Design and Development of Tele-Diagnosis System of Medical Image Based on Mobile Terminal

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Abstract—A mobile tele-diagnosis system of medical images has been developed, doctors can diagnose patients with the help of Mobile Terminal anytime and anywhere. System uses the "cloud + client" application development model for development and design. The cloud platform, as the system servers, saves remote diagnostics data. Android-based mobile terminal, as a client, exchange information with cloud platform by HTTP protocol. Through this application, users can achieve appointment registration, electronic medical records, medical image processing and viewing, remote diagnosis, the doctor-patient interaction, medical certificate issued, diagnostics and management functions etc.

Keywords— Mobile Terminal, Medical imaging, Tele-Diagnosis, Cloud Storage

I. INTRODUCTION

Mobile Internet in the change of human daily life, at the same time, also brings a revolution to the medical field. Mobile Internet provides the most suitable platform for globalization of medical services[1]. February 2012, the U.S. Food and Drug Administration approved the medical imaging specialists can view medical images and medical diagnosis via Iphone/Ipad for the first time. Ipad / IPhone can be used as an auxiliary means of medical imaging diagnostic[2]. At present, mobile imaging telemedicine systems are mostly based on wired networks, it is difficult to meet the remote medical diagnosis’ need in remote areas of inconvenient access web. The development of mobile Internet provides the possibility to break through this limitation. Nowadays, it is gradually beginning to walk into people's lives in china. Some medical software companies begin developing software related to telemedicine. But these software mostly belong to the class of software consulting disease. The software of medical diagnostic should include such functions as medical imaging, laboratory orders, electronic medical records, doctor-patient interaction. The purpose of this project is to develop convenient medical software for remote medical diagnosis.

II. OVERALL ARCHITECTURE AND DESIGN

Medical imaging remote diagnosis based on the mobile terminal is one of the sub-topics of the research group is developing cloud-based medical imaging remote diagnosis system, which aims to enable doctors in the condition does not have access to a wired network, with the mobile phone, tablet computers and other mobile terminal as a remote diagnostic workstations, access remote diagnostic medical imaging cloud server through the mobile Internet, and to establish a wireless connection between the mobile terminal client and remote diagnostic medical imaging cloud servers. Because of the diagnostician can browse the image information in the region away from the PACS, the remote diagnosis comes true.

Although the performance of mobile terminals constantly is improved, its performance is still far from PC. The entire system bases on C/S architecture which can improving response rate of diagnostic systems[1]. The system is divided into server side and smart device client. The server side includes remote diagnosis web server, database server, medical images storage server and so on. Overall architecture and design for medical image remote diagnosis system based on smart handheld devices is shown in Figure 1. The Web server provides the system management and maintenance. Users can access the Web server through the browser and download the smart devices client. Smart device client as remote diagnostics workstation is used to manage, browse the medical images and remote diagnostics. This paper discusses the development of medical images remote diagnosis system in the Mobile Terminal client.

III. SYSTEM FUNCTIONAL DESIGN

To achieve mobile health, the system uses Android as the operating platform of the mobile terminal. Android is currently the most popular mobile operating system and the best choice of the mobile medical client operating system[4]. It show in Figure 2 that the main functions of the intelligent terminal client of the project.

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A. User Management

The users can register and login in the remote diagnosis system by smart handheld devices after downloading and installing the client. Taking into account the diversity of users and security of database, user roles including expert, community physician and patient are design in the system. When logging in the system, users need to select the Log Identity. Experts and community physicians have permission to modify information and submit database. Community physicians can propose diagnosis application. Experts can give the remote diagnosis report. If you log in the system as a patient, you only have permission to browse information.

B. Diagnosis Information Management

Diagnostic information management includes appointment registration, querying diagnostic information, adding diagnostic information, viewing diagnostic information, updating diagnostic information and medical diagnostic image management, etc. When the user login, he can choose doctors and hospitals and apply remote diagnosis. Community doctors can make an remotely diagnose application for patients and make first review for appointment registration. The query for diagnosis information is divided into exact query and fuzzy query. When the users have sufficient accurate query conditions, such as the number of patients, patient's name or image report number, he can choose the exact query. The fuzzy query would be chosen when the query condition is not accurate enough. By selecting a certain time period or the patient's last name in fuzzy query, the system will generate a list of the related information for query.

C. Remote Diagnosis

Remote diagnostic module including hospitals guidance, departments guidance, disease guidance, medical imaging diagnostic, certificate of illness Diagnosis issued etc. After logging in the system, community physicians can apply for remote diagnosis for patients; experts can download medical image from the server and issue a medical certificate (patient report). The effect of remote diagnosis with smart handheld devices is shown in Figure 3. In order to ensure the reliability of patient report, electronic signature technology is used. Taking into account the smart device memory and screen resolution limit, the system provides some simple image processing functions, such as magnification, the window.
width/window level adjustment, the image gray-scale inversion and edge detection, etc.

Figure 3. Navigation Interface of Hospital Department

Figure 4. Diagnosis Interface of Medical Image

D. Health Records

To enable remote diagnosis more reliable, the system also includes health records module which includes basic health records and electronic medical records of patients. Users can input the patient's health records and medical information into the system. In addition, user can download the data from health records database of cooperative hospitals by external system interface. If patients go sick by the remotely diagnose system, he can query the health records system through the system. These data can be used as important reference information during remote medical diagnostic process.

