CHAPTER 6

DESIGN AND ARCHITECTURE OF REAL TIME WEB-CENTRIC TELEHEALTH DIABETES DIAGNOSIS EXPERT SYSTEM

6.1 INTRODUCTION

This chapter presents the design and architecture of real time Web centric telehealth diabetes diagnosis telemedicine system. Diabetes is the single most important metabolic disease, which can affect nearly every organ system in the body. It has been projected that 300 million individuals would be afflicted with diabetes by the year 2025. In India, it is estimated that this deadly disease affects presently 19.4 million individuals. The figure is likely to go up to 57.2 million by the year 2025. The reasons for this escalation are changes in life-styles, greater longevity (ageing) and low birth weight. However, access to medical care is sometimes very difficult for people living in rural and underserved areas. They have to trek long distances for a medical diagnosis. Even if medical facilities are available in urban areas, due to lack of time due to work schedule, the time taken to go in for the comprehensive procedures of getting appointment and spending a whole day in the labs for screening mean a woeful experience for many and in some cases, the elderly people may have no one to take them to the hospital for screening. We propose a medical network based on state-of-the-art medical kiosk that addresses the problems of providing
preventive and diagnostic health care. This chapter presents a Web-centric diabetes expert system kiosk that is similar to a bank ATM. The patients can directly enter and can be screened for diabetes with all the necessary tests that are fully automated. The tele diabetes expert system runs on a telehealth server and is connected to the kiosk through the WWW. Based on the symptoms, tests taken and previous history of the patient, a prescription is generated by the expert system that is also sent to a hospital where the doctor is online. Any changes required can be made by the physician in the diagnosis and prescription generated by the expert system and sent to the patient at the kiosk end as a printout. This Web-centric telehealth care diabetes solution will also allow the expert system itself to be proactive and to send diagnosis alerts to the registered user and doctor, informing each one of any emergencies, thereby allowing them to take immediate actions.

6.2 OVERVIEW OF REAL TIME WEB-CENTRIC DIABETES DIAGNOSIS TELEMEDICINE SYSTEM

The use of the artificial intelligence technique involves intelligent diabetes diagnosis and treatment services. Internet technology allows these services to be universally accessible using WWW. Database technology is used to manage the centralized electronic patient medical records and personalized lifetime health care plan. Finally, multimedia is used for “intuitive” and comprehensive healthcare information illustration and dissemination. The three main components of a fully automated real-time tele-healthcare solution are patient kiosk end, healthcare institution end and telehealth server end. Figure.6.1 shows an overview of the Web centric expert system.
6.2.1 Patient end

The patient end consists of a kiosk with two monitors supported by a single processor. One monitor is used for the patient interaction and the other for testing. Two monitors are used to reduce the time taken for processing inside the kiosk. This kiosk end requires a technician to assist the patient in taking the tests.

- *Patient query kiosk end*

A person with diabetes symptoms has to register himself with the telehealth server through means of Internet facility either at home or at the Kiosk end. Any registered user gets the privilege of accessing the telehealth care solution. A registered user has to enter his symptoms using a touch screen system user interface. Based on the symptoms given, the tele expert system at the server end suggests suitable tests that have to be carried out by the patient through the Internet at the kiosk user interface. The patient has to move to the testing kiosk end, which is interfaced with all the needed diagnostic instruments. With the assistance of a technician, the user undergoes the prescribed tests. Data acquired during the tests processes is automatically fed into the tele expert system through the Internet for diagnosis.
Figure 6.1. Overview of the Web centric expert system

- Patient testing kiosk end

The testing kiosk end is interfaced with all the needed diagnostic instruments. Assisted by a technician, the user undergoes the prescribed tests. Data acquired during the tests process is automatically fed into the tele expert system through the Internet for diagnosis. The diagnosis report generated by the tele expert system will be submitted to the doctor end of the chosen hospital for further review and confirmation. A confirmed diagnosis report along with the prescription will be submitted to the testing kiosk end for a print out.

6.2.2 Healthcare institution end

The diagnosis report generated by the expert system will be submitted to the doctor end of the chosen hospital for further review and confirmation. Confirmed diagnosis report along with the prescription will be submitted to the...
patient end for print out. Under a critical condition, the patient is suggested to come online with the doctor through videoconferencing facility or messaging for further medical assistance.

6.2.3 Telehealth server end

All data generated during the processes such as symptoms, test results, initial diagnosis made by the expert system, approved report from the doctor end, are recorded into the telehealth server database for future reference from any end. A registered user can use his patient ID along with the pin number for viewing his clinical history – episodic illness, medical check-up, medication suggested, tests undergone as Web page sitting at home using Internet facility. All the information is given for display to the user as a static Web page. The user can send queries through e-mail to the specific doctor.

The tele expert system would help doctors to make consistent diagnosis by integrating different experiences into the knowledge database. Besides diagnosis, other important outputs of the system could be the potential to evaluate the risk of diabetes occurrence, its progression and when and how should the patient be treated. Consultation typically takes no more than 15 minutes and the clinician will verify and modify the report generated by the expert system with the help of the patient answers, test results, past history and offer mental health advice.
6.3 ARCHITECTURE OF A FULLY AUTOMATED REAL TIME WEB-CENTRIC DIABETES DIAGNOSIS SYSTEM

6.3.1 Architecture of diabetes diagnosis expert system

Fig. 6.2 represents the system architecture of a diabetes diagnosis expert system. This architecture includes a) hospital network, (b) telehealth kiosk (patient), (c) Web server.

