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Intelligent E-Healthcare Management System in Medicinal Science

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Abstract: In this paper is presented a distributed e-healthcare system that is expert of automatically diagnose the situation of a patient based on data provided by the patient without involvement from a physician. This service is provided over the internet and can be used to observe the situation of a patient. When the situation of a patient changes, the system will automatically alert the doctor. This was implemented by using Adaptive Neuro-Fuzzy Inference System. This system may be helpful for people cannot habitually visit a physician or who are living in rural areas.
Keywords- Diagnosis of diseases, Distributed Networks, E-Healthcare, NFIS, Neuro- Fuzzy Systems

Introduction

E-Health is a recent term coined for health care practice supported by electronic communication processes. The expressions for E-health is interchangeable with health informatics, in a broad definition focusing electronic/digital processes in health while others use it in the narrower sense of healthcare practice using the internet. There are many forms of E-health which consist of: electronic health records, telemedicine, consumer healthcare informatics and different additional services. An Electronic Health Record (EHR) is a collection of medical data of patients. It is stored in digital form and can be accessed by medical personnel across different healthcare settings by connecting to the network. These data may comprise medical history, results of lab tests, personal information, billing information, records of prescribed medicines prescribed and so on. Tele-medicine is the use of recent electronic communication technologies in order to provide medical care at a distance. It can develop the quality of healthcare that is available at places that are located far from the urban centers. It can also be useful in emergencies and can save patients distant away from medical centers and in need of immediate medical assistance. CHI is a service that is mainly aimed at patients and provides them access to health care information. CHI provides services such as Information Resources, Communications, Remote Monitoring, Videoconferencing, and Telepresence among others. M-Health is the use of mobile communication devices such as mobile phones, PDAs etc., to facilitate the delivery of healthcare and information. Hospitals and other institutions that provide healthcare are gradually adopting E-Health services. E-Health services are especially useful in India where around 60% of the population lives in rural areas whereas most of the practicing physicians are in urban centers.

In this paper, an E-Healthcare system is proposed that can be used to monitor and diagnose neck and arm pain disease while the patient is in his home. The patient can regularly check his vital signs and can upload this data to a server. This data is then accessed by a diagnostic agent who performs a diagnosis on the data and can suggest remedial measures to the patient. The system also contains a database that is used to store the data. If the condition of the patient becomes critical, the diagnostic agent will immediately inform a physician by email. Physicians can also check the current condition of patients through the database.

Previous Work

Selvi et al. proposed an Artificial Neural Network model called BIONET for diagnosing diseases based on a priori knowledge. Diagnosis of neck and arm pain diseases was attempted as a^2 case study using BIONET and was also tested for solving an XOR problem. Su and Wu described the design and development of a highly distributed information infrastructure called MADIP(Multi Agent base Distributed Information Platform) implemented using the JADE (Java Agent Development Environment) which is able to notify the responsible care provider of abnormality automatically, offer distance medical advice, and perform continuous health monitoring for those who need it. [1]

Koutkias et al[7] , Proposed a multi agent system for monitoring heart failure in a home care environment. This system continuously monitors medical data submitted by the patients (like the measurements of his/her vital parameters, e.g., blood pressure, temperature etc., or bio-signals like ECG), identifies patterns of abnormality and, when necessary, notifies the medical personnel immediately. All the data flow[1] is stored in computerized patient records, specifically designed to meet the functional requirements of the home care systems.

Mabry et al[9], proposed and tested an intelligent agent based system for patient monitoring and diagnostics which is capable of performing monitoring and diagnosis using fuzzy logic, connection network, trend analysis and qualitative logic methods where the agents are autonomous, interactive, mobile and capable of performing dynamic intelligent interference during execution.

Kart et a1[7] , presented a distributed e-healthcare system that uses the service-oriented architecture as a basis for designing, implementing, deploying, managing and invoking E-Healthcare services implemented using web services, speech software and Atom/RSS.Liu et al[11] , presented a 3G network solution to Internet-based health tele-monitoring with increased interactivity and mobility for both patients and physicians[8] .

