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DESIGNING MOBILE BASED FUZZY EXPERT SYSTEM FRAMEWORK FOR VIRAL INFECTION DIAGNOSIS

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ABSTRACT

A lot of research has been carried out in medicine and artificial intelligence domain and several fuzzy expert systems have been developed for diagnosing severe disease, such as liver disorders, blood disease, tuberculosis and many more. A very common disease, viral infection is caused due to viruses that use host cells to reproduce and disturb the immune system. In this paper the framework to construct a fuzzy expert system for mobile users is proposed to diagnose viral infections. The fuzzy expert system shall be hosted on the web-server and web-services shall be used as a communication medium between the fuzzy expert system and the handheld devices. Thus the mobile users will be able to achieve quick assistance for their common disease symptoms which a medical practitioner would suggest when they visit the clinic. With the world converging towards handheld devices, assistance in terms of medicine for common diseases on such devices can be very fruitful with respect to time and security.

Keywords: Fuzzy Expert System, Mobile Application, Web-service, Knowledge Engineer, Artificial Intelligence

INTRODUCTION

Expert Systems have been proven very effective in a number of problem domains where generally intelligence possessed by human expert is needed. Application domains include law, basic and applied science, military operations, commerce and the list goes on. Web-based fuzzy expert systems are web applications which deal with fuzzy set of data to produce results based on the expert knowledge stored in the expert system's knowledge base. A survey of web-based fuzzy expert system in [1] describes various applications in the field of health sector, agriculture, real-time applications like flood forecasting system, vehicle registration fee computation, applied mechanics and materials and tourism. With the advent of mobile technology, different web applications are converging towards mobile applications due to the flexibility and easy access to all sorts of resources. In this context, this paper tries to mobilize one more type of application in the health sector domain.

Background

Expert Systems

Expert systems (ES), one of the products of artificial intelligence (AI) which emerged during early 1970s, has become one of the most important innovations of AI because they have been shown to be successful commercial products as well as interesting research tools [2]. Expert system is a bunch of code dealing with

encoded knowledge to solve problems in specialized domain that requires human expertise. The information from the experts is taken and coded to generate the knowledge base which thereafter is used for inference and reasoning processes. The knowledge base is developed by performing some encoding techniques on the information available from the domain experts and other sources like databases, journals, articles and texts. This knowledge base is tested, refined if necessary and used thereafter by the system.

Fuzzy Expert Systems

In the real world, the situations are hardly possible to refer by dichotomous value (yes or no). Eventually, it was very difficult to map the real data to a strict Boolean value 0 or 1. To address the uncertainties in the real world by reasoning through probability theory and statistics gave rise to fuzzy set and fuzzy logic. Fuzzy logic refers to the logic that describes uncertainty and vagueness. A fuzzy set refers to an ordered pair of an element and its membership. Membership refers to the degree with which the element belongs to the fuzzy set. Collection of fuzzy membership functions and rules to analyze the data is called a fuzzy expert system [3].

Fuzzy Expert Systems in Healthcare

Formalizing medical entities as fuzzy sets and reasoning in a rule-based system has been described in [4] and the authors have built a rule based system which uses fuzzy logic to diagnose Lung Diseases. The system takes input as a set of symptoms consisting of patient's clinical status and results in terms of diagnosis of Lung Diseases. Fuzzy expert systems have been developed for diagnosis of diseases like heart, diabetes, asthma as in [5], [6] and [7]. The pattern used for fuzzy expert system is the symptoms for diseases are mapped to the severity of the symptom to construct the rule-base. Inference engine is designed using one or combination of membership function along with the appropriate algorithm to predict the severity or presence of the disease.

Mobile Expert Systems

In recent time (over a decade) it has become possible to link up and share any type of data anytime and anywhere. Having said this, the first device that comes to our mind is the mobile phone – a portable communication device that provides mobility irrespective of time and region. As the technology advances, these mobile phones have leaped from talking devices to devices which are capable of transferring data and voice. Integrating expert systems with mobile has resulted into easy, quick and ultimate utilization of expert knowledge. Using mobile, expert system can be accessed eliminating time and region boundaries, with a small pre-requisite of signal availability.

Expert systems using Mobile in healthcare

The significance of application of artificial intelligence to solve problems in mobile learning has been described in [8]. Problems in mobile learning are discussed and how artificial intelligence is beneficial in solving these problems is explained in the paper. To provide Islamic Medication (IM) without consulting IM experts, research has been carried out in [9]. Therapies for physical and internal illness are made available to the mobile user by displaying the verses and instructions from Quran and Hadith through the expert system in between.