Figure. 6.2 Architecture of diabetes diagnosis expert system

6.3.2 Web-Centric telehealth server

This WCTS is a central learning diabetes expert system. It consists of a Web application, an expert system, data store. The expert system consists of inference engine and knowledge acquisition module, and an explanation sub system. The inference engine compares the patient information with the knowledge in the knowledge base, and derives whatever conclusions shall logically follow. The knowledge database is capable of holding large amounts of data and provides functionality for fast traversal of this data. It contains only data regarding the
development of diabetes and does not hold any personal information about the patients involved.

An appropriate explanation subsystem and user interface are constructed, to help the user query expert system and understand the result. The patients/registered users are not able to change any of their data. The only functionality that they have is to enter their symptoms into the system through touch screen or customized keyboard to obtain an updated diagnosis. Then that diagnosis will be sent back to this user.

Figure 6.3 shows that the architecture of Web application, consists of (a) dot net framework with ASPX files, (b) dot net framework Web services with ASMX files, (c) data access objects, (d) business objects, (e) style sheets, (f) html files. The data store consists of (a) diabetes knowledge base, (b) patient database, (c) hospital database, (d) file database.
The patient database holds all existing patient data, permits changes to that data and allows for addition of new patients and patient data. Also, the registered user data is stored in this database so that these users also are able to obtain diabetes diagnosis from the system. Patient data is classified into two different types: 1. demographic, 2. Diabetes clinical data. Demographic data relates to information of the patient such as age, sex etc. Diabetes Clinical data is further distinguished in physical findings and laboratory results. Physical findings are those detected by a physical examination of the patient like weight, height, waist size, etc. Laboratory results are those detected via laboratory tests, glucose test, HbA1c, GTT, etc.

6.4 THE FUNCTIONALITY OF THE TELEHEALTH CARE SOLUTION

The functionality of telehealth care solution is to interact with the patient via the Internet through the user interface at the patient kiosk. The tele expert system will conduct a virtual consultation session with the user, through the user interface to determine his/her current health profile. The virtual consultation session is a GUI based dialogue between the user and the tele expert system application during which the expert system forwards the questionnaire to the user either to collect information / verify available information and / or derive conclusions. The user is expected to provide valid responses to the questions presented by the expert system in a touch screen mode or through the customized keyboard.
Based on the user’s responses, the next questionnaire is generated and passed back to the user. Each consultation session spans across multiple transactions between the user and the tele expert system. The attractive feature of the tele expert system is that it dynamically generates the questions to be asked of the user, based on the user’s current health profile and his / her earlier submitted responses. During the consultation, patient is suggested to undergo a series of suitable tests. The Patient has to move to the testing kiosk system, which is interfaced with all the needed diagnostic instruments. Assisted by a technician; user undergoes the prescribed tests. Data acquired during the tests processes is automatically fed into the tele expert system for diagnosis.

The expert system makes a diagnosis by not just considering the current signs and symptoms of an individual but taking into account factors such as the individual medical history, present medications and treatment plans if any as recorded in the individual’s telehealth patient database. The diagnosis report generated by the tele expert system will be submitted to the doctor end of the chosen hospital for further review and confirmation.

Figure 6.4. shows the kiosk end: tele-health server analyses the responses and suggests and Tests to be undergone by the patient.
Figure 6.4 shows the kiosk end: tele-health server analyses

The doctor interface helps the clinician to view his own patients who has requested healthcare assistance. The Doctor can view the patient history, test results and the diagnosis summary generated by the expert system based on the symptoms and history of the patient and medication. The doctor can review and confirm the diagnosis report and the same is forwarded to the patient end through the telehealth server. A copy of the summary is recorded in the telehealth patient database. A database (case database) is maintained to record the patient name, location of patient request, consulting doctor and the hospital and so on.

A confirmed diagnosis report along with the prescription will be submitted to the patient end for print out. Under critical conditions, the patient is suggested to come ONLINE with the doctor through videoconferencing or messaging facility for further medical assistance.

When any request is received from the kiosk to the telehealth server, the server checks for validity of the user. If the patient is a
registered user, the tele expert system conducts a virtual consultation session based on previous history and is viewed as Web page into the patient kiosk end. Load Balancing is the major feature that is looked after by the telehealth server. When server receives multiple requests simultaneously, load balancing is done to get optimal resource utilization and decrease computing time. 2-mirrored HDD are used to attain greater degree of fault tolerance, which allows the service to continue even in the face of server down time due to server failure or server maintenance.

Once the dialogue between the healthcare institution end and the patient kiosk end is complete, a copy of the generated report from the expert system and the finalized report from the doctor end is stored in the telehealth patient database.

6.5 RESULTS AND DISCUSSIONS

The study was performed on 15 sample patients. The responses of the attendant medical doctors were compared with those of the Web-centric diabetes expert system. The Web centric diabetes Expert System developed was interfaced with glucometer at the patient end to monitor the blood glucose level. Figure. 6.5 shows the interface at the doctor end to verify, monitor and confirm the diagnosed report generated by the expert system.
Figure. 6.5 Doctor interface at the hospital end to verify, monitor and confirm the report

The potential benefits of decision support systems for diabetes patient management are seen to be the cost saving they provide in terms of man-hours of verbal instruction by medical experts, the support in terms of objective and consistent decision making.

6.6 CONCLUSIONS

The fully automated real time telehealth diabetes diagnosis kiosk for diabetes progression monitoring supplies (via usage of Web-centric technology) the ability to access our diabetes expert system from any part of the world. This telehealth care solution aims to act as an “intelligent” proactive agent representing and guarding the person’s long term health related interests and concerns, serve as an efficient healthcare information management infrastructure to collect, organize, and distribute relevant knowledge and service information to the
individuals, provide remote, Web based health care monitoring and diabetes diagnostic services, accessible from the home, or kiosk. The system includes integrated Web server, secured data storage and transfer and delivery of data. It can be adapted for any E-health System.