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Web based Fuzzy Expert System Implementation using jFuzzyLogic and JAX-Web Service for Diarrhea Diagnosis

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Abstract— Viral infection is a common disease people suffer from, especially when there is a change in season or food habit. One of the common diseases is diarrhea; which may be caused due to viral or bacterial infection. With the revolutionizing technology, medical assistance and disease diagnosis for acute health problems can be done without going to the clinics and hospitals. People are very cautious while taking preventive measures for illness; technology has become a boon and is playing a vital role by providing enormous support in detection and cure. The paper illustrates the fuzzy expert system implementation for diagnosing diarrhea using jFuzzyLogic and Java API for XML Web Services (JAX-WS). The system provides convenient, realistic and reasonable means for medical practitioners and common man to diagnose health condition; so that proper medication can be taken.

Keywords— Artificial Intelligence, Bell Shaped Membership Function, Centroid of Area Defuzzification Method, Disease Diagnosis, Fuzzy Expert System, Triangular Membership Function

I. INTRODUCTION

With the advent of introduction and expansion of technologies, there has been a gigantic enhancement in problem solving capabilities using computers and electronic items. The desire of increased comfort in the people has evolved equipments that are mobile in terms of usability and have excellent decision making potential. Such systems are developed by injecting Intelligence and hence Artificial Intelligence domain has come into existence. An expert system is a computer system that emulates the decision-making ability of a human expert [1]. Contrary to the conventional programming procedure, these systems are designed to solve complex problems using reasoning through Boolean logic as if an expert advices to a problem. But the real world problems do not use Boolean values, instead they use crisp data. This triggered development of fuzzy expert system (FES), which uses fuzzy logic dealing with approximate reasoning rather than fixed and exact. The FESs are generally used as control systems or artificial intelligent systems for problem solving in various domains. One such emerging domain is disease diagnosis, where FESs can be exercised. This paper describes the FES for viral infection diagnosis using J2EE web application development and JAX-WS technology. The Section II describes the related work followed by system implementation as an experiment in Section III. The Section IV refers to the results and Section V concludes the paper.

II. RELATED WORK

The FESs have been used widely in the past two decades for problem solving in variety of domains like basic and applied science, law, agriculture, tourism, military operations and many more. Reference [2] describes the application of FES in performance assessment of health, safety, environment (HSE) and ergonomics system factors in a gas refinery. The system integrates the HSE and ergonomics system using fuzzy logic. Apart from reducing the human error, interpretation of enormous vague data are the main uses of the system. The system uses centroid average method and center of gravity defuzzification methods. The system acts as a decision support system to assist to evaluate the impact of the indicators on the performance, propose the solution for the predicted future deficiencies by the system. Reference [3] discusses the implementation of fuzzy logic based intelligent software for controlling the traffic lights. The system uses sensors that count the number of cars providing the controller to calculate the density of lane and hence allowing better traffic assessment. The system is also responsible for controlling the length of the green light depending on the lane density. Min Max implication defuzzification technique is used. The result of the system is in graphical representation such that user can analyze the controller performance. The paper also shows the comparison between the fuzzy logic control and conventional fixed-time traffic control. A distributed FES is explained in [4] as solution to petroleum engineers to solve the lost circular problem. From the interview sessions with experts, knowledge was extracted and organized in a hierarchical form. Thereafter the rules were created consisting of antecedent and consequents to develop the knowledge base – knowledge acquisition tool. The inference engine uses both the backward chaining as well as forward chaining. The paper illustrates the fuzzy algebra of strict monotonic operations for finite ordinal scales based on multi-sets and its implementation as a web based system as a solution to lost circular problem domain. With the motto of protecting water ecosystem, [5] articulates a rule based system for diagnosis and supervision of waste water treatment. The system focuses on automatic generation of fuzzy rules from the recorded data according to the decided structure. The

system is designed using Gaussian and triangular membership functions for input and output linguistic variables respectively. The system uses few physical and chemical variables recorded continuously and decides the water quality. Ref. [6] describes the FES for analysis of umbilical cord acid based data. The knowledge base not only includes the expertise of obstetricians, neonatologists and physiologists, but also combines the knowledge of the errors. The error might be encountered during acid-base measurement, generation of physiological knowledge of plausible results and statistical knowledge of a large database of results. The system identifies for errors in input parameters and provides a solution intelligently. The web based FESs are developed for heart disease diagnosis [7], managing tourism information [8] and frost warning in horticultural crops [9].

