SIMULATION OF MEDICAL DIAGNOSIS SYSTEM FOR MALARIA USING FUZZY LOGIC

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ABSTRACT

One major problem that the developing countries are facing is the shortage of medical expertise in medical science, most developing countries are spending fortune to meet this challenge but still they are unable to meet the demands. Because of these, they are unable to provide good medical services to their people. Patients also find a huge queue in hospitals particularly in government hospitals. It has become of great concern to find a lasting solution to the problem of malaria in Africa because the government of these countries has spent most part of their budget on the control of malaria and related diseases. An expert system has been found to be one of the solutions to the above problems since it help to diagnosis difference types of diseases. One major problem in medical diagnostic is precision and accuracy. The traditional method of medical diagnostic is characterized with the aforementioned problems. The advent of computer has led to the development of several algorithms and technologies to ensure accuracy and precision, one of such technologies is fuzzy logics which is a branch of artificial intelligence. In this paper the authors developed a medical diagnostic system using fuzzy logic; so as to enhance the accuracy and precision of the entire system. The proposed medical diagnostic system was developed using Visual Prolog Programming language. The proposed system will go a long way in bringing precision and certainty to the overall method of medical diagnose and assist medical personnel in the tedious and complication task of diagnosing and further provide a scheme that will assist medical personnel. More advance medical diagnosis system can be designed to help in the area like drugs prescription, registering of patients as well as keeping of patients' details and records in the medical sector.

Keywords: Malaria, Fuzzy Logic, Expert system, Diagnosis, Artificial intelligence

1. INTRODUCTION

Nowadays the use of computer technology in the fields of medical diagnosis, treatment of illnesses and patient pursuit has highly increased. Despite the fact that these fields, in which the computers are used, have very high complexity and uncertainty and the use of intelligent systems such as fuzzy logic, artificial neural network and genetic algorithm have been developed. Malaria has been a challenge for the developed and developing countries of the world for irradiating. Malaria remain to be the most vital cause of morbidity and mortality in many tropical countries with complete 2 to 3 million new cases arising every year Priynka, Singh, Manoj & Nidhi (2013). Malaria is a major health problem in the world. Malaria is well-known oldest chronic and most widespread fatal disease that has plagued mankind for centuries, which also causes economical loss Priynka, et al. (2013). At present, malaria is the Third World's most dreaded killer (Singh & Rahman, 2001).

The direct costs of malaria include combustion of personal and public expenditures on both prevention and treatment of the disease and the indirect cost of malaria are the human sufferings caused by the disease Priynka, et al (2013). In recent time, Artificial Intelligent methods have significantly been used in medical applications and research efforts have been concentrated on medical expert systems as complementary solution to conventional technique for finding solution to medical problems. The emergence of Information Technology (IT) has opened unprecedented opportunities in health care delivery system as the demand for intelligent and knowledge-based systems has increased as modern medical practices become more knowledge-intensive Djam, & Wajiga (2012). The diagnosis of diseases involves several levels of uncertainty and imprecision. The task of disease diagnosis and management is complex because of the numerous variables involved Eve, & Michael (2008). It is made more so because of a lot of imprecision and uncertainties. Patients cannot describe exactly how they feel, doctors and nurses cannot tell exactly what they observe and laboratories results are dotted with some errors caused either by the carelessness of technicians or malfunctioning of the instrument. Medical researchers cannot precisely characterize how diseases alter the normal functioning of the body. All these complexities in medical practice make traditional quantitative approaches of analysis inappropriate. Computer tools help to organize, store and retrieve appropriate medical knowledge needed by the practitioner in dealing with each difficult case and suggesting appropriate diagnosis, prognosis, therapeutic decisions and decision-making technique.

