fuzzy inference system has been used extensively to capture expert knowledge so allowing its use to describe the expert skills in a more intuitive, more like an expert in decision making [4]. Medicine is an example to the application of fuzzy logic problems, because there is uncertainty, inaccurate measurements, diversity and of subjectivity which clearly present in medical diagnosis [5].

Chronic Kidney Disease (CKD) is a pathophysiological process with various causes (etiology) are varied and result in a progressive decline in renal function which generally end up with kidney failure. Laboratory test is required in the process of early detection Chronic Kidney Disease. Creatinin serum levels, ureum plasma levels and value of glomerulus filtration rates became a strong indicator expresses a patient diagnosed with the Chronic Kidney Disease or not.

Medical personnel or doctors are elements that give the most impact in the treatment of patients. If in his duty doctor was unable to attend or not in place, there will be problems in medical

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

services to patients. One of which is the delay in the examination treat a patient. Meanwhile, the nurse can not absolutely ensure a diagnosis without a doctor. An expert is a person skilled in the art, but in reality, an expert has limited memory and stamina work. One factor reduction expert performance due to age. So that at tasks could have mistakes on the outcome of the diagnosis which will affect the solution that will be given to the patient.

According to its case, the research problem of the studies is how to build expert system for the diagnosis of chronic kidney disease based mamdani fuzzy inference system using matlab software and how the level of accuracy of the system in the process of diagnosis chronic kidney disease based on existing data. The purpose of this research is to build expert system the diagnosis of chronic kidney disease with the help of matlab R2009a software and get to know the level of accuracy of the system in diagnosing of chronic kidney disease.

2. RESEARCH METHOD

The method used in this study consists of several stages, namely, literature, problem formulation, problem solving and conclusion. The study of literature is the research source literature relevant will be used to collect data and information needed in research. Data taken from a medical record RSI Sultan Agung Semarang and RSUD Tugurejo Semarang. The data was need to be processed based on input data and data will be used for the test. Age, gender, hemoglobin content, creatinin serum levels, ureum plasma levels and value of glomerulus filtration rates used as an input data while the data output of the system for the diagnosis of this disease. Solving a problem begins with the development of software in the process of the diagnosis Chronic Kidney Disease used Agile Method that can be seen in figure 1.

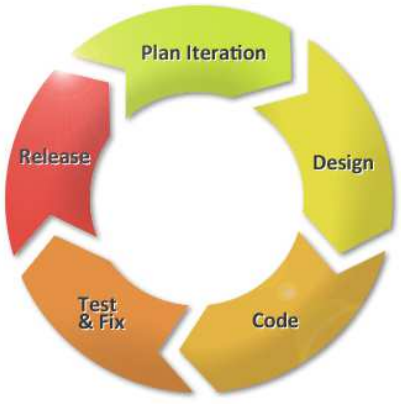

Figure 1. Agile Method

Agile method is methodology development of software is based on the same principles or short-term system development that require adaptation rapidly than the developer to changes of any form. Generally, Agile methods can be divided in two main groups on the basis of their fundamental practices: software development and software management [6]. The design stage is the process of translation systems in accordance algorithm used. It is intended that the program made in accordance with the results of the needs analysis. Coding stage is the stage of system design translation has been made into a form that is understandable commands the computer. In this research writing program code corresponding to the design step by using the Matlab R2009a software. Matlab software has tools that can facilitate the process of making program [10]. In the coding system also created interfaces to facilitate interaction between the programs with user. This stage has a real stage in working out a system. On test & fix stage system will be ascertained whether the system is in accordance with the purpose of which will be achieved. Testing is also done by counting the accuracy of the system in diagnosing illnes or whether the patient suffers from Chronic Kidney Disease. In this research testing system using confusion matrix. Based on the calculation accuracy of confusion matrix can be seen in the results of the accuracy of some defuzzification method. Release stage is the launch phase chronic kidney disease diagnosis software. In plan iteration, consists of several iterations of the launch of the software to be developed. The software removed from the first release to be acceptable and the system can be implemented in full.

