Multi-Agent based Diagnostic Model for Diabetes

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Abstract: With the advent of Agent Technology, and the challenges facing the health care sector and also the distributive and complex nature of the activities in the medical domain, there is need to use the new programming paradigm in order is to explore, develop, design and implement a prototype system for multi-agent diabetes diagnosis that finds the possibility of illness based on the patient's symptoms which will aid in solving the problems as a result of wrong diagnoses especially in the developing countries like Nigeria. Fuzzy Rule Based Reasoning was used to build the knowledge based of the system based on the studied data of the diabetic patient. The prototype system is capable of diagnosing (Predicting) diabetes without measuring the glucose level of the patient and monitoring diabetic patient by providing them with the required amount of insulin based on the patient weight to enable the patients send an update to the doctors. The experimental result of the diagnosing aspect of the system shows that the accuracy of the system is 0.75 while sensitivity and specificity of the system is 0.88 and 0.5 respectively.

Keyword: Fuzzy, Polyurea, Polydipsia, Polyphagia, Agent

1.0 INTRODUCTION

Now a days it becomes a true fact that health care problem is the major problem in many developing countries like Nigeria. Conventional medical and healthcare system of such countries failed to provide the minimum service. Agent approach is chosen because Multi-Agent Systems are appropriate in the medical domains due to the knowledge required to solve a problem which is spatially distributed in different locations. The solution of a problem involves the coordination of the effort of different individuals with different skills and functions, since Muti-Agent Systems (MAS) are very suitable in distributed and homogeneous environment. Hence, the need to explore and utilize the enormous benefit provided by the MAS in the Medical domain which will in turn help in the management of chronic diseases taking diabetics as a case study. Again the need may arise from the fact that a particular ailment is becoming rampant. As the importance of good health care delivery cannot be over emphasize in our society and modernization of health care system using agent technology becomes important. However, there are various Medical Diagnosis Systems such as Multi-Agent based Clinical Diagnoses System that take care of early stage of patient but most of the systems are not capable of diagnosing and monitoring patient online. Hence, there is need to develop a MAS based system that will also be able to diagnose, monitor patient and update the doctor with the patients progress for patient suffering from chronic diseases such as diabetes.

In [2] the authors identified the need to design and construct a multi-agent system with the following characteristics: i.e. it is possible to book a visit to a doctor, the user may access the medical record, the user can also find medical stores in the city, and can chat or mail to the doctors.
The authors are of the view that multi-agent systems offer an appropriate platform for developing health-related application in order to provide convenience for people seeking medical service anywhere, anytime. The proposed multi-agent system was implemented using JADE (Java Agent Development Framework) which contain six different types of agent which are user agent, main agent, doctor agent, media and government agent, Database wrapper

According to [3] health care problem is a problem in many poor countries in which the medical and health care system of countries like India failed to provide the minimum service and this problem is attributed to the scarcity of medical practitioners as well as infrastructure problems. The authors proposed a multi-agent system based Clinical Diagnosis System (CDS) using algorithmic approach. An agent called User Agent (UA) is responsible for taking the user input while the Master Agent (MA) convert it into knowledge which is done with the help of user interface. Global Knowledge Base (GKB) stores the knowledge. The MA also selects a Specialist Doctor Agent (SDA) for handling that particular case. For each SDA, there is an individual Local Knowledge Base (LKB) associated with each of them. After having the solution, the SDA will give the solution to the MA and the solution is stored in the in the Solution Knowledge Base (SKB). The CDS algorithm is capable of handling the system efficiently

In [1], the authors pointed out that a reliable, cost-efficient, and fast medical diagnosis is still a challenge in today's world. Their paper presents a medical diagnosis system that combines the advantages of multi-agent system technologies and neural networks in order to realize a highly reliable, adaptive, scalable, flexible, and robust diagnosis system for diseases. An experiment was carried out with different types of simple neural nets. The advantage of differently structured agents is that the agents may discover artifacts generated by agents with a different structure. The result is satisfactory in the sense that the diseases are correctly identified.