Diagnosis is concerned with the development of algorithms and techniques that are able to determine whether the behaviour of a system is correct or not. If the system is not functioning correctly, the algorithm should be able to determine, as accurately as possible, which part of the system is failing, and which kind of fault it is facing. The computation is based on observations, which provide information on the current behaviour. The expression diagnosis also refers to the answer of the question of whether the system is malfunctioning or not, and to the process of computing the answer. This word comes from the medical context where a diagnosis is the process of identifying a disease by its symptoms. Among all the soft computing techniques, the concept of fuzzy logic is adopted in this research mainly due to its capability to makes decisions in an environment of imprecision, uncertainty and incompleteness of information. In addition, another advantage of choosing fuzzy logic is due to the fact that, fuzzy logic resembles human decision making with its ability to work from approximate reasoning and ultimately find a precise solution. Fuzzy expert systems incorporate elements of fuzzy logic, which is a logically consistent way of reasoning that can cope with uncertainty, vagueness and imprecision inherent in medical diagnosis.

It is widely accepted that the main components of soft computing are fuzzy logic, probabilistic reasoning, neural computing, and genetic algorithms. Fuzzy logic was adopted in this work because it is a powerful tool for dealing with the problem of knowledge representation in an environment of uncertainty and imprecision. Soft computing methods can be used in an uncertain economic decision environment to deal with the vagueness of human thought and the difficulties in estimating inputs. Fuzzy logic has been used to bridge the gap between traditional approaches of diagnosis and computer-assisted diagnosis by handling the issues of vagueness, imprecision and ambiguity inherent in medical diagnosis. Every trustworthy expert knows that his or her medical knowledge and resulting diagnosis are pervaded by uncertainty with imprecise formulations.

Where uncertainty exists such as in the medical field, fuzzy logic could play an important role in making decisions. Fuzzy logic is the science of reasoning, thinking, and inference that recognizes and uses the real world phenomenon that every-thing is a matter of degree. In the simplest terms, fuzzy logic theory is an extension of binary theory that does not use crisp definitions and distinctions. Instead of assuming everything must be defined crisply into black and white (binary view), fuzzy logic is a method that captures and uses the concept of fuzziness in a computationally effective manner.

2. RELATED WORKS

The history of computerized medical diagnosis is a history of intensive collaboration between physicians and mathematicians respectively electrical engineers or computer scientists. In the late 1950s Ledley and Lusted published Reasoning Foundations for Medical Diagnosis Ledley & Lusted (1959), Lipkin, & Hardy (1958) and Ledley & Lusted (1962) wrote on the methods for the use of card and needle systems for storage and classification of medical data and systematic medical decision-making. In the 1960s and 1970s various approaches to computerized diagnosis using Bayes rule Wardle, & Wardle (1976) and Woodbury (1963) factor analysis, and decision analysis Ledley, & Lusted, (1962). On the other side artificial intelligence approaches came into use, e.g., DIALOG (Diagnostic Logic) Pople, Myers & Miller (1975) and PIP (Present Illness Program) Parker et al. (1976) which were programs to simulate the physicians reasoning in information gathering and diagnosis using databases in form of networks of symptoms and diagnoses.

A medical expert system for managing tropical diseases was proposed by Adekoya, Akinwale & Oke (2008). The proposed Medical Expert Solution (MES) system was to assist medical doctors to diagnose symptoms related to a given tropical disease, suggests the likely ailment, and advances possible treatment based on the MES diagnosis. The MES uses a knowledge-base which composes of two knowledge structures; namely symptoms and disease. The MES inference engine uses a forward chaining mechanism to search the knowledge-base for symptoms of a disease and its associate therapy which matches the query supplied by the patient. The MES is useful for people who do not have access to medical facilities and also by those who need first-aid solution before seeing medical consultant. Obot, & Uzoka (2008) designed a fuzzy rule-based framework for the management of tropical diseases. The objective of the research was to apply the concept of fuzzy logic technology to determine the degree of severity on tropical diseases. The root sum square of drawing inference was employed to infer the data from the rules developed. Center-of-gravity method was used for defuzzification.

