A Low-Cost Community Healthcare Kiosk

Guiqin Sun, Shenyi Tao, Yongqiang Lu, Yu Chen, Yuanchun Shi, Ni Rong
Research Institute of Information Technology, Key Laboratory of Pervasive Computing, Ministry of Education, Tsinghua University
Beijing, P.R.China
luyq@tsinghua.edu.cn

Rui Wang, Xiaojuan Lu
General Hospital of PLA Second Artillery
Beijing, China P.R.China
ieee201103@gmail.com

Abstract-This paper presents a low-cost community healthcare kiosk, which is used in public areas and developed to help people on daily healthcare and long-term chronic disease monitoring. This kiosk integrates some low-cost biological devices and controls them with a built-in industrial computer. A touch-screen based Graphic User Interface and a remote service interface is offered too. The results will be automatically sent to the remote server with 128bit encrypted https protocol and without any user information except an ID number which is delivered by the trusted third-party who will support the kiosk based medical service. Users can query their records via internet and receive reminders and help in case their records should show abnormality. Some trial results are presented at the end of this paper.

Keywords-community healthcare; healthcare kiosk; telehealthcare

I. INTRODUCTION

People have been paying more and more attention to their health status. The focus of modern medical treatment is gradually changed to prevention of diseases and improvement of physical fitness, e.g. via early warning of disease [1]. Instead of going to hospital, some people are willing to have a convenient device to monitor their long-term bio-data economically and easily. On the other hand, there are many requirements for general and authentic medical information pushing platform for the public.

Stephandis et al. have predicted that public information systems, terminals, and information appliances will be increasingly used in a variety of domains [2]. There are really some successful applications in the teledicine area, such as the Health Buddy system by Health Hero Network [3], the Health Engage Asthma by Health Engage [4] and the VoIP based Tele-homecare Application kiosk [5]. All of them are personal healthcare systems, helping people to monitor their health status. However, the first one doesn’t provide a complete healthcare solution, and the second one is so far a proprietary system which can’t be integrated with any other existing infrastructure [5]. At the same time, they are all limited to private use.

This paper proposes a low-cost, compact and extendable healthcare kiosk which is available for applications based on community. This system mainly resolves the problem of bio-data gathering and preprocessing at public place. It’s an extension of hospital function, and acts as a supplementary approach of daily physical examination for the public. By measuring ECG, blood oxygen saturation, weight, temperature and blood pressure, it can help people recognize the abnormal health status and give corresponding advice timely with less expense. The kiosk makes healthcare service accessible to anyone at anytime. With its implement, it can also solve the problem of "push the healthcare information to the public". The system covers 2 aspects, public information pushing and personal information pushing, while the personal pushing includes SMS pushing and system pushing.

The paper is organized as follows. Section II describes the technical framework; section III presents the detailed technology including the architecture, devices and integration in both hardware and software; section IV illustrates the real implementation and trial statistics, and section V will give the conclusion and future work.

II. TECHNICAL FRAMEWORK

As Figure 1 shows, this paper employs the three-level healthcare framework [6] in the kiosk designing process which isolates the physical devices and business logic effectively and provides friendly interfaces and control mode to users and developers.

![Figure 1. The three-level healthcare architecture.](image)

This work is supported by the Tsinghua National Laboratory for Information Science and Technology Cross-discipline Foundation and FIT Foundation on the Research on the Key Technologies on Healthcare Information Management.
A. Device level

This level focuses on the medical/biological devices. Using wireless or wired connections the framework integrates devices which are selected in particular designs. There are corresponding interfaces designed in device level for reading data and controlling devices respectively.

B. Data level

This level focuses on data processing and data transfer. Our framework can integrate a variety of devices, each of which has its own data format. In this paper, we design general data formats in data level for convenience of reading and controlling devices and easy support of applications in the framework. More details will be described in section III.

C. Application level

This level is composed of a variety of medical applications. Some applications just show data to user; some analyze; some connect to remote server.

Based on the framework, a low-cost community healthcare kiosk is implemented. Strictly speaking, the community healthcare kiosk is not a device-level-only apparatus. It should cover the first level and part of the second level because there is a server behind the kiosk and it also processes some of the data gathered from users. Furthermore, the kiosk mainly focuses on how to integrate devices, how to interact with the users, how to adapt to most Medical devices and how to connect remote server securely.