3. RESULTS AND DISCUSSION

Results

Expert system diagnosis of Chronic Kidney Disease is constructed through several steps. The early stages of software development is a defining variable.

In this research, there are six variables used, namely: age, levels of hemoglobin, creatinin serum levels, ureum plasma levels, value of Glomerulus Filtration Rates (GFR) and variable diagnosis. Fuzzy set for the variable age is shown in Figure 2.

Journal of Theoretical and Applied Information Technology
10th August 2015. Vol.78. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

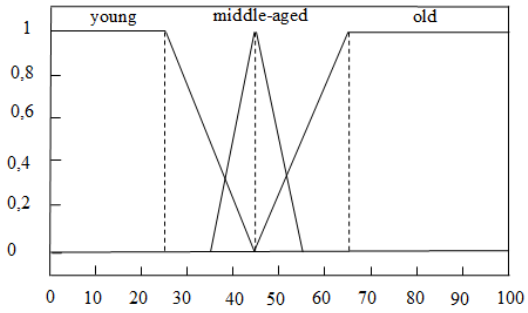

Figure 2. Curve Of Fuzzy Set On Age Variable

Membership function equation for the age variable is declared using equation (1), equation (2) and equation (3).

$$\mu_{young}[x] = \begin{cases} 1 & ; \quad x \leq 25 \\ \frac{45-x}{20} & ; \quad 25 \leq x \leq 45 \\ 0 & ; \quad x \geq 45 \end{cases} \quad (1)$$

$$\mu_{middle-aged}[x] = \begin{cases} \frac{x-35}{10} & ; \quad 35 \leq x \leq 45 \\ \frac{55-x}{10} & ; \quad 45 \leq x \leq 55 \\ 0 & ; \quad x \leq 35 \; atau \; x \geq 55 \end{cases} \quad (2)$$

$$\mu_{old}[x] = \begin{cases} 0 & ; \quad x \leq 45 \\ \frac{x-45}{20} & ; \quad 45 \leq x \leq 65 \\ 1 & ; \quad x \geq 65 \end{cases} \quad (3)$$

Hemoglobin variables divided into three linguistic attributes, there are: low$\left(< 13{,}2 \frac{g}{dl}\right)$, normal $\left(13{,}2 \frac{g}{dl} - 17{,}3 \frac{g}{dl}\right)$ and high $\left(> 17{,}3 \frac{g}{dl}\right)$. Based on the distribution of attributes and problem diagnosis of Chronic Kidney Disease, which attributes affect only low levels and normal levels so that it can be determined membership functions for fuzzy sets on variable hemoglobin is, low and normal. Fuzzy set for variable hemoglobin can be seen in Figure 3.

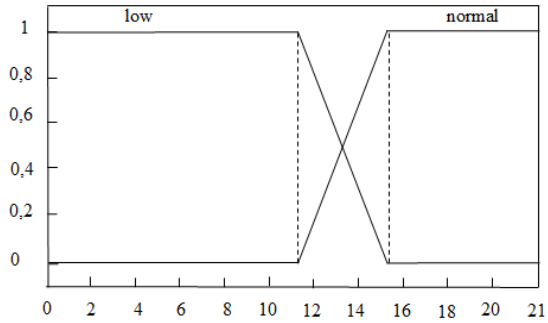

Figure 2. Curve Of Fuzzy Set On Hemoglobin Variable

Membership function equation for the hemoglobin variable is declared using equation (4) and equation (5).

$$\mu_{low}[x] = \begin{cases} 1 & ; \quad x \leq 11{,}2 \\ \frac{15{,}2-x}{4} & ; \quad 11{,}2 \leq x \leq 15{,}2 \\ 0 & ; \quad x \geq 15{,}2 \end{cases} \quad (4)$$

$$\mu_{normal}[x] = \begin{cases} 1 & ; \quad x \geq 15{,}2 \\ \frac{x-11{,}2}{4} & ; \quad 11{,}2 \leq x \leq 15{,}2 \\ 0 & ; \quad x \leq 11{,}2 \end{cases} \quad (5)$$