An expert system for malaria environmental diagnosis by Oluwagbemi, Adeoye, & Fatumo (2009) was developed for providing decision support to malaria researchers, institutes and other healthcare practitioners in malaria endemic regions of the world. The motivation of the work was due to the insufficient malaria control measures in existence and the need to provide novel approaches towards malaria control. Several related work have shown that malaria remains a major public health problem in Africa Khalid et al (2009). However, concerted efforts are continually been made to control malaria spread and transmissions within and between communities. In the work carried out by Utzinger et al., (2001), it was reported that monthly malaria incidence rates and vector densities were used for surveillance and adaptive tuning of the environmental management strategies; which resulted in a high level of performance. Within 3-5 years, malaria-related mortality, morbidity and incidence rates were reduced by 70-95% Utzinger et al., (2001). In a recent study, it was concluded that malaria control programmes that emphasized environmental management were highly effective in reducing morbidity and mortality Keiser, Singer, & Utzinger, (2005). Another study also showed that Environmental management of mosquito resources is a promising approach with which to control malaria, but it has seen little application in Africa for more than half a century Gerry et al, (2004).

The great failure of malaria control in Africa, from a district perspective in Burkina Faso was highlighted in the work carried out by Kouyaté et al., (2007).An integrated approach to malaria control was presented by Clive, (2002). In the scientific commentary delivered by Jeffrey, (2001), he stressed the need for a new global commitment to disease control in Africa. In the commentary, malaria was among the diseases highlighted Jeffrey (2001). However, in the work carried out by Vincent & Thomas, (2003), it was observed that malarial control strategies consisted majorly of chemotherapy directed against the malaria parasite and prevention of mosquito vector/human contact using insecticide-impregnated bednets. This control strategy achieved minimum results Alibu, & Egwang (2003).

Another research was carried out on the island of Bioko (Equatorial Guinea). The purpose of this study was to access the impact of the two control strategies (insecticide treated nets (ITNs) indoor residual spraying (IRS) on the island of Bioko (Equatorial Guinea), with regards to Plasmodium infection and anaemia in the children under five years of age. The results obtained showed that IRS and ITNs have proven to be effective control strategies Gema, et al (2006). Recently, a research was conducted to determine the cost effectiveness of selected malaria control interventions. It was concluded that on cost effectiveness grounds, in most areas in sub-Saharan Africa, greater coverage with highly effective combination treatments should be the cornerstone of malaria control Chantal, Jeremy, & David, (2005). Therefore, there is a pressing need to research into the best methods of deploying and using existing approaches, such as rapid methods of diagnosis, to have effective control over malaria transmissions Guerin, et al, (2002).

3. DESIGN OF THE PROPOSED SYSTEM

3.1 Proposed Fuzzy Medical Diagnosis System
This section describes the approach adopted in developing the overall framework for the fuzzy medical diagnosis system for malaria fever (Fig.1). The framework comprises of three major components; User Interface, Information Manager, Knowledge Base, Fuzzy Inference System, Results output.
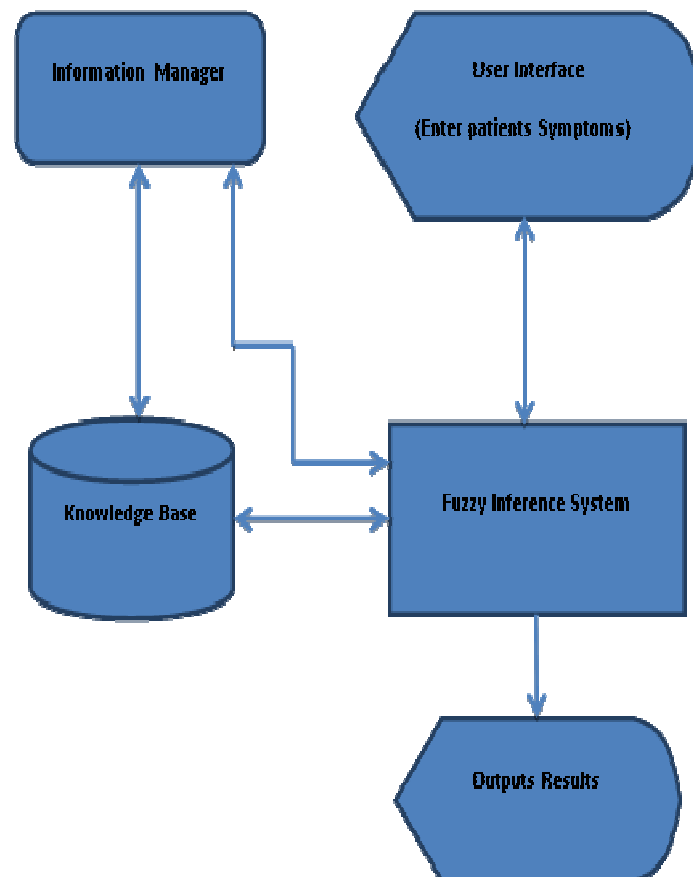