From [5], a Multi-agent intelligent learning environment design to support training of diagnostic reasoning and modeling of domains with complex and uncertain knowledge based on Bayesian network approach called AMPLIA (a multi-agent intelligent learning environment designed to support training of diagnostic reasoning and modeling of domains with complex and uncertain knowledge) is introduced. They identify a case in which a physician can diagnose a disease based on some symptoms, but the diagnosis will be only a hypothesis, which can be wrong. A mistake may come from the incomplete knowledge about the pathology in question, from determinant symptoms not detected yet, due to the initial evolution phase of the disease, or from the lack of complementary tests.

[4] realized the need to use multi-agent systems where distributed knowledge-based systems are considered as cooperative agents in cancer diagnoses to address the different kinds of problems in cancer diagnosis, including patient scheduling and management, medical information access and management, and decision. As a result of that a multi-agent based prototype system for cancer diagnosis in selected organs (Lung, Kidney and Liver) that finds the possibility of illness, its severity, and its potential complications including a statistical belief, based on the patient's symptoms and laboratory examinations was implemented. Similarly, the system covers prescriptions for treatment and makes useful indications, suggestions and prognosis of cancers. At the end they used fuzzy model to classify stages of lung, kidney cancers and calculate survival rate of patients. In an open-source platform, the cancer diagnosis system was implemented using the Jade agent development environment, Java and JavaDB derby database, supported in Windows and Linux platforms, and forms a distributed environment with four different types of computing nodes with at least one active Database agent.

An experiment was carried out in which the performance is analyzed with the number of users against average response time and throughput. As the number of users increases, the average response time for Agent based system is better when compared to systems without agents. And for the throughput as the number of user increases, the task is carried out in each node so the throughput is high in agent based system. This proposed work extends the traditional scope of e-health applications by providing a distributed agent-based approach which provides security and privacy to patient data. The approach is good in that human knowledge is symbolic so encoding is easier. Also the application acts as a globally distributed information and knowledge repository for Cancer diagnosis and prognosis.

In [4] multi-agent prototype system was developed for cancer diagnosis in selected organs (Lung, Kidney and Liver) that finds the possibility of illness, its severity, and its potential complications including a statistical belief, based on the patient's symptoms and laboratory examinations. So in this research a system that predicts the possibility of a patient suffering from diabetes was developed. However, [4] limited their work to cancer.

The aim of this research is to analyze the various problems facing the Nigeria health care system in order to come up with a Multi-Agent based system architecture that will deliver better health care services in order to address the problems mentioned in section 1.0. The objectives are to:

a) Construct knowledge based system for diabetic health care (diagnosis and monitoring) using the Fuzzy logic rule base according to human expert's knowledge of a medical field.
b) Design and implement a Multi-Agent based Medical System Architecture that will be use for patient, diagnose and monitor (to take care of) diabetic patient.

2.0 METHODOLOGY

Multi-Agent Systems Engineering (a methodology for developing multi-agent system) was used in the analysis and design of the proposed system and the Fuzzy logic rule base is used to built the knowledge base of the diagnosing aspect of the system.

Diabetic patients' record (symptoms observed by the doctor on the patient) from the diabetic clinic of Gombe State Specialist Hospital was studied and used in the construction of the knowledge base while the lab result (the same patient) was used to test the accuracy of the diagnosing aspect of the system in such a way that our system will diagnose a patient based on his or her symptoms and predict the result and compare it with the lab result.

Xampp, a free and open source cross-platform web server that incorporates Apache, PHP (Hypertext Preprocessor) and MySQL were used in the development of the prototype.

3.0 DIABETES SYMPTOMS CLASSIFICATION

Apart from the three classical feature (symptoms) of diabetes (Polyuria, polydipsia, polypeagia), there are others which includes family history, tingling effect are more associated to diabetes than rest of the symptoms which includes nausea, fatigue and weight loss based on the cases recorded at the Diabetic Clinic Of the Specialist. Of all the classical feature polyurea is the most common because it is observed in more 90% of the diabetic patient.

Since the aim is to develop a system that can automatically diagnose (predict) diabetes without measuring the glucose level of the patients using the previous knowledge (cases recorded at the clinic) and determine the accuracy of the system with the result of the laboratory test so that the system can aid in the management of diabetic patient since most of the times errors are recorded in carrying out such test in the laboratory. That is, why getting data from data from a diabetic clinic is necessary.