Proposed System Architecture

The proposed system works on the internet to provide ea health monitoring service or other types of monitoring services over a large area. The different agents in the system reside in different places. Agents use an asynchronous communication channel ACC to communicate each other. The system is composed of six types of architectural components, which map on to the corresponding human agent in the real world scenario:

A. User agent

The user agent may be anything from a personal computer, to a mobile phone. It may be any kind of electronic communication device. The user communicates with the system using a user agent. It can be used to first authenticate the user and send the data collected by the user to the system. It is also used to present the diagnosis and other information to the user and used for videoconferencing with a doctor.

B. Physician agent

The physician agent is the interface of the doctor with the system. It may be any electronic communication device that can be used to read electronic mail and for video conferencing. After the diagnosis is complete, if the diagnostic agent determines that the patient needs intervention from the doctor, then the relevant information is sent to the physician agent. The doctor can also request for any medical history or past interactions of the patient from the database using the physician agent.

C. Diagnostic agent

The data send by the patient is send to the diagnostic agent by the server. The diagnostic agent analyses this data and sends the results back to the server. If there is a change in the status of the patient, it notifies the server which in turn notifies the physician agent and schedules an appointment.

D. Server

Responsible for overall management of the system.

Related External Services

The related external services contain the environment hardware and services including mobile phone, email, and short message services (SMS). The external service is an extensible component varied on different scenario of applications. If the condition of the patient is not critical then the system will inform the patient about remedial measures. In case the condition of the patient is critical, external services will be initiated by diagnostic agent to inform the responsible physician.

The system is implemented on the public internet. The user agent can be run on any kind of electronic communication device able to connect to the internet and is used by the patient to send their physiological information to the system. The user uploads the information to the system server. Once the data has been uploaded on the internet, MA TLAB software running on another system will automatically download this data. This data is then stored in a database and also loaded automatically into the MATLAB workspace. After this step, the diagnostic agent will start running and it performs a diagnosis on the above data. The data analysis is done by an ANFIS (Adaptive Neuro-Fuzzy Inference System). Once diagnosis is completed, depending on whether the condition of the patient is critical or not, an email is sent either to the patient or a physician. The physician can also get data about a patient at any time.

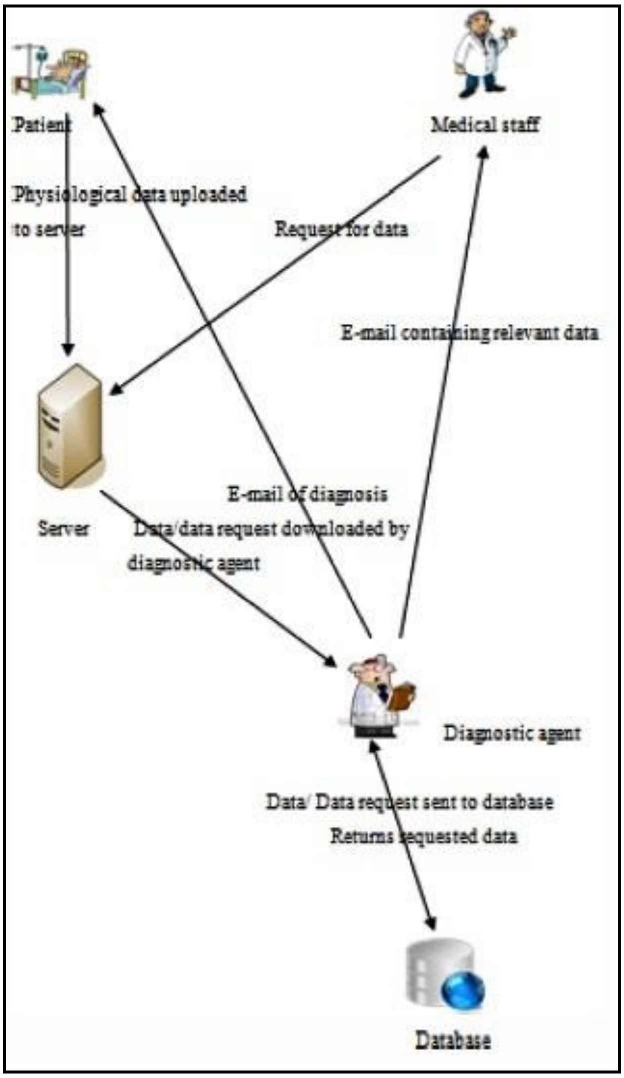

Fig. I. Proposed System architecture

Implementing Diagnostic Agent

The diagnostic agent is responsible for diagnosing the condition of the patient based on the data sent by the patient. It has been implemented using an Adaptive Neuro-Fuzzy Inference System (ANFIS). In this project the diagnostic agent has been built to diagnose neck and arm pain.