Figure 1: Fuzzy medical diagnosis system

❖ **User Interface**: This provides a graphic interface showing the symptoms considered and their respective acronyms. Also provides based an interactive interface where patient can enter their symptoms in relation to its intensity during knowledge acquisition.

❖ **Information Manager**: This is used in creation and manipulation of information I the Knowledge base, for maintaining the patient history. The information manager manages the Knowledge base. This system uses time series forecasting method to predict the future using past and present data.

❖ **Knowledge Base**: The symptoms of the patient is keyed into the system and based on the weights of the symptoms stored in the knowledge base, the symptoms are fuzzified. Also it is base is used to store rules related to patient's symptoms and diseases. The knowledge base maintains two tables for each entity set to store the current data and historical data separately.

❖ **Fuzzy Inference System**: The inference engine has two components namely a scheduler for scheduling the rules to be fired and an interpreter that fires the rules using forward chaining inference technique. It applies fuzzy rules to make decision on diseases.

❖ **Result Output**: The result is displayed which shows the diagnosis of the patient.

3.2 Algorithm for the propose system
Step 1:
Input signs and symptoms of patient complaint into the system.
Where n = number of signs and symptoms.
Step 2:
Search the knowledge-base for the disease d, which has the signs and symptoms identified.
Step 3:
Get the weighing factors (wf) (the associated degree of intensity) wf = 1, 2, 3, 4
Where 1 = Mild, 2 = Moderate, 3 = Severe, 4 = Very Severe.
Step 4:
Apply fuzzy rules.
Step 5:
Map fuzzy inputs into their respective weighing factors to determine their degree of membership.
Step 6:
Determine the rule base evaluating (non-minimum values).
Step 7:
Determine the firing strength of the rules R.
Step 8:
Calculate the degree of truth R, of each rules by evaluating the nonzero minimum value.
Step 9:
Compute the intensity of the disease.
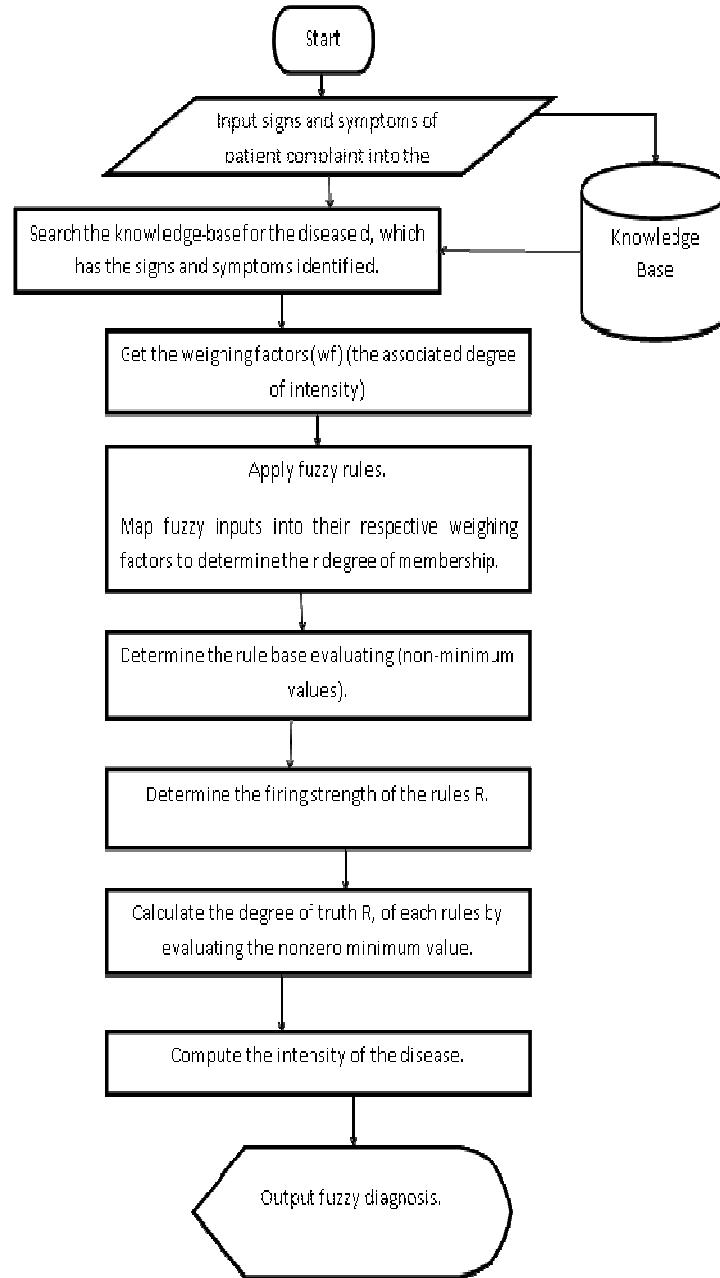*Step 10:*
Output fuzzy diagnosis.