Expert systems using Mobile for viral infections

Viruses are capsules consisting of genetic material which are even smaller than bacteria cause viral infections [10]. A virus particle called 'virion' consists of nucleic acid segments that are enclosed in capsid. Depending on the nature of their nucleic acid contents, viruses are categorized either DNA or RNA viruses. When the virus come in contact with host cell (where virus resides), it secretes its genetic material

(DNA or RNA) inside the cell to infect it [11]. This infected cell is controlled by virus either by killing the cell or by altering its normal functions and replicates to infect other cells. Some viral infections can be detected based on symptoms and for some various tests like blood test, urine test shall be done. Antiviral drugs are the medicine used either to interrupt the replication process of viruses or strengthen the immune system of the host [12].

To address this area of medicine, a fuzzy expert system can be developed which can be accessed by mobile users. This paper refers the prototype for construction of a fuzzy expert system to diagnose viral infections and offer corresponding remedies.

Literature Review

Lot of research has been carried out in developing intelligent systems in last two decades. One of the much focused domains is healthcare sector. A fuzzy expert system for the management of malaria has been presented in [13]. 35 patients were tested by the system. The authors considered set of 5 diseases and set of signs and symptoms for each disease. Weighing factors were assigned to each set of signs and symptoms and a triangular fuzzifier was employed on these weighing factors to convert them to triangular fuzzy values. For each patient, rules will be fired from the rule-base to generate the respective output membership function strength (range: 0-1) using Root Sum Square inference technique. The output fuzzy set is thereby defuzzified using discrete Centre of Gravity technique giving the possibility of malaria in terms of percentage.

In [14], computer package has been developed using java to implement fuzzy expert system and UML is used to demonstrate the structure and behaviour of proposed packages. Deriving a system-level fuzzy conclusion from individual rule-level fuzzy conclusions and de-fuzzification is implemented using two java classes – java.awt.Polygon and java.awt.geom.Area. Polygon class defines fuzzy conclusions and Area class defines enclosed area of two-dimensional space along with their geometrical manipulations. Using the clipping method for triangular membership function, rule-level fuzzy conclusion is calculated for a single fuzzy rule. For multiple fuzzy rules, system-level fuzzy conclusion is estimated by applying some geometrical operations on all of the individual rule-level fuzzy conclusions. Thereafter, the Center of Area (COA) defuzzification method is applied to determine the defuzzified value. A console based, windows-based and two web-based applications are discussed in the paper to validate the proposed package.

An ICD10 based Medical Expert System has been discussed in [15] which offers advice, information and recommendation to the physician using fuzzy temporal logic. The system uses ICD coding to represent data and clustering algorithm to produce the most possible diseases for the given symptoms. Apart from the knowledge base, the system also consists of a temporal database to store the past and current history of the patient. The system also separates the rules into temporal and non-temporal (fuzzy) rules. The inference engine is composed of a scheduler - which schedules the rules to be fired and an interpreter – which fires the rules using forward chaining inference technique. Least square method is used to generate the curve. Interpolation and extrapolation techniques are used to make the first level decision. Using the same technique, set of other decisions are made using temporal information manager and inference engine. Eventually, the decision manager makes a decision based on the top scores.

Another malaria control programme has been discussed in [16] whose main aim is to develop a technology based healthcare solution to prevent control and eventually eliminate malaria.

Responsible and designated malaria staff is trained and given mobile phones for routine checkup, new case investigation and treatment activities. Information about patients is captured even in places where telephone signals are not available and are synchronized later when signals are reachable, thus eliminating the paper based methods. Summary statistics and maps of all the cases covered by the health service area can be generated.

The Diabetes Diagnosis System described in [5] is one more web-based fuzzy expert system application to diagnose the diabetes disease. The system is implemented using Fuzzy Expert system and Sungeno's inference technique. Based on the user answers to the questionnaire of diabetes risk factors and symptoms, the system generates an estimated result giving some recommendations to prevent or lower the risk, which may in turn be interconnected with the user life style and medication.

In this paper, the architecture for fuzzy expert system for diagnosis of viral infection using mobile is proposed. A fuzzy expert system can be developed and hosted on a web-server. A client can be installed on the mobile handheld device which communicates with the web-server through web-services.

Architecture

The Fig. 1 below shows the architecture of the proposed model. The model can be broadly sub-categorized into two – system and user.