Creatinin serum variables divided into three linguistic attributes, there are: low$\left(< 0{,}7 \frac{mg}{dl}\right)$, normal $\left(0{,}7 \frac{mg}{dl} - 1{,}5 \frac{mg}{dl}\right)$ and high$\left(> 1{,}5 \frac{mg}{dl}\right)$. Based on the distribution of attributes and problem diagnosis of Chronic Kidney Disease, which attributes affect only normal levels and high levels so that it can be determined membership functions for fuzzy sets on variable creatinin serum is, normal and high. Fuzzy set for variable creatinin serum can be seen in Figure 4.

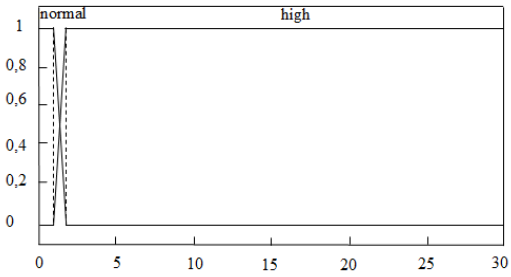

Figure 4. Curve Of Fuzzy Set On Creatinin Serum Variable

Membership function equation for the creatinin serum variable is declared using equation (6) and equation (7).

$$\mu_{normal}[x] = \begin{cases} 1 & ; \quad x \leq 1{,}2 \\ \frac{1{,}8-x}{0{,}6} & ; \quad 1{,}2 \leq x \leq 1{,}8 \\ 0 & ; \quad x \geq 1{,}8 \end{cases} \quad (6)$$

$$\mu_{high}[x] = \begin{cases} 0 & ; \quad x \leq 1{,}2 \\ \frac{x-1{,}2}{0{,}6} & ; \quad 1{,}2 \leq x \leq 1{,}8 \\ 1 & ; \quad x \geq 1{,}8 \end{cases} \quad (7)$$

Ureum plasma variables divided into three linguistic attributes, there are: low$\left(< 10 \frac{mg}{dl}\right)$, normal $\left(10 \frac{mg}{dl} - 50 \frac{mg}{dl}\right)$ and high$\left(> 50 \frac{mg}{dl}\right)$. Based on the distribution of attributes and problem diagnosis of Chronic Kidney Disease, which attributes affect only normal levels and high levels so that it can be determined membership functions for fuzzy sets on variable ureum plasma is, normal and high. Fuzzy set for variable ureum plasm can be seen in Figure 5.

Journal of Theoretical and Applied Information Technology
10th August 2015. Vol.78. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

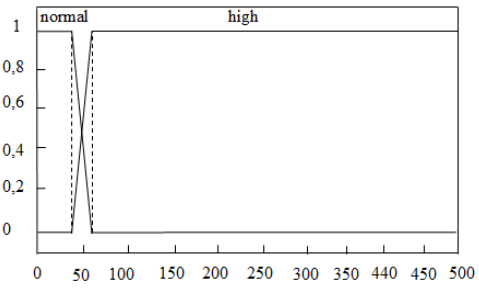

Figure 5. Curve Of Fuzzy Set On Ureum Plasma Variable

Membership function equation for the ureum plasma variable is declared using equation (8) and equation (9).

$$\mu_{normal}[x] = \begin{cases} 1 & ; \quad x \leq 45 \\ \frac{55-x}{10} & ; \quad 45 \leq x \leq 55 \\ 0 & ; \quad x \geq 55 \end{cases} \quad (8)$$

$$\mu_{high}[x] = \begin{cases} 0 & ; \quad x \leq 45 \\ \frac{x-45}{10} & ; \quad 45 \leq x \leq 55 \\ 1 & ; \quad x \geq 55 \end{cases} \quad (9)$$