Ref. [10] publicizes the framework for mobile based FES for viral infection diagnosis. This paper is the partial extension of it; which explain the implementation of the FES and web service integration.

III. PROPOSED WORK

This section describes the development and hosting of the FES for medical practitioner to diagnose acute viral infection - diarrhea. An archetypal web application is developed to use the intelligent system to diagnose the viral infection. The core objective to develop the web application instead of mobile client is to test the functionalities of the web service and the inference mechanism of the FES.

The major components of the system are FES, Web Service, Web application and Web Server. Fig. 1. shows the architecture of the proposed system.

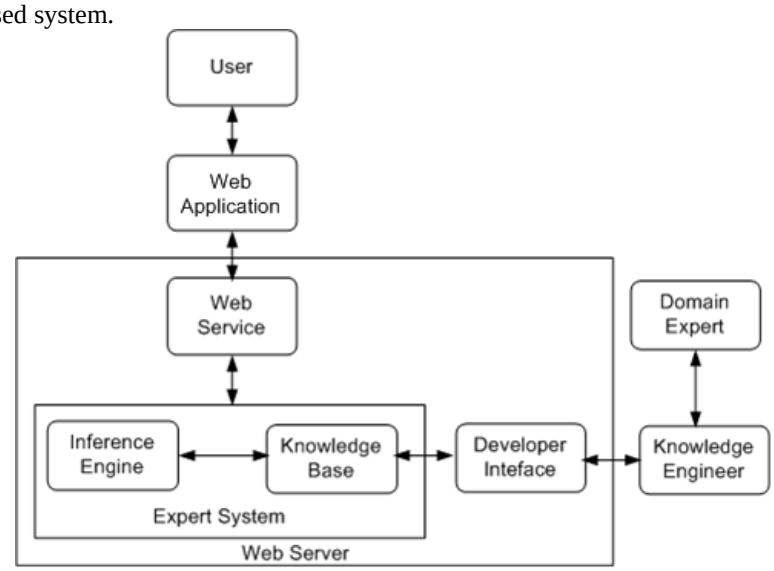


Fig. 1. System Architecture

A. *Web Application*

The web application is the client to test the FES; to diagnose diarrhea. The user inputs the symptoms and its severity and sends the request. The request is directed to the web service; where in the symptoms and corresponding severity are extracted from the request, fuzzified and set as input parameters to the inference engine. The result of the FES is formatted and the response is sent back to the web application. The input screen and the result screen are displayed in the Fig. 2.

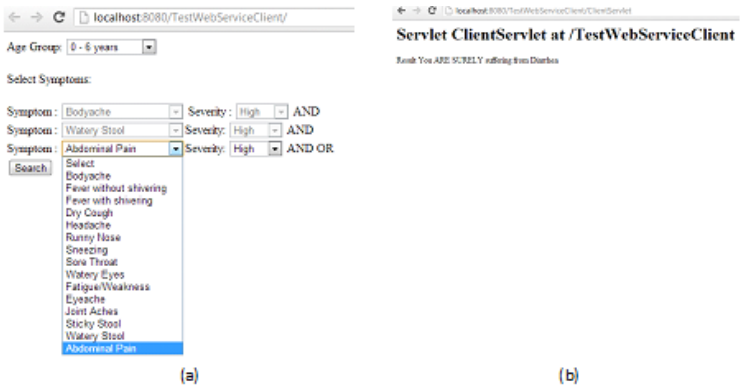


Fig. 2. Input and Output Screen

B. *Web Server*

The GlassFish Server is used as the Web Server which manages the two web-applications, the client web-app that takes the symptoms and severity from the user and displays the response in the form of possibility of diarrhea. The second web-app includes the web-service which communicates with the FES to diagnose the diarrhea.