Figure 2: Flowchart for the medical diagnosis system

3.3 Unified Modeling Language

The Unified Modeling Language (UML) analysis proposed system could be done using the following:

a.   Class Diagram

b.   Use Case Diagram

c.   Sequence Diagram

d.   Activity Diagram

3.3.1 Class Diagram

The class diagram (Fig. 3) in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects.
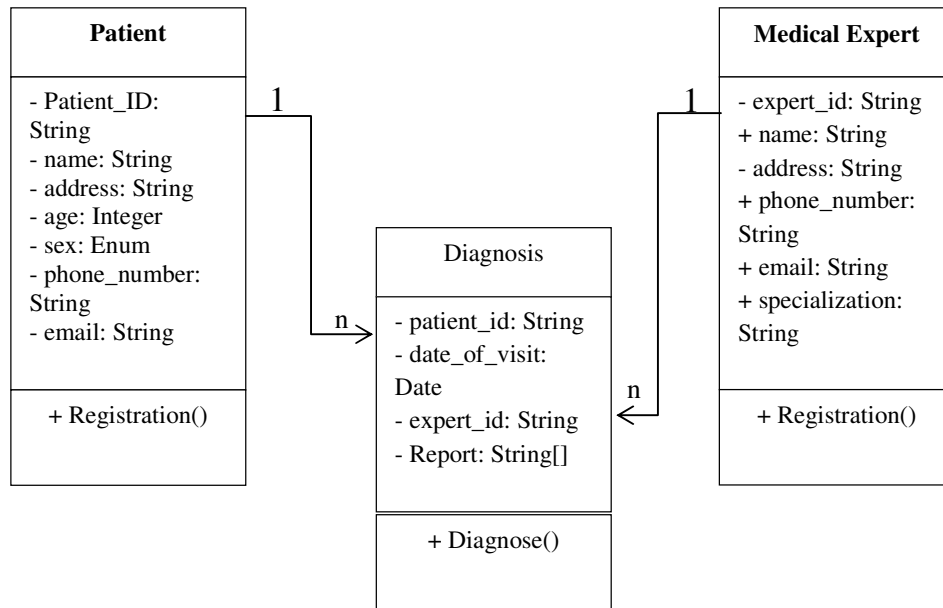