A. Anfis

ANFIS is a method through which an FIS can be tuned. In this method the parameters of the input and output membership functions are tuned using a hybrid of back-propagation and least -squares method. In this way, the FIS can be made to learn using a set of training data. In this ANFIS, the inputs can take any membership functions but the output can only be linear or constant.

B. Neck and Arm Pain

Neck pain is is caused due to degenerative changes caused due to aging and may be caused by cervical spondylosis, collagen disorder, caries spine (tuberculosis of the cervical spine) and malignancy (tumors of cervical spine). Cervical spondylosis and collagen disorder are uncomplicated whereas caries spine and malignancy are serious cases. In order to diagnose the neck and arm pain the following examinations are done:

- General examinations.
- Regional examinations.
- Neurological examinations.
- Vascular examinations.
- Examination of cardio-vasculo system.
- Examination of respiratory system
- Examination of abdomen.
- Hematological examinations.
- Radiological examinations/computerized tomography (CT) scan.
- Mantoux test (Mx-test).

The symptoms used to identify the disease are

- Neck pain on activity
- Neck pain on automobile travel
- Neck pain on lifting strain
- Resting pain/discomfort
- Neck pain on early morning
- Worsening of pain in night
- Stiffness after early morning and rest exceeding 30 min
- Persistent stiffness
- Slow onset
- No progression
- Slow progression
- Relapse and remission
- No constitutional symptoms
- Constitutional symptoms present
- Well nourished
- III nourished
- Cachexia
- Spinal tenderness
- No spinal tenderness
- No restriction of range of movement (ROM)
- Partial restriction of ROM
- Total restriction of ROM
- Trapezius tenderness present
- Trapezius tenderness absent
- Associated pain and swelling of smaller joints
- Etc…

Diagnostic agent is implemented in two phases, trammg phase and diagnosis phase. Initially four Fuzzy Inference Systems are built with 45 inputs and one output. Then, in the training phase, the signs and symptoms of patients (training samples) are given as inputs to the diagnostic agent and this is trained to diagnose the nature of disease. After training, in the diagnosis phase the outputs are obtained for the given inputs. Four ANFIS are built for each of the four diseases. The inputs are given to these four ANFIS at the same time and four outputs are obtained. Based on the values of these outputs we can determine the disease that the patient has.

Usage Scenarios

The systems allow physicians to detect abnormities of patients and to view in real time the patient data ubiquitously using a PDA, a laptop, or a desktop computer. Under this circumstance, two types of users are distinguished in the proposed system: physicians and regular users whose health needs to be monitored. In this section, the implementation scenarios from these two types of users are described.

a) Physicians' Perspective

While a physician needs to perform routine check for his patients, he interacts with the server through the physician agent and makes an order to collect his patients' up-to-date health data through a PDA, or a mobile phone or a laptop user interface. The physician may then switch off his device and proceed with his daily work. The server can authenticate whether the physician is allowed access to the requested data. Then, the server will search the database to acquire the information it needs. When the needed information is found, if the authentication was passed, the data is retrieved and is emailed to the physician. The physician can access this data when he comes online

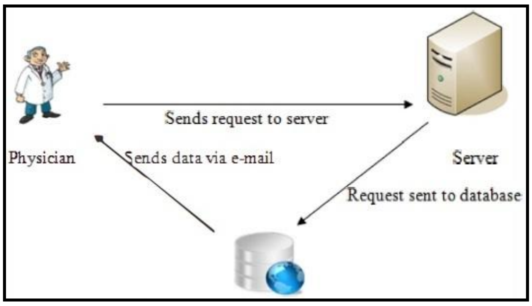

Fig: 2 Scenario I: Physician's viewpoint

Implementation

The physician must log onto the server using a user name and password. He can then place a request to retrieve data about a patient and then log off. This request is downloaded by MATLAB which then retrieves the data from the database and sends the data to the physician via email.