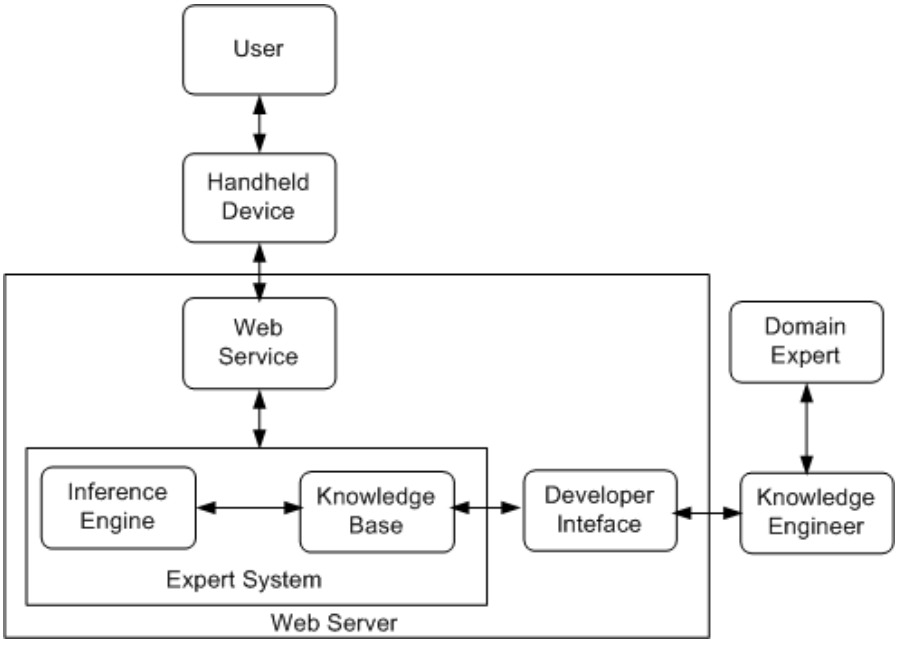

Figure 1: Proposed Architecture of a fuzzy expert system for mobile user

System

The system is developed with two main components – one component will be deployed on the web-server and the other on the user handheld device. The web-server mainly consists of the fuzzy expert system and the web-service to handle the communication with the handheld device.

Web-Server Component

Fuzzy Expert System

The fuzzy expert system proposed here computes the action in terms of remedy for the user symptoms. Similar to any other expert system, this fuzzy expert system also comprises of two main sub-components.

Knowledge Base

The knowledge base is developed by the knowledge engineer. The knowledge engineer and the domain expert(s) together list the possible symptoms and severity for a disease and corresponding remedies. Thereafter the knowledge engineer reforms this list into pre-digested form which is nothing but a complex set of pattern-action (symptoms-remedy) rules. To build the knowledge base, an interface should be developed which can take the patterns and action to generate the rules. This eventually will construct a rule-based knowledge system.

Inference Engine

Inference engine applies a control structure to identify the symptom pattern and provide the remedy. Various inference mechanisms are being used such as triangular membership function or trapezoidal membership function can be applied to come to a conclusion. Based on the conclusion, medicine can be decided or any other remedy can be suggested.

Web-service

The web-service is a medium which can be used for the mobile to talk to the web-server. Whenever user makes a request, it propagates from the mobile device to web-server using web-service and when expert system generates a response, it is carried to the mobile device through the web-service.

Handheld device

On the handheld device, two clients need to be installed. The first would be able to fetch user input in terms of symptoms. These would be directed to the second client that ultimately would convert the user input in a format that is understood by the web-service residing at the web-server.

Client Application

This application would be the user interface through which the input variable will be initialized for our fuzzy expert system. The symptoms inserted to the system would be acting as the input variable, more specifically linguistic variable.

Web-service client

The web-service client is the client component to invoke the actual web-service servicing at the web-server. The main task of the web-service is to convert the user-data into a compatible format, recognized by the web-service ready to serve at the other end.

Actors

Without the actors, system is of no use. There are three possible actors for the system categorized depending on their role.

Domain Expert

Domain expert is a person with special knowledge and skills in a particular area. This knowledge is acquired through the experience and learning over a period of time. In our system, the domain experts would be medical practitioners and doctors who are well versed in diagnosing viral infections.

Knowledge Engineer

Knowledge Engineer is a technical person who is more focused on mapping the domain expertise to form a complex set of pattern-action to develop the knowledge base. As per our proposed system, the knowledge engineer will be dealing with the domain experts for knowledge acquisition and thereafter work on it to form rules that can be stored in the knowledge base. To include all the possible symptoms along with their severity that can be mapped to the linguistic variables later used by the inference engine and develop concise rules is the important and crucial task of the knowledge engineer.