Figure 3.: Class Diagram for the proposed System

3.3.2 Use Case Diagram

A use case diagram (FIG 4) at its simplest is a representation of a user's interaction with the system and depicting the specifications of a use case. A use case diagram can portray the different types of users of a system and the various ways that they interact with the system. This type of diagram is typically used in conjunction with the textual use case and will often be accompanied by other types of diagrams as well.
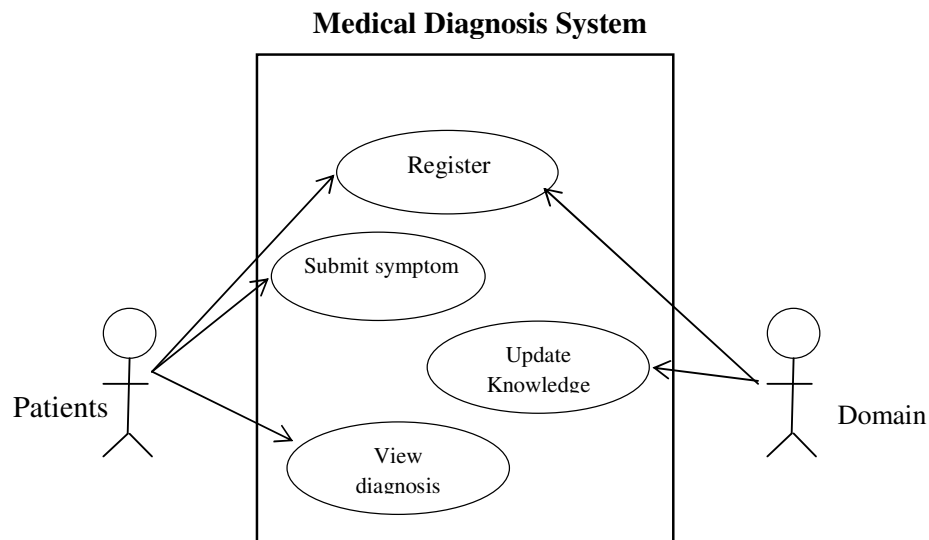

Figure 4: Use Case Diagram for the proposed System

3.3.3 Sequence Diagram
A sequence diagram (Fig 5) is an interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams, event scenarios
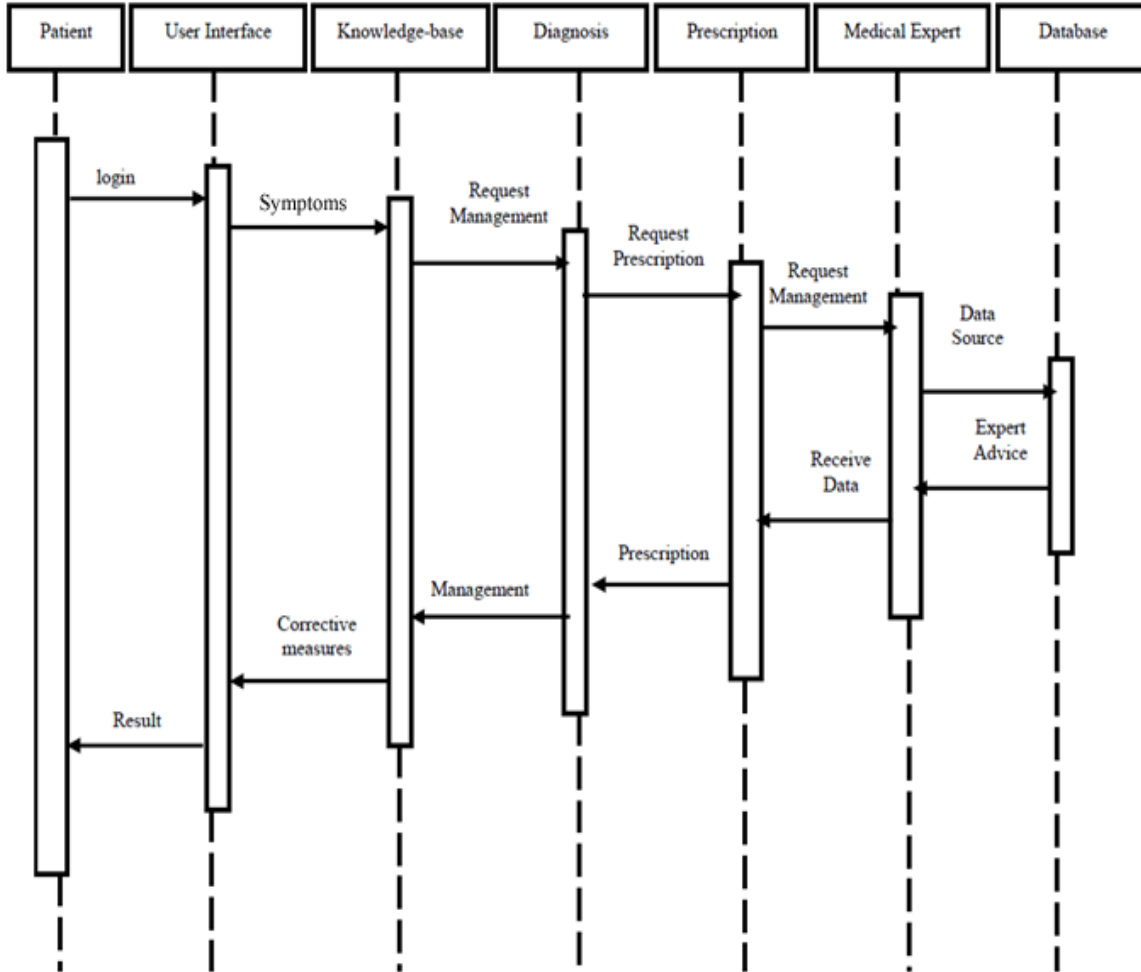