b) User's Perspective

The user turns on his portable vital sign monitor to check his condition of health. After checking, he initiates his user agent by using his device and uploads his vitals. The collected data is stored in the database. The data is checked by the diagnostic agent against the profile that contains the user's criteria of abnormality. If the diagnostic agent determines that the condition of the patient is not critical, it will send an email to the patient with remedial measures based upon his condition. If abnormal condition was detected, the diagnostic agent will notify the associated physician(s) immediately and suggest suitable follow-up procedures based on the patient's history of medical treatment by using email

Implementation

The user wanted to update his vital signs data that he just measured. By logging onto the server he can upload the data. This data is then downloaded by MA TLAB and it is stored in the database. Then MA TLAB starts the diagnostic agent which analyses the data. In case an abnormality was detected, the diagnostic agent would instantaneously report the situation to corresponding physicians via Email

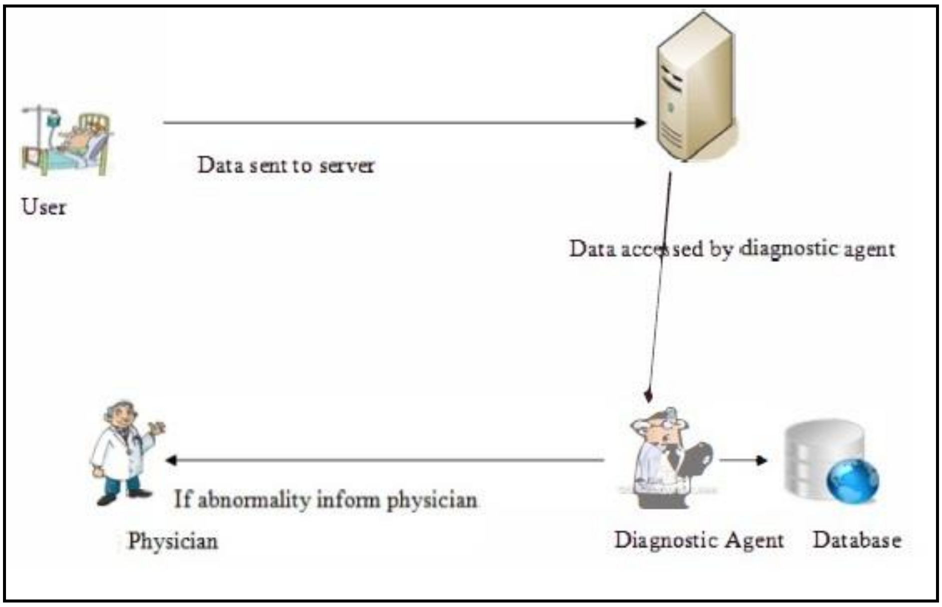

Fig 3: Scenario 2: User's perspective

Results

Thus data available at a remote server is downloaded automatically by MA TLAB and loaded into the workspace Sending Diagnosis Back to the Patient and Physician.

Accessing the Data

Fig. 4. Sample data available at a server

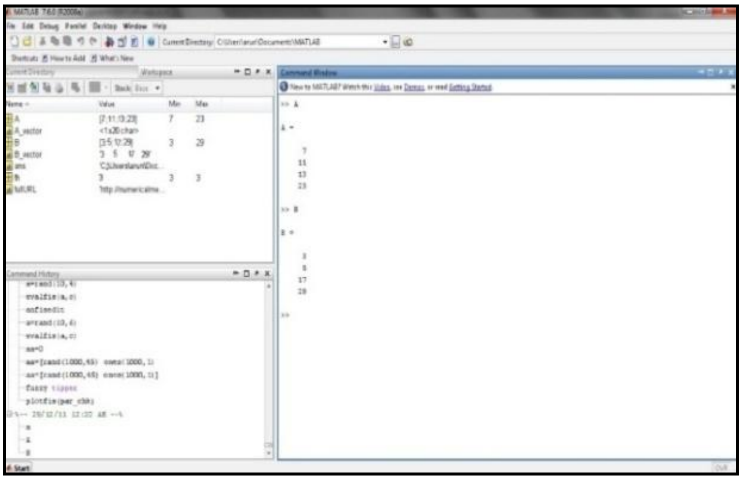

Fig. 5. Data downloaded and loaded in MATLAB workspace

Thus an email was sent automatically by the MATLAB software.

