Designing Online Diabetes Diagnosis System Based On Chinese Health Information Platform

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Abstract—Providing high quality health care to people is a challenge for almost all the countries in the world. Chinese government also carries on medical reform and takes actions on developing Health Information Platform, which can support Electronic Health Record (EHR) as well as tiered regional health information database. Diabetes is one of the four priority non-communicable diseases identified by the World Health Organization. It has become a serious, burgeoning epidemic in China. Nowadays in China, there are two problems in diabetes diagnosis system, i.e., realizing real time diabetes blood glucose monitoring and health information transmitting between patients and EHR database. To solve these two problems, this paper, an online diabetes diagnostic system, consisting of patient side and EHR interface side, is discussed. The patient side monitors diabetic blood glucose continuously and transmits data to EHR interface. Specifically a Personal Blood Glucose Monitor System (PBGMS), which consists of an Android application and its corresponding server interface, is designed and implemented to record the diabetes patients measured blood glucose indexes and send the data to an EHR interface. In addition, this application supports the data analysis, data review, and data storage for the measured data. This application allows users to set alarms for themselves and check feedbacks obtained from the doctors. Thus, the software can be used as a tool for diabetes diagnosis based on Chinese Health Information Platform(CHIP).

Index Terms—health information platform, EHR, diabetes diagnosis system, android application

I. INTRODUCTION

Almost all the countries in the world are facing the challenge of providing quality health care to people [1]. By 2009, the average number of doctors for one thousand urban population were 1.75, while for agricultural population the number was only 0.47 in China, comparing to 3.59 in United States in 2005, 3.37 in French, 2.2 in UK and 1.6 in South Korea [2]. In April 2015, Chinese national medical and health institutions provided diagnosis and treatment for 640 million patients, which was increased 1.6%, comparing to the same time in previous year [3]. Doctors and medical institutions are not able to cope with large amount of patients. Due to the insufficient and uneven distribution of medical service, work intensity of doctors is high, but reception time of each patient is shortened, which means the quality of treating a patient can not be guaranteed.

Although large amount of health care knowledge is generated based on medical services every day, these data are not systematically documented [1]. As a result the data format is not compatible among different services. Moreover, the current health care platform has not considered the current situation of medical resource distribution. Therefore many countries including China decided to build up an unified health information platform which can computerize health care records, and thus to avoid serious medical errors, reduce costs, and improve the quality of medical treatment.

Diabetes has become a serious, burgeoning epidemic in China. Nowadays in China, there are two problems in diabetes diagnosis system, i.e., realizing run time diabetes blood glucose monitoring and health information transmitting between patients and EHR database. To solve these two problems, this paper, an online diabetes diagnostic system, consisting of patient side and EHR interface side, is discussed and presented. The patient side monitors diabetic blood glucose continuously and transmits data to EHR interface. Specifically a Personal Blood Glucose Monitor System (PBGMS), which consists of an Android application and its corresponding server interface, is designed and implemented to record the diabetes patients measured blood glucose indexes and send the data to an EHR interface. In addition, this application supports the data analysis, data review, and data storage for the measured data. This application allows users to set alarms for themselves and check feedbacks obtained from the doctors. Thus, the software can be used as a tool for diabetes diagnosis based on Chinese Health Information Platform(CHIP).

The paper is organized as follows: in Section II, background of this research is discussed. In particular, current situation of building up EHR in different countries are investigated. Chinese Health Information Platform(CHIP) is presented and the current diabetes diagnosis condition in China is also investigated. In Section III diabetes diagnostic system design is discussed. In Section IV system development and testing is presented. In Section V future work is discussed.

II. BACKGROUND

A. Electronic Health Record (EHR)

Electronic Health Record (EHR) is defined as a comprehensive collection of health information about individual patients and populations, which is electronically stored in a digital format [4]. These records could be accessed through different medium and devices, such as hospital and clinic web sites and patients’ end devices etc. The general medical health records include three parts, i.e., personal health records, family health records and community health records [5]. Personal health records are frequently used in general health care, and have the highest value in practice [6]. Family health records are established according to the actual family situation. Community health records do not have unified
requirements, and are mainly used for assessing physicians’ knowledge to the health state of residents in community [6].