Fig. 5: Sequence Diagram

3.3.4 Activity Diagram

Activity diagrams (Fig 6) graphically show represent the performance of actions or sub activities and the transaction that are triggered by the completion of the actions or sub actions. It is a means of describing the workflow of activities.
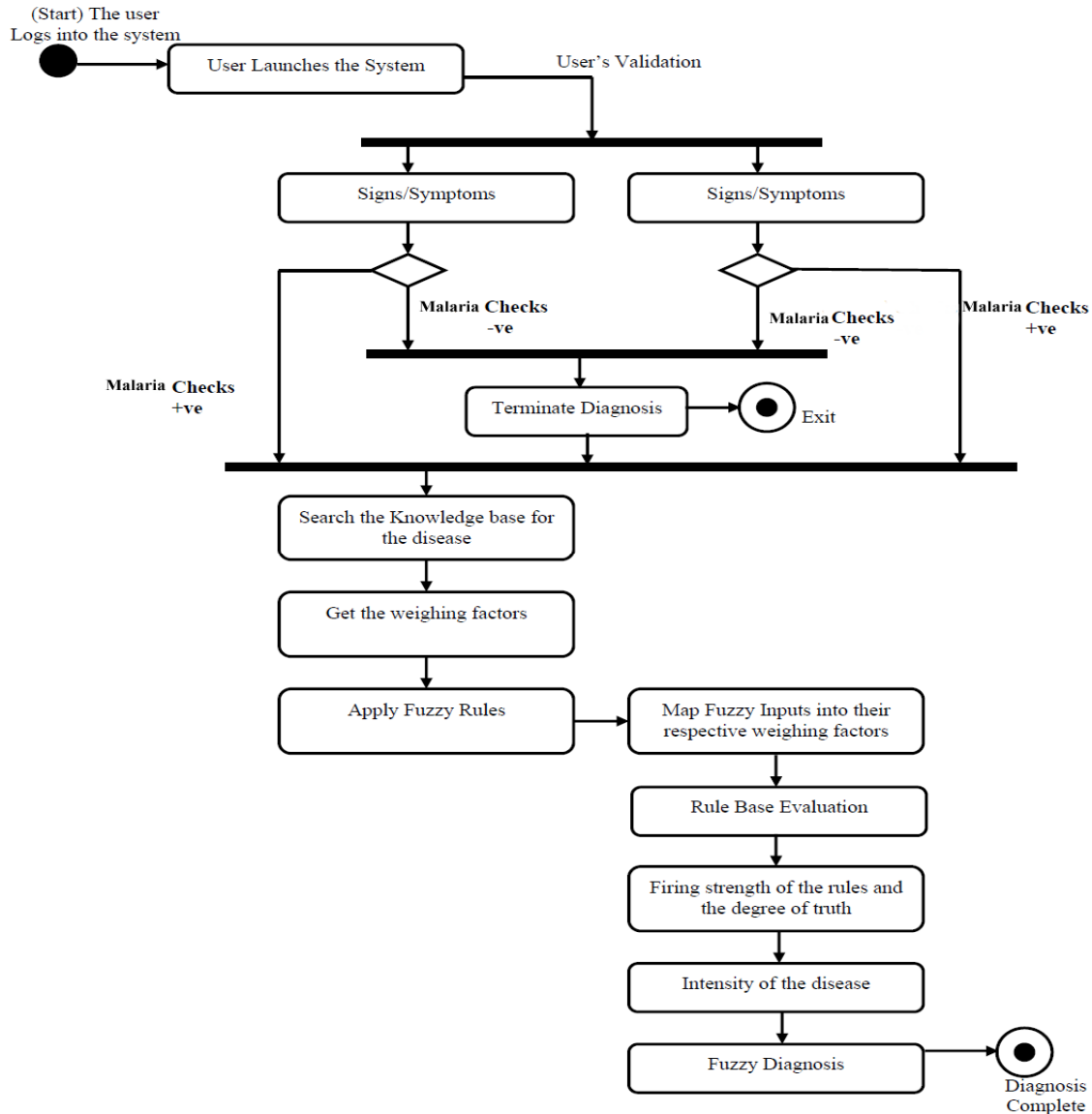