User

User is a common person who would be using this system. User may be a patient or a helper to the patient who wants to diagnose whether he/she is suffering from viral infection. If the system detects positive result for diagnosis, it

would eventually give the remedies to control the disease.

Flow Diagram

The flow diagram for the proposed architecture is shown in the below Fig. 2. Following are the steps for a single request cycle.

Step 1: The user provides the input in the form for symptoms using the handheld device.

Step 2: The device invokes the pre-processed web-service client which converts the input data into request data format to be sent to the web-server.

Step 3: At the web-server, first the input data is extracted from the request data format and the expert system is invoked with input data as the parameters.

Step 4: The expert system consults the knowledge base to fetch the rules and applies them on the input data to produce the output data which are the actual actions or remedies to be taken in account of the symptoms.

Step 5: This output data is thereafter reformed into the output data format and sent back to the client device.

Step 6: The handheld device formats the received data for the user. The resultant data would be composed of action to be taken for the symptoms keyed by the user at the start of the request.

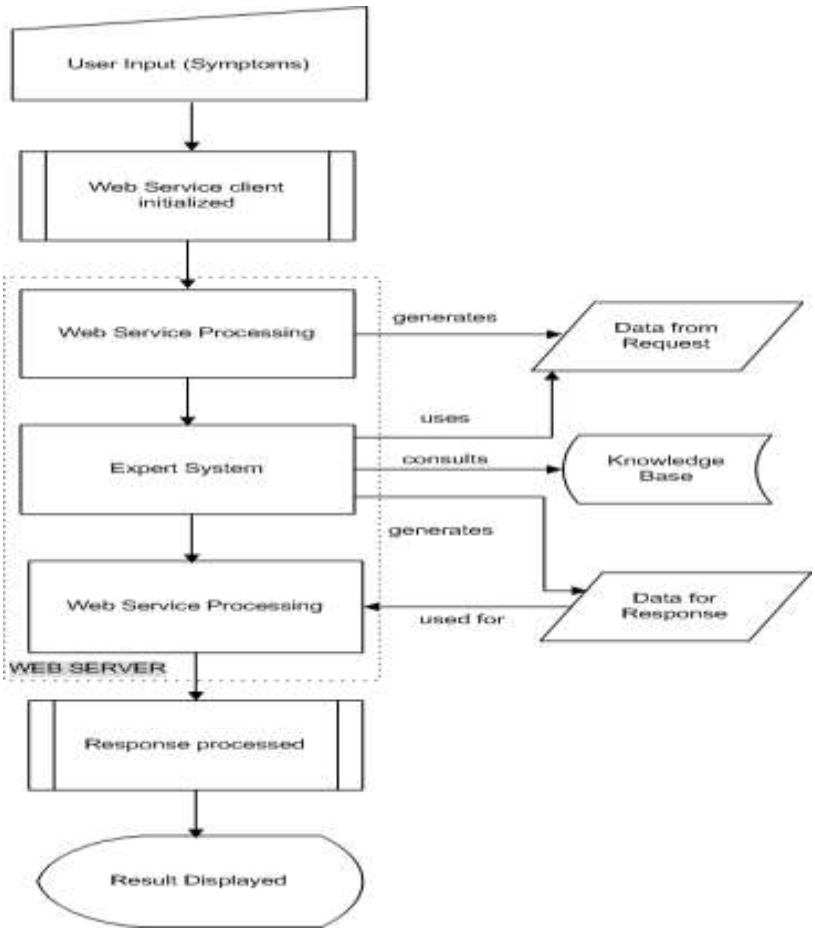

Figure 2: Flow diagram of a request cycle

This architecture will be very beneficial to a common man, if implemented. For not so strong symptoms, this system can guide the user to take immediate actions which a general practitioner

would suggest. It would save time because without going to the clinic or hospital, the system gives remedies for common diseases like viral infections especially acute viral infections.

DISCUSSION AND CONCLUSION

Mobile applications are more secure since we can identify the device user rather than a web-application where user tracking is difficult and is generally based on IP address or user authentication, which can be easily shared or hacked. Keeping this into account, the design is proposed for a fuzzy expert system for mobile users to diagnose viral infections in this paper. The basic working of the system deals with the symptom acquisition from the user and expert system driving the action and remedies derived from the rule-based knowledge base. Web-services are put forward for communication. Many web-based fuzzy expert systems are developed so far to aid different user categories. The next task is to implement the system. Also the same architecture can be used in other domain and implemented to provide assistance through web-services. Thus usage of expert system in the medical domain can be very beneficial to the mobile users in the busy world and safe in terms of security. Without taking doctor's appointment, the handheld device users will be able to get the remedies for common disease – viral infection.

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