In the mid and late 1990s, with the increasing research on electronic medical record system, the western developed countries devote to the study of EHR [7]:

- In 1995, Japan introduced common specifications on saving electronic medical image, and set up a special committee to the development of electronic health records. The committee consists of the government officers, academia and industry people;
- In 2004, American former president Bush emphasized on hospital information system construction and pointed out computerizing health care records. He also demanded that in the next 10 years the vast majority of Americans could share EHR;
- In 2007, the United Kingdom invested 6.4 billion pounds on establishing a general practitioner data system, doctor network software system, and Europe EHR etc in 10 years.
- The ministry of health of Canada spent $140 million on establishing a national electronic health file sharing system. The target was to complete 8 categories of EHR system.
- In 2009, U.S. President Barack Obama announced investing $20 billion on developing EHR information technology system.
- Chinese government formulated a tiered Health Information Platform, which is based on EHR, to make medical treatment easier and cheaper [8]. Zhejiang province covering 22 counties (or districts) started a pioneer project in 2012 [9]. The project established electronic medical record system, and set up a standard on sharing EHR information among 12 million residents in Zhejiang area [9].

B. Chinese Health Information Platform (CHIP)

Chinese government started to build up a Health Information Platform to manage the electronic health records (EHR) in order to achieve effective communications among clinicians, community doctors and patients in a local area [10]. The platform supports data transmission among different medical organizations, which mainly consist of electronic health record, point of service system, and primary medical institutions [10]. Point of service system is the information system used in medicinal institutions, which refers to hospital information system [18] [19], basic health service information system [20], and public health system [21] [22]. The primary medical institutions contain community health service centre, health clinics in towns and village clinics. These three components contribute to collecting and managing the health information to reduce the stress of health care. The general structured for the platform is shown in Figure 1.

The platform provides the following service: Registration service, EHR integration service, EHR management service, EHR read service, EHR cooperative service, Data warehouse, Information Security Services, Health File Browser, Public Service for Residents Health, One-Card for Residents’ Health and Health Information Access Layer(HIAL). This platform has not been widely established in China yet. However, many companies have already worked on developing software to support the platform [11]. Furthermore, some softwares have already been developed and used in hospitals [12]. For example, Sanming built the first public health information service management
platform in China in 2015 [12]. This platform has integrat-
ed unified electronic medical records and residents’ health
records, which are considered as the core of the underlying
database, in order to provide medical service and health
monitor service etc. [12].

C. Diabetes Diagnosis in China

Diabetes is one of the four high priority non-
communicable diseases (NCDs) identified by the World
Health Organization [13]. It is a common, chronic, and costly
illness which characterized by hyperglycaemia (high levels of
glucose in the blood). There are two types of diabetes. Type
1 diabetes is due to lack of insulin. Type 2 diabetes is due to
insufficient insulin and insulin resistance [14]. Diabetes
has become a serious, burgeoning epidemic in China. In
2013, the international diabetes federation reported that there
were 371 million people with diabetes, and approximate-
ly 100 million patients were from China [15]. China has
proposed treatment and regulatory schemes for diabetes in
recent years to prevent and treat diabetes. However, diagnosis
system for diabetes is not broadly available in China. The
first reason is that regular diagnosis and treatment cannot
be guaranteed. In China, a health management mode, i.e.,
hospital-community-family three-level health manager mode,
has been executed to provide diabetics with convenient
treatment [16]. In this mode, hospital is responsible for the
diagnosis and hospitalization of diabetics. Family should be
responsible for blood glucose measurement and providing
the data to doctors. Community should focus on providing
common therapeutic regimens with diabetics, and timely
checking the measured data via telephone contact. Therefore,
itis quite possible that the blood glucose of diabetics has
not been monitored all the time and the patients do not
realize the abnormal situation of their blood glucose index
-especially at midnight) [17], which may lead to emergent
circumstances. On the other hand, although CHIP (mentioned
in section II-B) is being constructed to manage the diagnosis
and treatment information, which is shared among hospitals
and communities [10]. Doctors in hospital and community
should be able to check the patients information via this
platform, understand the health status of the patient and give
proper feedback. However, this platform integrate different
data formats with various history data, which makes data
accessing and exchanging difficult. It is required to provide
certain methodology to solve these problems.

In this paper, a software system is designed and developed.
The system consists of two components, one is for the
patients side, and the other is for EHR interface, i.e., for
doctors (community and hospital) to access data through
CHIP. Specifically a personal Blood Glucose Monitor Sys-
tem (PBGMS), which consists of an Android application
client and its corresponding server program, is designed and
implemented. The client side records the diabetes patients
measured blood glucose indexes and sends the data to the
server, which serves as EHR interface. The client side pro-
gram supports the data analysis, data review, and data storage
for the measured data and allows users to set alarms for
themselves and check feedbacks obtained from the doctors
regularly. The server checks the data regularly, and gives
some feedbacks according to the patients illness state.