Figure 6: Sequence Diagram for the proposed System

3.4 Knowledge Base Design

The system has been designed in such a way that it has a strong knowledge base. The knowledge base consists of rules for 11 symptoms in which each rule has symptoms and corresponding weight with the number of symptoms ranging from 3 to 10 depending on the part selected by the user. Moreover, there are many rules for the 11 symptoms that are created for making decisions. Each rule has symptom and their corresponding conditions based on its weight. The total number of conditions in each rule base varies from 10 to 110. Along with it, there are separate rules for common and general symptoms and conditions. For every symptom the user is selecting, the rule base generates the possible conditions from the above said table for disease diagnosis.

4. CONCLUSION

With the problems in shortage of medical professionals in medical field and due to shortage of medical specialists they are getting a huge chain of patients in hospitals. This has created very big problems especially in rural areas where we have young medical doctors or don't have medical specialist at all. Fuzzy logic has been found to be very useful in our today's world ambitious by technology. When expert's knowledge is take out and stored, such knowledge can be used to replace the expert in case of failure. The use of fuzzy logic for medical diagnosis provides an competent way to assist inexperienced physicians to arrive at the final diagnosis of malaria more fast and proficiently. The developed Fuzzy logic based medical diagnostic system provides decision support platform to assist malaria researchers, physicians and other health practitioners in malaria endemic regions. If the approach proposed in this study, if used smartly, could be an effective technique for diagnosing malaria. Furthermore, execution of Fuzzy logic based medical diagnostic system will reduce doctors' workload during consultation and ease other problems associated with hospital session.

5. FUTURE WORK

Due to different types of malaria infections, and the complexities of medical professions, a fully automated system to handle diagnosis in general should be developed. The proposed system has the ability to diagnose a person suffering from any of the specified malaria infections, a similar system should be introduced in the health sector to assist all medical professions to make accurate and precise diagnosis. More advance medical diagnosis system can be designed to help in the area like drugs prescription, registering of patients as well as keeping of patients' details and records in the medical sector.

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