Glomerulus Filtrations Rates variables divided into three linguistic attributes, there are: low $\left(< 90 \frac{ml}{minutes}\right)$, normal $\left(90 \frac{ml}{minutes} - 130 \frac{ml}{minutes}\right)$ and high $\left(> 130 \frac{ml}{minutes}\right)$. Based on the distribution of attributes and problem diagnosis of Chronic Kidney Disease, which attributes affect only low levels and normal levels so that it can be determined membership functions for fuzzy sets on variable Glomerulus Filtrations Rates is, low and nomal. Fuzzy set for variable ureum plasm can be seen in Figure 6.

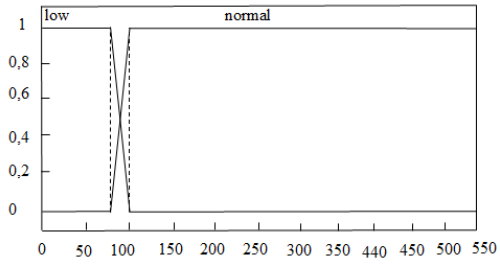

Figure 6. Curve Of Fuzzy Set On Glomerulus Filtration Rates Variable

Membership function equation for the glomerulus filtration rates variable is declared using equation (10) and equation (11).

$$\mu_{low}[x] = \begin{cases} 1 & ; \quad x \leq 80 \\ \frac{100-x}{20} & ; \quad 80 \leq x \leq 100 \\ 0 & ; \quad x \geq 100 \end{cases} \quad (10)$$

$$\mu_{normal}[x] = \begin{cases} 1 & ; \quad x \geq 100 \\ \frac{x-80}{20} & ; \quad 80 \leq x \leq 100 \\ 0 & ; \quad x \leq 80 \end{cases} \quad (11)$$

Diagnosis output variable is 1 to 100, who presented two linguistic attributes, namely: CKD $(50 \leq x \leq 100)$ and NON CKD (<50). Fuzzy set for diagnosis variables can be seen in Figure 7.

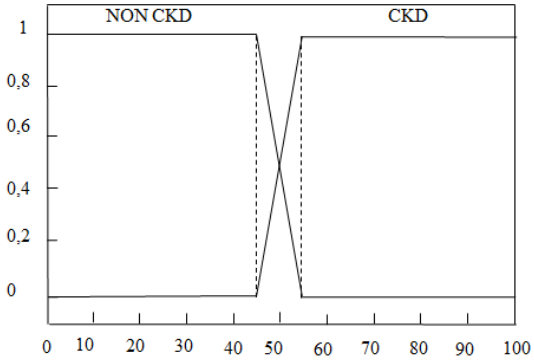

Figure 7. Curve Of Fuzzy Set On Diagnosis Variable

Membership function equation for the diagnosis variable is declared using equation (12) and equation (13).

$$\mu_{non\ ckd}[x] = \begin{cases} 1 & ; \quad x \leq 45 \\ \frac{55-x}{10} & ; \quad 45 \leq x \leq 55 \\ 0 & ; \quad x \geq 55 \end{cases} \quad (12)$$

$$\mu_{ckd}[x] = \begin{cases} 1 & ; \quad x \geq 55 \\ \frac{x-45}{10} & ; \quad 45 \leq x \leq 55 \\ 0 & ; \quad x \leq 45 \end{cases} \quad (13)$$

The next stage is the analysis system. Analysis system can be defined as the decomposition of a complete information component into component parts, with the intent to identify and evaluate the problems and needs that are required in this research. Analysis consisted of analysis of hardware requirements, analysis of software requirements, analysis of user needs and requirements analysis process.

The next step is designing the system. Designing the Chronic Kidney Disease built using the software Matlab R2009a. System design consists of the design interface for page consultation and design interface for page development. Page consultation is not reserved for experts to conduct diagnosis. Page dedicated to the development of an expert system administrator to develop a system. Once the design of the interface

Journal of Theoretical and Applied Information Technology
10th August 2015. Vol.78. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

and the settings are made, then the next step is to implement the system as a whole. Coding and the manufacturing system interface is done at the stage of implementation. Interface consultation pages used in this research are presented in Figure 8.