III. DIABETES DIAGNOSIS SYSTEM DESIGN

In this paper, a Personal Blood Glucose Monitor System
(PBGMS) is designed, seeking to support monitoring the
diabetic blood glucose regularly and obtain feedbacks from
doctors. This system consists of an Android application and
its corresponding server program. The patient side monitors
diabetic blood glucose continuously, saves the real time data,
analyzes the measured data through a simple algorithm and
sends the blood glucose indexes to the EHR interface. The
server checks the data regularly, and gives some feedbacks
according to the patients illness state. Below are some issues
that were investigated before system design.

A. Some Design Issues

- **Fundamental treatments for diabetes blood glucose
  control** Major monitoring indexes for diabetes blood
glucose control include fasting plasma glucose (FPG),
postprandial glucose (PPG), nocturnal glucose, glycated
hemoglobin (HbA1C) and dynamic glucose monitoring
[23]. Table 1 [23] provided a general description of the
glycemic control target for patients in different ages.
In this paper, the integrated data are collected according
to the table in order to design the analysis algorithm for
the measured data. Specifically, the measured time could
be divided into four category, which are before meals,
after meals, before sleep and dawn. The normal range
for these four category are respectively in the range of
3.9 to 9, 4.5 to 14, 4.4 to 11, and 4.0 to 11.
- **Glucose Detectors** In this project, the measured data
  for blood glucose should be transmitted to PBGMS.
Therefore, a glucose detector [24], such as a sensor
or glucometer, which supports the data transmission, is
needed. Many devices have been invented to measure
the blood glucose. Some available glucose detectors are
listed below:
  - Diasensor 1000 [25]: a blood glucose monitor sen-
or invented by Biocontrol Technology Company,
which uses near-infrared technology and multivari-
ate regression to estimate blood glucose level.
  - GlucoWatch Biographer [26]: a glucometer pro-
vides automatic, frequent and noninvasive blood
glucose measurements for up to 12 hours.
  - Noninvasive Glucose Meter [27]: an apparatus de-
vloped by Pindi Products Company for noninva-
sive detection and quantitation of analyses which
utilizes special membrane electrodes.
  - GlucoNIR [28]: a blood glucose measurement
system developed by CME Telemetrix Company,
which uses infrared spectroscopes in near-IR spec-
trum. In addition, this product is equipped with a
LCD display and powered by battery. It has a com-
bination port which supports the acquisition of
measured data.
  - Abbott Free style Navigator [29] [30]: This product,
equipped with wireless receiver, supports continu-
ous real-time detection of blood glucose and simple
analysis function.
- **Smartphone Operating System Investigation** In 2013,
the ZOL in China has conducted a survey on the
peoples smartphone operating system [31]. The result
shows that the majority of mobile phones use Android operating system. Thus, the personal blood glucose monitor system is designed as an Android application so that majority of people in China are able to utilize this system.

- **Java Servlet and Apache Tomcat** Servlets are small, platform-independent Java classes complied with an architecture neutral bytecode that can be loaded dynamically into and run by a web server [32]. Apache Tomcat, an open-source web server developed by the Apache Software Foundation (ASF) [33]. Tomcat implements several Java EE specifications including Java Servlet, JavaServer Pages (JSP), Java EL, and WebSocket, and provides a pure Java HTTP web server environment in which Java code can run [33]. In addition, Apache Tomcat is also regarded as the servlet container that is used in the official reference implementation for the Java Servlet and Java Server Pages technologies [34]. Therefore, Apache Tomcat is chosen to publish the servlet in this project. In addition, a free dynamic domain name service resolution software called Oray Peanut Hull is utilized in this project [36]. This software helps developers to build a fixed domain Internet host with their personal computers. Then, clients in different areas are able to access the system server via the Internet.

![Deployment Diagram](image1)

Fig. 2. System Deployment Diagram

![Structure Diagram](image2)

Fig. 3. Structure of the Program

**B. System Design**

- Figure 2 is the deployment diagram of the system. The system is based on client-server architecture. The client side is the smart phones based on Android operating system, and the server side is the personal computer based on Windows. In addition, all servers in server side should be published to a web server, which is Tomcat in this case. The server side also need to connect with a database server.

- Figure 3 illustrates that designed system is split into subsystems. In particular, the client program supports the user register, user login, data manipulation, feedback check and alarm setting. The server program includes register confirmation, login certification data storage and feedback extraction.