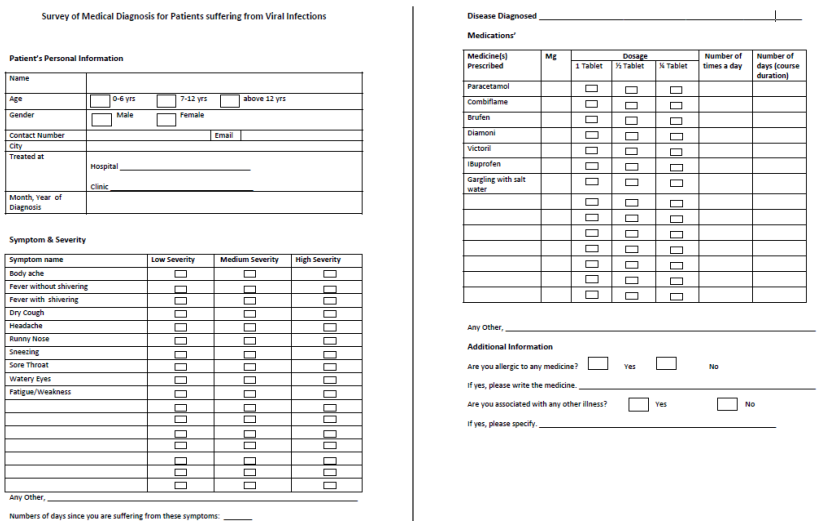
C. Web Service

Web services are web-based enterprise applications that use open, XML-based standards and transport protocols to exchange data with calling clients [11]. The purpose of implementing the web-service is to create a common communication medium between the FES and the client – a web application, a mobile application or a PDA client. In this system, Java API for XML Web Services (JAX-WS) specification has been used. The responsibilities of the web service are to extract the list of symptoms and corresponding severity from the request and convert it into the acceptable format of the inference engine and to convert the FES response in the presentable format.

D. Fuzzy Expert system

FES is a type of expert system that is oriented towards numerical processing. Fuzziness describes vagueness, so the fuzzy logic variables also termed as linguistic variables have value that fall between 0 and 1 [12]. The degree of truth is represented using membership functions, which ideally is a mapping between the crisp value and the fuzzy value. The process of conversion of crisp value into fuzzy value is called fuzzification. The fuzzy value is processed by the inference engine which iterates through the rules defined in the knowledge base to check for the ideal condition to predict the output. The output; being the fuzzy value, has to be converted into crisp value which is done by defuzzification process. The book chapter [13] describes the steps to develop the FES. The knowledge base and the inference engine are the constituents of FES. The knowledge base is developed by the knowledge engineer and the domain expert, where the domain expertise is converted into the pattern-action format that can be stored in the data store. Following sub sections explain the conceptual and developmental methodology for the system.

1) *Knowledge Acquisition:* Knowledge base is an essential part of the expert system; it is used for decision making. The knowledge base is the collection of expertise where the expert's knowledge is converted in to the data storage format – generally if-then rules. The process of excavating, formatting and organizing knowledge from one source to a software component is called knowledge acquisition [14]. Various ways of knowledge acquisition include questionnaire, interviews with experts, e-materials like encyclopaedia and books, previous research results.



Survey of Medical Diagnosis for Patients suffering from Viral Infections

Patient's Personal Information

Name	
Age	0-6 yrs 7-12 yrs above 12 yrs
Gender	Male Female
Contact Number	Email
City	
Treated at	Hospital _____ Clinic _____
Month, Year of Diagnosis	

Symptom & Severity

Symptom name	Low Severity	Medium Severity	High Severity
Body ache			
Fever without shivering			
Fever with shivering			
Dry Cough			
Headache			
Runny Nose			
Sneezing			
Sore Throat			
Watery Eyes			
Fatigue/Weakness			

Any Other, _____

Numbers of days since you are suffering from these symptoms: _____

Disease Diagnosed _____

Medications'

Medicine(s) Prescribed	Mg	Dosage: 1 Tablet	½ Tablet	¼ Tablet	Number of times a day	Number of days (course duration)
Paracetamol						
Combiflame						
Brufen						
Diamoni						
Victorii						
Ibuprofen						
Gargling with salt water						

Any Other, _____

Additional Information

Are you allergic to any medicine? Yes No

If yes, please write the medicine. _____

Are you associated with any other illness? Yes No

If yes, please specify. _____

Fig. 3. Questionnaire for viral infection diagnosis

2) For the case study, a series of interviews were carried out with multiple doctors to collect the symptoms and associated medicine. The symptoms' severity were also considered while calculation of medication. Medicine books and encyclopedia were referred to generalize the collected information. A questionnaire was designed to survey the symptom and medication list as shown in Fig. 2. A survey of 100 patients was carried out to collect the data about symptoms, disease and medications. After collecting all the data, we had a number of sittings with the experts to finalize the knowledge base for symptoms, diseases and their medications.

