

TELEHEALTH APPROACH FOR GLAUCOMA PROGRESSION MONITORING

Mihaela Ulteru, Alexander Grabelkovsky

ABSTRACT: *This paper presents a Web-Centric [3] extension to a previously developed glaucoma expert system that will provide access for doctors and patients from any part of the world. Once implemented, this telehealth solution will publish the services of the Glaucoma Expert System on the World Wide Web, allowing patients and doctors to interact with it from their own homes. This web-extension will also allow the expert system itself to be proactive and to send diagnosis alerts to the registered user or doctor and the patient, informing each one of any emergencies, therefore allowing them to take immediate actions.*

The existing Glaucoma Expert System uses fuzzy logic learning algorithms applied on historical patient data to update and improve its diagnosis rules set. This process, collectively called the learning process, would benefit greatly from a web-based framework that could provide services like patient data transfer and web-based distribution of updated rules [1].

KEYWORDS: *Neuro-Fuzzy Diagnosis and Prediction, Web-Centric Expert System, Telehealth, HL7 standard*

1. INTRODUCTION

Glaucoma is a progressive eye disease that damages the optic nerve, usually associated with increased intraocular pressure (IOP). If left untreated, it can lead to blindness.

An expert system would be useful to 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 glaucoma occurrence, its progression and when and how should the patient be treated (for example when to do surgery taking into account alcohol breath, problems using drops, timing, etc).

2. OBJECTIVES AND SYSTEM REQUIREMENTS

The objectives of this work are:

- Increase the accuracy and consistency of diagnosing the progression of glaucoma
- Centralize data from different type of tests
- Develop a Fuzzy Inference Machine to analyze patient data
- Allow worldwide doctors and patients access to Glaucoma Expert System

The major system requirements are defined as follows:

- Ability to access the system from any part of the world
 - Use of Fuzzy-logic learning algorithms to update and improve diagnosis
 - SSS (Stability, Scalability and Security)
 - Support one of the most widely used E-Health standards
 - Support 2 types of users: on-line and off-line
 - Notification and Alert messaging service
 - Clientless configuration for on-line users
 - System architecture should ensure delivering of various types of data, such as text, images, binary data, etc
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3. DATA FLOW AND ANALYSIS

The proposed Web-Centric glaucoma diagnosis system serves as a framework upon which medical services can be offered over the World-Wide Web (WWW). The most important of these services are provided by the Web-Centric Expert System via the inference engine (implemented using the Fuzzy Control Manager (FCM) software from Transfertech GmbH Germany), which has the ability to diagnose the severity of a case of Glaucoma based on patient data within the system. Data transfers normally performed informally between the doctor and the patient will now be managed by the web-centric glaucoma system, including data from expert eye examination devices. The Web-Centric extension focuses on implementing the data transfers that are required between the Internet and the Web-Centric Expert System, Fig. 1. The doctor is able to enter new patient data on the Web that is subsequently sent to the Web-Centric database. When a user (this is a doctor,

patient or a registered user) requires a glaucoma diagnosis, the data that he submits through the Web, combined with the stored user profile, are entered into the FCM. The FCM will then, based on the rules and the submitted information, generate a diagnosis for that user. Finally, that diagnosis will be sent back to the user who will still be online. Alert messages are implemented so that they are sent out to the user as well as to the doctor (only if that user is a patient of a particular doctor) in emergency situations, so that immediate actions can be taken. Appropriate graphical user interface (GUI) is developed that allows the doctor to enter/change/retrieve patient data, Fig. 2. Another administrative GUI is designed in order to manage registered users who do not belong to a specific doctor. The patient or the registered user has access to his/her diagnosis but is not able to modify the data that was entered by the doctor or the system administrator. Finally, a Web-Centric extension will also be able to receive data from expert eye examination devices and update the Web-Centric database with these test results so that an updated diagnosis can be generated. Thus, the user and possibly the doctor (if that user is a patient of a particular doctor) can be informed about the new patient status.

4. HL7 version 3.0 SUPPORT

Health Level Seven (HL7) is one of several ANSI-accredited standards developed by the Standards Developing Organization (SDO) operating in the healthcare arena. HL7 domain is clinical and administrative data. "Level Seven" refers to the highest level of the International Standards Organization's (ISO) communications model for Open Systems Interconnection (OSI) - the application level. The application level addresses the definition of the data to be exchanged, the timing of the interchange, and the communication of certain errors to the application. The seventh level supports such functions as security checks, participant identification, availability checks, exchange mechanism negotiations and, most importantly, data exchange structuring.

Why we chose HL7 standard?

- An HL7 message definition, known as the Hierarchical Message Description (HMD) is technology neutral;
- Version 3 includes the idea of an Implementable Technology Specification (ITS) to define how a message can be instantiated from its definition;
- HL7 has chosen Extensible Markup Language (XML) as the target of the first (and so far the only) ITS specification;
- XML schemas and non-healthcare specific XML parsers can be used to parse inbound and outbound messages;
- Parsers are "free";
- XML-related tools are readily available, e.g. viewing, testing, and conversion.

5. ARCHITECTURE

Figure 1 represents the present system architecture, which mirrors the majority of similar distributed web-based applications. This architecture includes a Web-Centric Production Server, Central Learning Expert System and 2 typical Web-Centric clients: On-line User, which has Internet browser only and a standalone user, which has his own Fuzzy Control Manager (FCM) and database. The Web-Centric Production Server and the Central Learning Expert System have the same architecture and modular structure, but they differ in the functionality of their manager objects.

5.1 Web Centric Server

5.1.1. FCM Service

The FCM service interacts with the doctor via the functional server. This FCM is able to receive new patient/registered user data and give an updated diagnosis regarding his/her condition.