After studying the record in the clinic, the classifications of the symptoms were given Most associated, More associated and Less associated with diabetes: each of the symptom with a value based on association with the decease. The analyses are given as follows

Most associated

a) Polyurea (24)
b) Polydipsia (18)
c) Polypeagia (18)

More associated

a) Family History (12)
b) Tingling effect (10)

Less associated

a) Nausea (6)
b) Fatigue (6)
c) Weight loss (6)

3.1 Rule Generation Based on Diabetes Symptom Classification

a) **If** Result (total point) is greater than or equal to 80 **then** patient is extremely positive.
b) **If** Result (total point) is greater than or equal to 60 **then** patient is positive.
c) **If** Result (total point) is greater than 37 but less than 60 **then** patient status is indecisive.
d) **If** Result (total point) is greater than 20 and less than 37 **then** patient is negative.
e) **If** Result (total point) is less than 20 **then** patient is Extremely negative

Even though in the result experiment three outcomes were used, that is, Positive, Negative and Indecisive but in the rule generation, extremely positive and extremely negative which are consider to be positive and negative respectively were used. The essence of generating the additional rules is to give a clearer degree of the possibility of illness since the proposed prototype is a critical system. The essence of using the 'indecisive' outcome is when the system cannot predict the result of the patient in order to avoid giving the wrong result so as boost the confidence of the users of the system and to stick to the ethics of medical profession.

4.0 PROTOTYPE ARCHITECTURE

The architecture of the MAS was developed is shown in figure 1 where each of the agent perform it own task under the coordination of the Master agent. The Patient Agent enable user to input his or her symptom while Diagnosing Agent is responsible for diagnosing patient based on the patient symptoms in order to predict the patient status in respect to the disease based on the knowledge based of the system. Doctor Agent is responsible for prescribing drug for the patient and making the final judgment regarding the system's prediction by either sending the patient to lab for test or support the lab result using the system prediction. In addition, the Doctor Agent also send some necessary information that will aid in decision making to the policy makers in the health care sector (the Government Agent), that is, reports through the Master Agent. Treatment Agent is responsible for calculating the insulin dosage required by the patient according to the patient weight. The Knowledge based for storing the professional medical knowledge was built using the Fuzzy rule base reasoning. Monitoring Agent monitors the patient progress and sends report to the Doctor Agent.

Figure 1: Multi-Agent Based System Prototype Architecture

5.0 RESULT AND DISCUSSION

Accuracy: Accuracy is the degree of correctness to calculate the performance of the system. Accuracy=TP+TN/(TP+TN+FP+FN), where TP is True Positive, TN is True Negative, FP is False Positive and FN is False Negative.

Sensitivity: It is a measure of how a system properly identifies correct solution (i.e. the chance of testing positive among those with the condition).

Sensitivity = TP/(TP+FN)

Specificity: It is a measure of how a system properly identifies the wrong solutions. i.e probability that the system indicates negative results for the patient (i.e. the chance of testing negative among those without the condition).

Specificity = TN/(TN+FP)

Where TP is True Positive, TN is True Negative, FP is False Positive and FN is False Negative.

In order to test the accuracy of the diagnosing aspect of the system for diabetes, data from the Specialist Hospital Gombe, Gombe State of Nigeria were used. The diabetes symptoms observed by doctor before sending the patient for diabetes test was collected for forty (40) patient, in which thirty (30) of the patients were confirmed to be positive while ten (10) of the patients were negative. Out of the forty (40) patients the system was unable (indecisive) to detect result for four (4) patients, three of which are positive while one (1) was negative based on the result of laboratory test. The essence of including indecisive in our system was to adhere to the medical ethics in which when the symptoms cannot be clearly use to predict the outcome of the disease since indecisive will be more acceptable than a wrong diagnoses. Table 1 shows the system result for the remaining thirty six (36) patients that the system was able to detect their result as either positive or negative.

TP	21
TN	6
FP	6
FN	3
Accuracy	0.75
Sensitivity	0.88
Specificity	0.5

Table 1: Evaluation

6.0 CONCLUSION AND RECOMMENDATION

Based on the experimental result, the diagnosing aspect of the system shows that the accuracy of the system is 0.75 while Sensitivity and Specificity of the system is 0.88 and 0.5 respectively. Based on the experimental result of the system it can be used by health care organization especially, the diagnosing aspect of the system can be use as an aid in the diagnosing and management diabetic patient in the diabetic clinic of Gombe State Specialist Hospital in order to avoid error resulting from diabetes test. This can also be adopted by others hospitals.

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