Sending Diagnosis Back To the Patient and Physician

Fig. 6. An automatically sent email

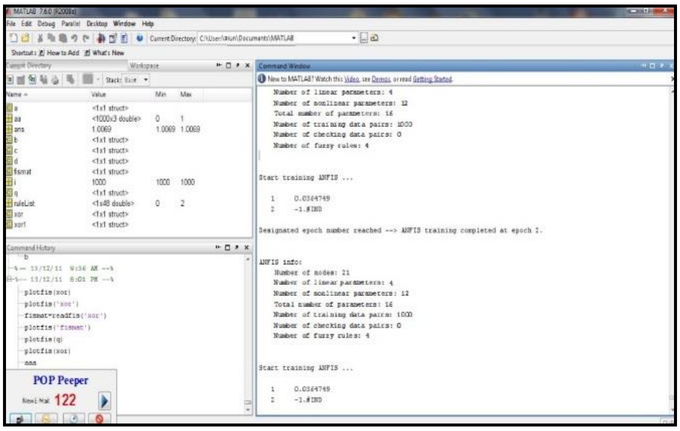

Fig. 7. Pop-up showing the arrival of new email.

Thus an email was sent automatically by the MATLAB software.

Diagnostic Agent

Four individual Adaptive Neuro-Fuzzy Inference Systems were trained for each of the four diseases which cause neck and arm pain.

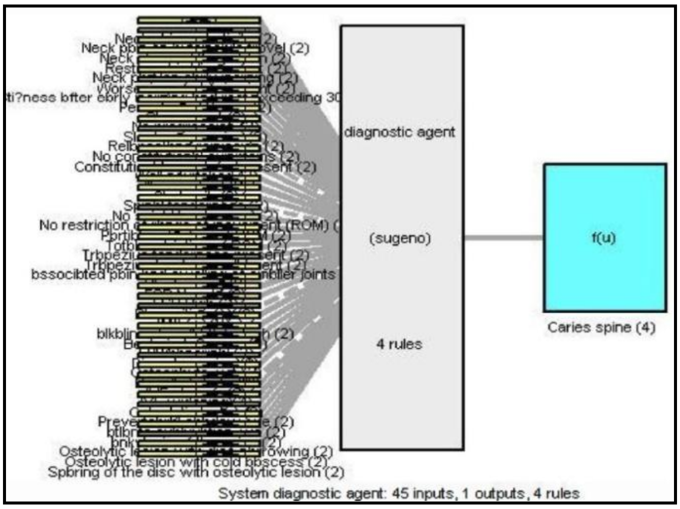

Fig. 8. Diagnostic agent for caries spine

Conclusion

In this paper we have designed and developed a mobile distributed e-Health system for patient monitoring and diagnosis on top of MATLAB package. This system is talented of downloading the Current status of patients from a server automatically and diagnose the status of the patient and suggest remedial measures if the condition of the patient is not critical. If the status is critical then the physician is alerted immediately using e-mail. The system also has a database that can store these values and the status of the patient. A physician can access the data pertaining to a particular patient from this database at any time. The diagnostic agent was developed using an Adaptive Neuro-Fuzzy Inference System (ANFIS). ANFIS was the trained to diagnose neck and arm pain. ANFISs were developed individually for each of the four diseases that can cause neck and arm pain. Based upon the output of these ANFISs we can determine which of the four statuses is causing the pain. By using this system the physicians need only check the patients in critical status and other patients can be handled by the system. This saves time for the medical staff as well as the patients and also saves on medical cost and travel costs for patients in remote areas

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