E. Short Message Management

Real-time interaction between smart device and remote diagnostics server is very important, so is between doctors and patients. Doctors need to ask about the patient at any time via SMS during the diagnosis period. When the users update the Web database information, a timely reminder must be sent to the server-side. In order to facilitate the operation, we have added a textbox of short message in the system which calls SMS messaging component of telephony. we can send a short message which needs not to exit the diagnosis system.

IV. DATABASE DESIGN

According to the requirement of the system, the main data table of the database is shown in Table 1. In order to facilitate data synchronization of the client and cloud server, The database was designed to be consistent.

| TABLE I | KEY DATA IN THE DATABASE |
V. SYSTEM IMPLEMENTATION

A. The system adopts the data storage mode of cloud + client.

The system adopts the mode of cloud + client[5]. The cloud platform as system service end shares data by HTTP with mobile terminals based on android and PC. User can save medical images and diagnostic data in the mobile client for offline operation if the Internet is not convenient. The client will automatically synchronize the diagnostic data and medical image to the cloud server when the mobile terminal can be connected to the Internet. The application database of mobile terminal adopts SQLite and the cloud database adopts MySQL. In order to get a very good client interaction and improve data corresponding speeds, the system adopts JSON formats for data encapsulation. Part code example of the mobile terminals connected cloud server is as follows:

```java
public static byte[] connect( URL url, String method, String postParam, int connectTimeout, int readTimeout) throws NullPointerException, IOException, ProtocolException {
    //create connection
    HttpURLConnection connection = null;
    connection = (HttpURLConnection)
    url.openConnection();
    // Set properties
    connection.setConnectTimeout( connectTimeout );
    connection.setRequestMethod( method );
    connection.setRequestProperty( "Accept-Charset", "utf-8" );
    // if passing parameter by posting , then process
    if( method == HttpClient.HTTP_POST && postParam != null ) {
        // Set properties
        connection.setRequestProperty( "Accept-Charset", "utf-8" );
        BufferedOutputStream out = new
        BufferedOutputStream( connection.getOutputStream(),8192 );
        System.out.println( "post parameter: " + postParam );
        out.write( postParam.getBytes( "utf-8" ) );
        out.flush();
        out.close();
    }
    ByteArrayOutputStream outStream = new
    ByteArrayOutputStream();
    int result = connection.getResponseCode();
    System.out.println( result );
    // judge whether the connection is successful
    if ( result == 200 ) {
        // The remaining code was omitted...
    }
    return outStream.toByteArray();
}
```

B. Medical Images Processing Module

This system conforms to DICOM 3 standard and supports DICOM3 transport protocol, including DICOM commands of C-FIND,C-MOVE,C-STORE ,etc. It can seamless access to standard PACS system of hospital. It can also open DICOM images of different equipment, including CT , CR , DR , MR , MG , US , DX, etc. Doctors can not only brows medical image, but also do operations on images including window level adjustment, partial enlargement , image zoom, image translation, image rotation, reverse display, window layout, image layout, multi sequence synchronization, sequence auto play, pseudo color, CT scanning line, image storage ,image measurement CT value, comment text, etc. Operation of medical imaging mainly utilizes two libraries in android including android.graphics. Bitmap and android.graphics.Matrix. You can achieve a variety of alteration of medical imaging with the aid of Matrix library. Now we elaborate on the implementation process of image rotation, Realization method of other image change are similar to it.

Image rotating means the image rotate a certain angle at some point as the center, then format a new image. The point is usually the center of the image. Since rotation is in accordance with the center of image, there will be a attribute which position is invariant away from the central position before and after rotation.

According to this property, we can obtain the corresponding relationship between the rotated coordinates.
of the point with original coordinates. Since coordinates’ origin of the original image is the upper left corner, we change the origin of the coordinates to the center of the image. Assuming the original image width is w and height is h, \((x_0,y_0)\) is the point within original coordinate, \((x_1,y_1)\) is the point after converting coordinates. So \(x_1 = x_0 - w/2; y_1 = y_0 - h/2.\)

In the new coordinate system, we assume the distance is \(r\) from \((x_0, y_0)\) to original point, the angle is \(b\) between line from \((x_0, y_0)\) to original point and x-axis, the angle of rotation is \(a\), the point after rotation is \((x_1,y_1)\), then the following conclusions:

\[
x_0 = r \cos b; y_0 = r \sin b
\]

\[
x_1 = r \cos (b-a) = r \cos b \cos a + r \sin b \sin a = x_0 \cos a + y_0 \sin a;
\]

\[
y_1 = r \sin (b-a) = r \sin b \cos a - r \cos b \sin a = -x_0 \sin a + y_0 \cos a;
\]

When getting the coordinates after conversion, we just need to re-convert these coordinates to the original coordinates. Another point to pay attention, Length and width of rotated image will change, so we will calculate the length and width of the new image.

VI. CONCLUSIONS

It is medical career development goals to provide equal medical service. It is the relentless pursuit of health workers how to provide convenient and efficient health care\(^5\). As long as the phone has signal, doctors can access the remote diagnosis central server to complete remote diagnosis by smart handheld devices at anytime and anywhere. The use of smart devices for the medical image remote diagnosis is an emerging technology, there are lacking in relevant standards. So there are some difficulties for the system's popularity and technology promotion. In addition, the medical images are usually in DICOM, CT format. So far, smart devices do not have the ability to display DICOM format images directly. We need converted the image into JPEG format and stored it to the server by the server process. On the other hand, the security measures is not mature enough to access Internet and server by smart devices. These issues also needed to be considered in the process of system development. These problems will look forward to be solved with more advanced hardware and software technologies in the future.

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