3) *Fuzzification:* Fuzzification is the process of converting the crisp data into fuzzy data or membership functions [15]. This process results into the data that falls between range 0 and 1. A membership function defines a mapping between the crisp data and the fuzzy data. A set is a collection of elements which have some degree to belong to it; i.e. a set having degree of membership (generally defined as a mathematical formula) is called a fuzzy set. Fuzzy sets were introduced as a extension of the classical notation of set [16]. A membership function for a fuzzy set A on the universe of discourse X is defined as

$$\mu A{:}X \rightarrow [0,1] \qquad 1$$

where each element of X is mapped to a value between 0 and 1. When the universe of discourse X is discrete and finite, the fuzzy set A can be represented as

$$A = \sum_{i} \frac{\mu A(xi)}{(xi)} \qquad 2$$

When the universe of discourse X is continuous and infinite, the fuzzy set A can be represented as

$$A=\int \frac{\mu A(x)}{(x)} \quad (3)$$

Various membership functions have been defined to derive the fuzzy sets. Singleton, triangular, trapezoidal, S-shaped, Gaussian are few examples of membership functions [17]. Selection of the membership function is also a critical part since the only restriction that a membership function has to satisfy is that the values must be in [0,1] range [18]. The system uses triangular and bell shaped membership functions. They are mathematically defined as (4) and (5) [19].

$$\text{triangle}(x;a,b,c)=\begin{cases}0, & x\le a.\\ \frac{x-a}{b-a}, & a\le x\le b.\\ \frac{c-x}{c-b}, & b\le x\le c.\\ 0, & c\le x.\end{cases} \quad (4)$$

$$\text{bell}(x;a,b,c)=\frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}}, \quad (5)$$

$$\text{triangle}(x;a,b,c)=\max\left(\min\left(\frac{x-a}{b-a},\frac{c-x}{c-b}\right),0\right) \quad (6)$$

The system has been tested for detecting diarrhea as case study. The major symptoms are watery stool and abdominal pain whereas the minor symptoms are fatigue, fever and body ache. For each symptom three levels of severity are bound – low, medium and high. The Fig. 4 shows the graphical representation of the membership functions. The subsections – (a), (b) and (c) represent body_ache, fever and watery_stool symptoms; linguistic input variables and (d) shows the membership function for diarrhea; linguistic output variable