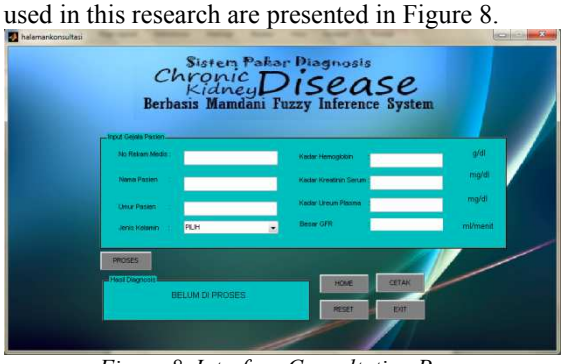

Figure 8. Interface Consultation Page

From Figure 8 there is a push button process of home, print, reset, and exit. Push the button process server to display the results of the diagnosis after entering the user's identity and the results of laboratory examination of patients. Push button home is used to enter front page form. Push button print serves to display the form printed page if you want to print the results of the diagnosis of Chronic Kidney Disease. Push button reset is used to delete all the input values as well as the output generated by the system. Push button exit functions to perform commands out of the system diagnosis of Chronic Kidney Disease. Interface page development used in this research are presented in Figure 9.

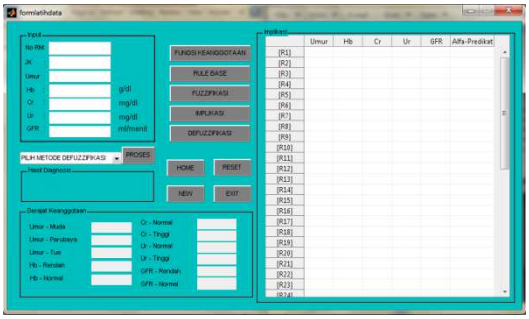

Figure 9. Interface Development Page

Form page of development used to edit the membership function, edit the rule base and to analyze the process of diagnosis of Chronic Kidney Disease based on Mamdani Fuzzy Inference System. In the form of this development page, input data obtained from a database stored of Ms.Excel "DATALATIH". Administrators only need to input the patient's medical record numbers, another input data will appear automatically. After the data input process is completed, the next step is to choose a defuzzification method to be used to know the results of the patient's diagnosis

Discussion

After the system is built , testing program needs to be done to determine the level of accuracy of the system in detecting the patient's pain based identity and laboratory results. In the process of testing system modification the fuzzy logic system using several methods defuzzification, namely MOM (Mean Of Maximum) and Bisector.

If given the identity of the patient and the results of laboratory examination of patients with a medical record number 1238964 (see Table 1). It will obtain the display form development as shown in Figure 10.

Table 1. Samples Identity and Laboratory Examination Results Patients

No	No RM	Nama	Jk	Umur	Hb	Cr	Ur	GFR	Diagnosis
7.	1238964	AI	P	48	13,1	22,75	181	2,3	CKD

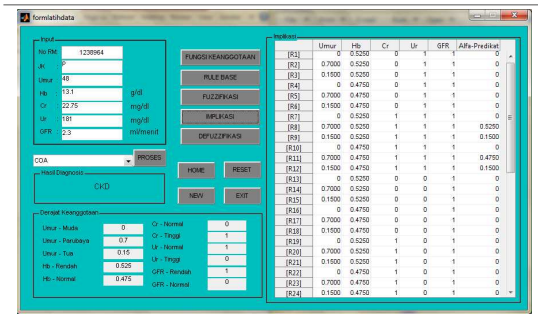

Figure 10. Interface Development Page and analisyst process

Analysis of process Mamdani Fuzzy Inference System method shown in Figure 10. fuzzification button push button is used to see the degree of membership of each variable. Implications push button serves to show the implications of the results shown in Table implications in Figure 10. The results of defuzzification shown in Figure 11.