5.1.2. Database

This database holds all existing patient data, permits changes to that data and allows for addition of new patients and patient data. Also registered user data is stored in this database (users who do not have a doctor) so that these users also are able to obtain glaucoma diagnosis from the system. Database is implemented by usage of Oracle technology.

5.1.3. Web-Centric Manager

The manager service acts as a barrier between the Internet and the local web-centric database containing the sensitive patient data. It handles all incoming requests and ensures that they are authorized and have not

been altered. All requests are verified to be unique and complete and if so, confirmation will be sent to the user to notify them of a successful transaction.

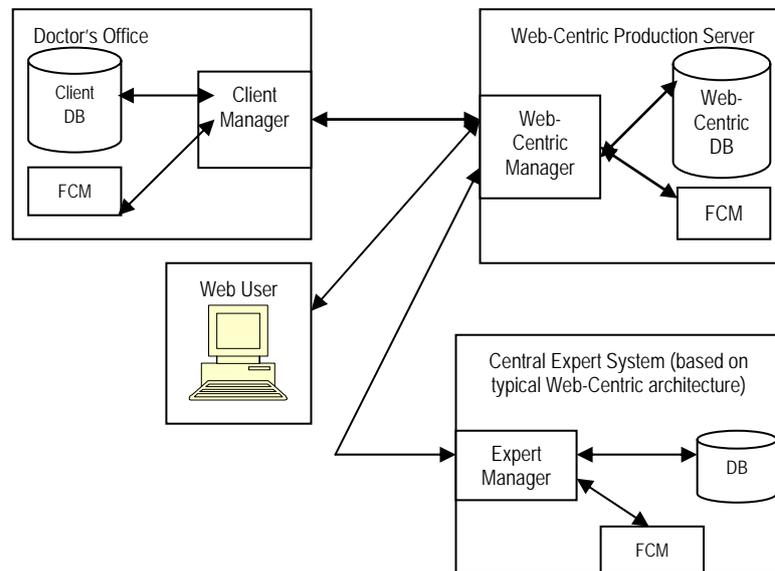


Figure 1. System Architecture

5.2 Central Expert System Server

5.2.1. FCM service

This subsystem performs the learning functions of the expert system. The FCM produces updated versions of the rules based on historical data [2].

5.2.2. Database

This 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 glaucoma and does not hold any personal information about the patients involved.

5.2.3. Expert Manager

The functional server provides the means of interaction between the Central learning expert system and the Web-Centric Production Server to allow the acceptance of new/changed data from the Web-Centric database and the transfer of new rules to the web-centric system. There are no interactions between this subsystem and the doctors or users.

5.3 Doctor's Office Software and On-line User

Doctor's Office Software has the same structure as a typical Web-Centric node, but it is extended by ActiveX control, which is responsible for data delivering management between the local database, the Internet Browser and the Fuzzy Control Manager. The local database is currently developed using MS Access, but it may be implemented using any different relational database system (RDBS) technology, which supports open database connectivity (ODBC).

A typical on-line user has Internet browser with XML support only. A doctor is able to perform all on-line user operations, but all data will be stored in the Web-Centric Production database. On-line patient/guest is able to submit his symptoms and obtain on-line diagnostic results only.

5.4. User Interface

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 to obtain an updated diagnosis. Then that diagnosis will be sent back to this user

The image shows two overlapping Oracle Forms Runtime windows. The top window, 'Patient history', displays a table of patient records with columns for Id, Date of Birth, and Gender. The bottom window, 'First visit', provides a detailed form for a patient's first visit, including fields for Date, Insurance Number, Reason, and various eye test results (Myopia OD, Visual OD, IOP OD, Disc OD, Myopia OS, Visual OS, IOP OS, Disc OS). It also includes sections for Past history, Orders, and Others.

Fig 2: GUI for patient (first visit) information screen

The doctor has the most control over the system. The doctor will have to enter/delete/modify/search detailed patient information. When a new patient arrives to the eye clinic or to the doctors office, the patient has to fill in a form containing personal information (complete name, date of birth, etc), the specific reason for the appointment, previous history of eye problems or injury, eye surgeries, allergies, medications the patient is on, medical history (diabetes, high blood pressure, kidney, etc), family history (diabetes, glaucoma, blindness, retinal detachment), personal and family eye health history, and surgeries. Then a nurse measures the patient's intraocular pressure.

5.5. Eye Test Machine Data

The eye test machine data consists of information diagrams stored in the Production and Central Expert databases containing information from the ophthalmic test machines (the Humphrey Field Analyzer (HFA) and the Humphrey and Heidelberg Retina Tomograph (HRT)). For the communication we use an Internet platform (since our system is a typical distributed web application), which performs XML-message exchange over the HTTP/HTTPS protocol

CONCLUSIONS

The proposed Telehealth system for glaucoma progression monitoring supplies (via usage of Web-centric technology) the ability to access our glaucoma expert system from any part of the world. Use of Fuzzy-logic learning algorithms offers a possibility to update the knowledge base continuously [1] and by this improve previous diagnosis, and share self-learning process data to other customers. We developed a generic interface to the diagnostic system that enables access from any part of the world. The system includes integrated Web server, secured data storage and transfer, delivering of data within XML messages, which are prepared according to HL7 v.3 standard. The proposed architecture of Glaucoma Progression and Monitoring System might be adapted for any E-Health System, which requires supporting of widely used E-Health standards.

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Author information

Mihaela Ulieru, Alexander Grabelkovsky - Department of Electrical and Computer Eng., University of Calgary. Calgary, Alberta, Canada T2N 1N4. e-mail: ulieru@enel.ucalgary.ca