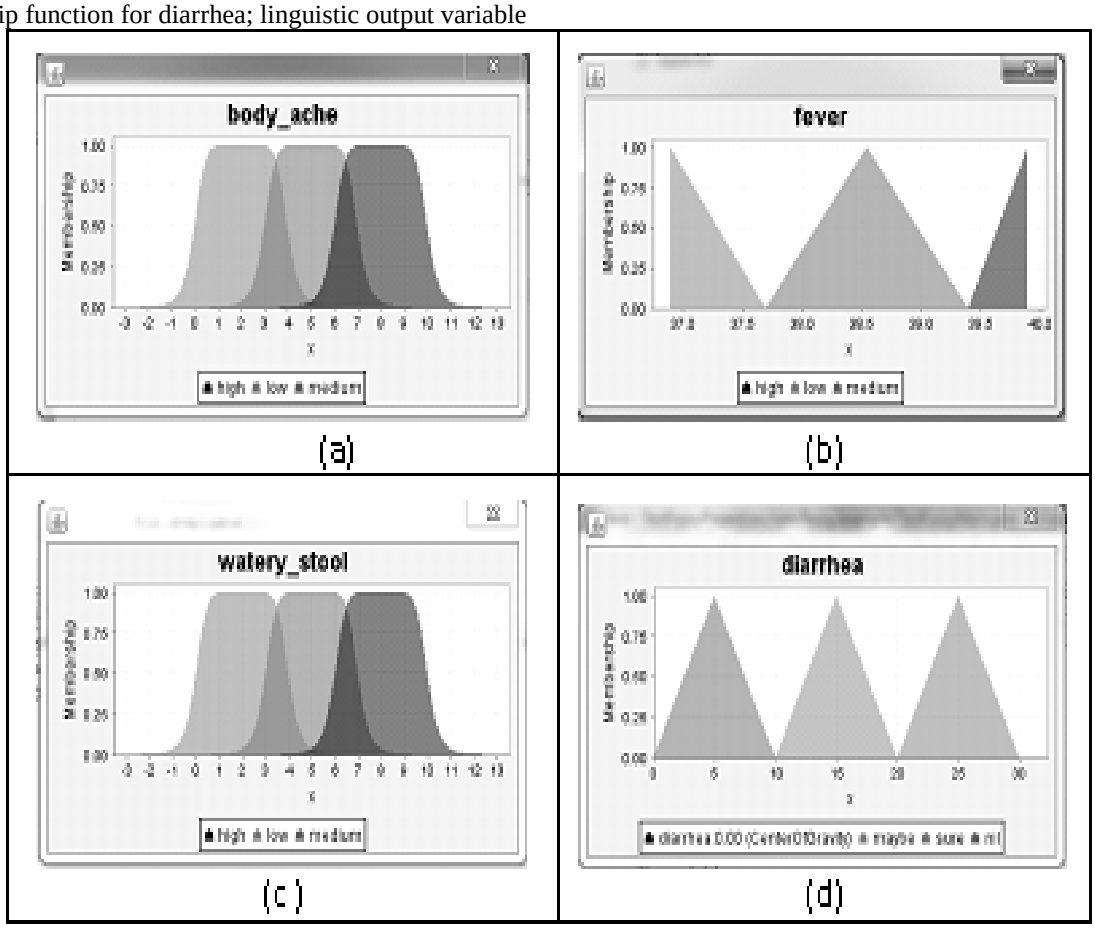


Fig. 4. Graphical representation of membership functions

Fig. 5 displays some of the rules; used by the inference engine for decision making.


```
RULE 1 : IF watery_stool IS high AND (body_ache is high OR fatigue is high
            OR abdominal_pain is high OR fever is high)
            THEN diarrhea IS sure;

RULE 2 : IF watery_stool IS high AND (body_ache is medium OR fatigue is medium
            OR abdominal_pain is medium OR fever is medium)
            THEN diarrhea IS sure;

RULE 3 : IF watery_stool is high AND (body_ache is low OR fatigue is low
            OR abdominal_pain is low OR fever is medium)
            THEN diarrhea is maybe;

RULE 4 : IF watery_stool IS medium AND (body_ache is high OR fatigue is high
            OR abdominal_pain is high OR fever is high)
            THEN diarrhea IS sure;

RULE 5 : IF watery_stool IS medium AND (body_ache is medium OR fatigue is medium
            OR abdominal_pain is medium OR fever is medium)
            THEN diarrhea IS sure;

RULE 6 : IF watery_stool is medium AND (body_ache is low OR fatigue is low
            OR abdominal_pain is low OR fever is medium)
            THEN diarrhea is maybe;

RULE 7 : IF watery_stool IS low AND (body_ache is high OR fatigue is high
            OR abdominal_pain is high OR fever is high)
            THEN diarrhea IS maybe;

RULE 8 : IF watery_stool IS low AND (body_ache is medium OR fatigue is medium
            OR abdominal_pain is medium OR fever is medium)
            THEN diarrhea IS nil;
```

Fig. 5. Fuzzy Expert System Rules

4) Inference Engine: The operations on fuzzy sets; fuzzy unions, fuzzy intersections and fuzzy complements are the fuzzy set operations. The fuzzy operations are used by the inference engine for deriving the result of expert system. Their role is like a brain of the human body; an inevitable component; used for reasoning. The inference engine is implemented using jFuzzyLogic – which is an open source fuzzy logic package (developed in java) that implements that fuzzy logic control (FCL) specification [20]. The FCL file consists of function blocks. A single function block consists of input and output variables; for each input variable a block is defined which defines how the variable is fuzzified and for the output variable a block is defined which evaluates how the variable is defuzzified. A rule block is another component of function block which defines the rules for the expert system. A single FCL file can have multiple function blocks.