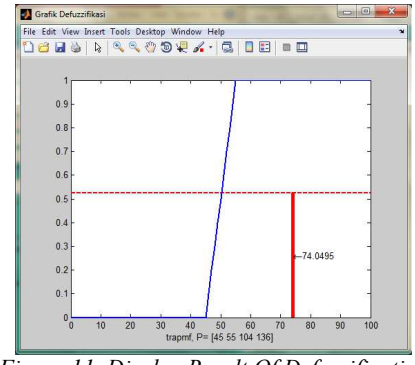

Figure 11. Display Result Of Defuzzification

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Results from the five defuzzification method is compared with the doctor's diagnosis that will be seen which method produces the highest level of system accuracy. Of the 100 training data and test data 75, obtained the analysis as shown in Table 2.

Table 2. Results Comparison of Defuzzification Method.

No	Deff	Result		*Accuracy*
		Recognized training data	Recognized test data	
1	MOM	97	73	97,14 %
2	Bisector	98	75	98,86 %

Based on Table 2, it was found that the defuzzification method on Mamdani Fuzzy Inference System which best in the in the process of diagnosis is a method of defuzzification Bisector which produces the highest level of system accuracy.

4. CONCLUSION

Based on the results of research and discussion of expert system based diagnosis of Chronic Kidney Disease Mamdani Fuzzy Inference System, it can be concluded as follows. (1) Development of expert system diagnosis of Chronic Kidney Disease begins with the formation of Fuzzy Inference System (FIS) using fuzzy logic toolbox in Matlab R2009a. FIS is formed to be used in the process of establishing the system. Early stage in the establishment of the system is the manufacture of interface design using Graphic User Interface, and then proceed with the complete code in Matlab R2009a. Once the diagnosis system is established, identity data and laboratory test results can be inputted patient. Further testing on the system by modifying defuzzification method to produce defuzzification method with the highest degree of accuracy. After that we will get the results of the diagnosis of the disease suffered by the patient. (2) In the measurement accuracy of the diagnosis system, made several modifications to the methods of defuzzification. There are two pieces of modification to produce a system with a high degree of accuracy. MOM method (Mean Of Maximum) produces an accuracy of 97.14% and Bisector produces accuracy of 98.86% generate the highest level of accuracy.

Expert system diagnosis of Chronic Kidney Disease allow for developed into a web-based system, so the system is easier to be accessed by the general public. For further research, it is expected the variable inputs detail because as the development of science, certainly still exist other variables that influence disease Chronic Kidney Disease.

REFERENCE

[1] Martin, J & S. Oxman. 1998. *Building Expert Systems a Tutorial.* New Jersey: Prentice Hall.

[2] Naik, M. V & Lokhanday, S., 2012, Building a Legal Expert System For Legal Reasoning In Specific Domain-A Survey, *International Journal of Computer Science & Information Technology (IJCSIT)* Vol 4, No 5, October 2012, pp 175-184.

[3] Samy S. Abu Naser, 1 Abu Zaiter A. Ola, 2008, An Expert System For Diagnosing Eye Diseases Using Clip, *Journal of Theoretical and Applied Information Technology (JATIT),* 2008 pp 923-930.

[4] Negnevitsky, M. 2005. *Artificial Intelligence A Guide to Intelligent Systems Second Edition*. England: Pearson Education.

[5] Khanale, P.B. & Ambilwade, R.P. 2011. A Fuzzy Inference System for Diagnosis of Hypothyroidism. *Journal of Artificial Intelligence,* 45. January 16-17, 2015.

[6] Gandomani, T.J., H. Zulzalil, A.Z.A. Ghani & A.A.MD. Sultan. 2013. Important Considerations For Agile Software Development Methods Governance. *Journal of Theoretical and Applied Informations Technology*. Vol. 55, No. 3 pp. 345-351.