Table I and Table II show the detailed module descriptions in client and server programs.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>MODULE DESCRIPTION OF CLIENT PROGRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client-Side</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>User Register</td>
<td>Support register with assist of server</td>
</tr>
<tr>
<td>User Login</td>
<td>Support login via checking from server</td>
</tr>
<tr>
<td>Data Manipulation</td>
<td>Measured data analysis, storage and view</td>
</tr>
<tr>
<td>Feedback Check</td>
<td>Show feedbacks from doctor with assist of server</td>
</tr>
<tr>
<td>Alarm Setting</td>
<td>Set alarm to add some reminding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE II</th>
<th>MODULE DESCRIPTION OF SERVER PROGRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Server-Side Module</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Register Confirmation</td>
<td>Check and insert the account information into database</td>
</tr>
<tr>
<td>Login Certification</td>
<td>Check the login information from database</td>
</tr>
<tr>
<td>Data Storage</td>
<td>Save the measured data and analysis result in database</td>
</tr>
<tr>
<td>Feedback Extraction</td>
<td>Extraction feedbacks from doctor server database</td>
</tr>
</tbody>
</table>

- The sequence diagram shown in Figure 4 illustrates how the client program communicates with the server program. In short, the client sends request to the server. Then the servlet executes some operation with the database server. Next, the servlet returns the results to the client.

**C. Detailed Design**

- **Client Side Design** The client side program is an Android application. The class diagram is illustrated in Figure 5. In addition, the interface HttpClient is consistent with the interface design in server side to support the communication between client and server.
Server program is a dynamic web application. The class diagram for the server program is shown in Figure 6. Six classes are designed, including Record, Register2, Login2, Feedback2, Database, and User. The first four classes are used to support the communication with the client side program. Thus, these four classes extend HttpServlet interface to support the inter-linkage between the client side and the server side. In addition, the “Database” class is used to connect the server side with the database server, and the “User” class is the entity to store the information extracted from the database.

Database Design In this project, two databases are created. One database is in the android application to store the measured data, and another database is in the server side to store the account information and measured data. In addition, the database in android application is designed to reduce the unnecessary waste of data size. Thus, users do not need to download the information of measured data. The database in client side is a SQLite database [37], which stores the measured data for users. The database in server side stores users personal information and measured data, including account, password, name, gender, height, weight, age, feedback, phone number and the measured data in different date and time.

User Interface In this application server program is mainly used for querying and storing the user information, such as the account information and measured data. Thus, the interface for server can be replaced by any Graphic-User-Interface tool for MySQL. One of the user interface design for the client side is shown in Figure 7.

Experimental Environment In this project, the android application and its server side are developed. The server installs the MySQL Server, Tomcat, Eclipse, Android Software Development kit Java Development kit (SDK), Android ADT, Java Runtime Environment, and corresponding Java Development kit (JDK). In addition, an Android smart phone is required to run the developed client application.

Client Side Program Five functionalities are implemented, i.e., login, register, data manipulation, feedback check and alarm setting. Data manipulation supports data analysis and storage, and data view function.

Server Side Program The server program mainly consists of four servlets which respond to the corresponding requests from the client application. In addition, the server supports the data query and modification to the database.

Project Deploy and Network Setting The server program is developed as a dynamic web application and deployed on the web server Tomcat. Oray Peanut Hull is used to build a static host for the developers personal computer and thus enables the access from client in different areas. The basic network configuration consists of three steps:

1) Create an account in the official website of this software
2) Download and install the software
3) Login in the software and then open the Network Mapping

TESTING The decision table based testing [39] has been applied to test the above functionalities. In order to test the capacity of the server, a load testing [35] was used to test the scripts and ensure that...
the server can handle multiple requests from a number of clients simultaneously. The load testing software SoapUI [38] was used and the simple strategy was chosen to test the program. The strategy runs the specified number of threads with the specified delay between each run to simulate a "breathing space" for the server. In this test, the thread, which was represented the client number, was increased from 0 to 1000 with the step of 200. In addition, the delay was set to a fix number, which was 1 second, and random was set to amount of delay. Figure 8 shows one testing result when the client number is increased to 1000. The load testing results illustrate that the performance of the server is acceptable since the response time is less than 0.5 second, though the response time increases as the client number increases.

![Load Testing Diagram](image)

**Fig. 8. Load Testing Diagram**

V. CONCLUSION

In this paper, a software system for diabetes diagnosis based on Chinese Health Information Platform (CHIP) is designed and developed. This is our first attempt and some improvements can be conducted. For example, the network mapped by the software Oray Peanut Hull sometimes is not stable. Therefore clients may not successfully access to the server all the time. In order to achieve a stable network, it is possible to deploy the server side into a cloud host instead of a personal computer. In addition, the user interface can be more intuitive and user friendly. For example, the measured data can be shown in a table or a pie chart. To make the system complete, another important program should be developed, i.e., the program for doctor side. The system should support doctors to access patients’ medical history and give proper treatment. Due to the deficiency of doctors, the system should support dynamic and intelligent allocation for doctors. Due to the confidentiality of patients, the system should also provide certain security mechanism.

REFERENCES