5) Defuzzification: In simple words, a defuzzifier's responsibility is to convert the fuzzy value in the crisp value and the process is called defuzzification. There are mainly five defuzzification methods – Centroid of area, Bisector of area, Mean of maximum, smallest of maximum and largest of maximum [19]. The system uses Centroid of area defuzzification method. Equation (7) demonstrates the calculation of defuzzified value.

$$z_{\mathrm{COA}} = \frac{\int_Z \mu_A(z) z \, dz}{\int_Z \mu_A(z) \, dz},$$

where μA(z) is the aggregated output of membership function. The inference engine results into the graph as shown in Fig. 6, when above defined membership functions and defuzzification method is used, with the following parameters as in Fig. 7.

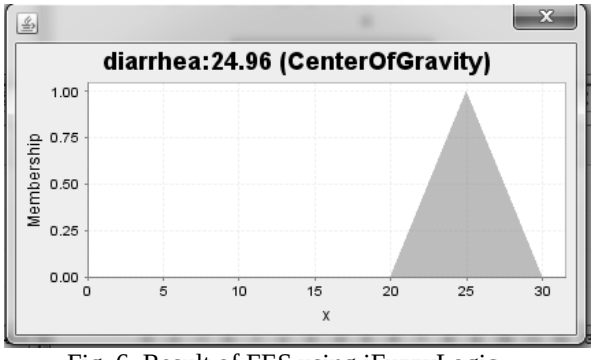


Fig. 6. Result of FES using jFuzzyLogic

```
// Set inputs
fis.setVariable("watery_stool", 7);
fis.setVariable("body_ache",7);
fis.setVariable("fever", 6);
fis.setVariable("abdominal_pain", 7);
fis.setVariable("fatigue", 8);
```

Fig.7. Input values

IV. RESULTS

The system has been tested for a sample of 50 patients suffering from diarrhea at five different clinics. Since the system is in the development phase, the symptom and severity list were taken manually and fed to the web application system. The web-app sends the request to the FES by invoking the web-service. The defuzzified response is sent to the web-app as the web-service response. The system gave results with 95% accuracy. The manual results and system results comparison is graphically described in the Fig. 8.

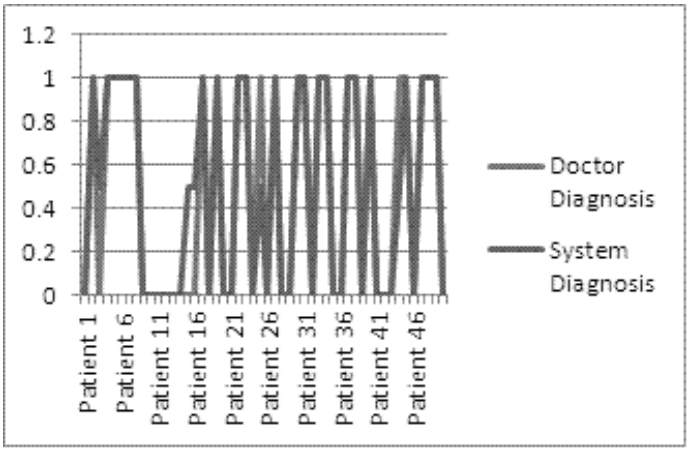


Fig. 8. Comparison of Diagnosis

Depending on the results, proper medicine can be given to the patient. In future, medicine detection can also be incorporated once the disease is diagnosed.

V. CONCLUSIONS

With the continuous innovations in the technology, most of the problem solutions are provided using technical systems. The paper presents a computerized solution to the medical practitioners for diagnosing diarrhea. The system described is an integration of FES, web-service and web-application; very much beneficial to the users to diagnose a very common and not-so-serious infection. The system uses jFuzzyLogic to implement the FES; triangular and bell shaped membership functions and Center of Gravity defuzzification method. The usage of web-service is novel in the system that allows the extension of the system. Currently, a web-app is used as a client, in future it can be extended by a mobile application client or PDA client app and detecting medications from the knowledge base.

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REFERENCES

[1] Peter Jackson, Introduction to Expert Systems (3 ed.): Addison Wesle, 1998.
[2] I.M. Fam, M. Khoshnoud, M. Nikafrouz A. Azadeh, "Design and implementation of a fuzzy expert system for performance assessment of an integrated health, safety, environment (HSE) and ergonomics system: The case of a gas refinery," vol. 178, no. 22, 2008.
[3] Marzuki Khalid and Rubiyah Yusof Kok Khiang Tan, "Intelligent Traffic Lights Control by Fuzzy Logic," vol. 9, no. 2, 1996.
[4] Ildar Batyrshin, Denis Filatov, Jorge Martinez, Hector Rodriguez Leonid Sheremetov, "Fuzzy expert system for solving lost circulation problem," vol. 8, no. 1, 2008.
[5] J Rodríguez , A Punal, E Roca, JM Lema EF Carrasco, "Rule-based diagnosis and supervision of a pilot-scale wastewater treatment plant using fuzzy logic techniques," vol. 22, no. 1, 2002.
[6] Jennifer A. Westgate, Emmanuel C. Ifeachor Jonathan M. Garibaldi, "The evaluation of an expert system for the analysis of umbilical cord blood," Artificial Intelligence in Medicine, vol. 17, pp. 109–130, 1999.
[7] Mehdi.Neshat Ali.Adeli, "A Fuzzy Expert System for Heart Disease Diagnosis", Hong Kong, 2010.
[8] Uzoka F.M.E Akinnuwesi B.A, "A Framework of Web Based Fuzzy Expert System for Managing Tourism Information," vol. 20, no. 3, 2009.
[9] Gerrit Hoogenboom, Ronald W. McClendon, Joel O. Paz Robert F. Chevalier, "A web-based fuzzy expert system for frost warnings in horticultural crops," vol. 35, 2012.
[10] Paresh Virparia Maitri Patel, "Designing Mobile Based Fuzzy Expert System Framework For Viral Infection Diagnosis," International Journal of Current Research and Review, vol. 4, no. 12, pp. 139-146, 2012.
[11] Sun Microsystems, The Java EE 5 Tutorial, 2007.

[12] V., Perfilieva, I. and Močkoř, J. Novák, Mathematical principles of fuzzy logic: Dodrecht: Kluwer Academic., 1999.
[13] Jonathan M. Garibaldi: Do Smart Adaptive Systems Exist?: Best Practice for Selection and Combination of Intelligent Methods, 2005, pp. 105-132.
[14] P.H. Jones, "Knowledge Acquisition," in Knowledge Engineering in Agriculture. ASAE Monograph No. 8: ASAE, 1989.
[15] Dali Wang Ying Bai, "Fundamentals of Fuzzy Logic Control – Fuzzy Sets, Fuzzy Rules and Defuzzifications," in Advanced Fuzzy Logic Technologies in Industrial Applications: Springer London, 2006, pp. 17-36.
[16] L. A. ZADEH, "Fuzzy sets," Information and Control, vol. 8, no. 3, 1965.
[17] Kálmán Milán Bolla Zsolt Csaba Johanyák, "Development Of A Toolbox Supporting Fuzzy Calculations," Annals Of Faculty Engineering Hunedoara – International Journal Of Engineering, pp. 193-196, 2011.
[18] Mariagrazia Dotoli, Bruno Maione , Dee Politecnico Di Bari , Dee Politecnico Di Bari Bernadette Bouchon-meunier. CiteSeerX. [Online]. http://130.203.133.150/viewdoc/summary?doi=10.1.1.52.8144
[19] Chuen-Tsai Sun, Eiji Mizutani Jyh-Shing Roger Jang, Neuro-fuzzy and soft computing: a computational approach to learning and machine intelligence: Prentice Hall, 1997.
[20] J. Alcala-Fdez P. Cingolani, "jFuzzyLogic: A Robust and Flexible Fuzzy-Logic Inference System Language Implementation," in IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Brisbane, QLD, 2012, pp. 1-8.