III. THE KIOSK DESIGN

A. Architecture

According to the framework mentioned above, a kiosk should mainly include three parts: healthcare kiosk, remote server, background service applications. As Figure 2 shows, the kiosks will be distributed at different public areas, people can get the same service at any kiosk available. All kiosks are connected to the remote server(s) by Internet. A telemedicine application with manual service is also developed to validate the real usage of the kiosk. The application on the remote servers are B/S based, doctors or professional service staff can login in at anywhere even with mobile devices, they can browse the user data and distribute the corresponding advices and related knowledge either through the system accessible at kiosks or through emails and phone calls/ instant messages.

B. Kiosk Biological Devices

As Figure 3 shows, there are five monitoring devices in our system, i.e. ECG, oximeter, blood pressure, thermometer and weighting scale. They are revised based on the existing ones which can be bought from markets and are selected according to the balance of cost and performance.

II. THE KIOSK DESIGN

A. Architecture

According to the framework mentioned above, a kiosk should mainly include three parts: healthcare kiosk, remote server, background service applications. As Figure 2 shows, the kiosks will be distributed at different public areas, people can get the same service at any kiosk available. All kiosks are connected to the remote server(s) by Internet. A telemedicine application with manual service is also developed to validate the real usage of the kiosk. The application on the remote servers are B/S based, doctors or professional service staff can login in at anywhere even with mobile devices, they can browse the user data and distribute the corresponding advices and related knowledge either through the system accessible at kiosks or through emails and phone calls/instant messages.

B. Kiosk Biological Devices

As Figure 3 shows, there are five monitoring devices in our system, i.e. ECG, oximeter, blood pressure, thermometer and weighting scale. They are revised based on the existing ones which can be bought from markets and are selected according to the balance of cost and performance.

III. THE KIOSK DESIGN

A. Architecture

According to the framework mentioned above, a kiosk should mainly include three parts: healthcare kiosk, remote server, background service applications. As Figure 2 shows, the kiosks will be distributed at different public areas, people can get the same service at any kiosk available. All kiosks are connected to the remote server(s) by Internet. A telemedicine application with manual service is also developed to validate the real usage of the kiosk. The application on the remote servers are B/S based, doctors or professional service staff can login in at anywhere even with mobile devices, they can browse the user data and distribute the corresponding advices and related knowledge either through the system accessible at kiosks or through emails and phone calls/instant messages.

B. Kiosk Biological Devices

As Figure 3 shows, there are five monitoring devices in our system, i.e. ECG, oximeter, blood pressure, thermometer and weighting scale. They are revised based on the existing ones which can be bought from markets and are selected according to the balance of cost and performance.

III. THE KIOSK DESIGN

A. Architecture

According to the framework mentioned above, a kiosk should mainly include three parts: healthcare kiosk, remote server, background service applications. As Figure 2 shows, the kiosks will be distributed at different public areas, people can get the same service at any kiosk available. All kiosks are connected to the remote server(s) by Internet. A telemedicine application with manual service is also developed to validate the real usage of the kiosk. The application on the remote servers are B/S based, doctors or professional service staff can login in at anywhere even with mobile devices, they can browse the user data and distribute the corresponding advices and related knowledge either through the system accessible at kiosks or through emails and phone calls/instant messages.

B. Kiosk Biological Devices

As Figure 3 shows, there are five monitoring devices in our system, i.e. ECG, oximeter, blood pressure, thermometer and weighting scale. They are revised based on the existing ones which can be bought from markets and are selected according to the balance of cost and performance.
All the devices are connected to the built-in industrial computer via either USB or serial port wires and controlled completely by the central computer. The kiosk exchanges data with remote sever by LAN access (normal RJ45). This all-in-one kiosk is fit for community use very much, e.g. it can be placed at public places that have an LAN access port or even cellular network.

2) Software Integration

a) Built-in Data Processor

There are various devices in the kiosk. By using the serial port and USB port, the built-in computer can communicate with them. However, every device has its own data format and protocol to communicate with others; they need to process dedicatedly to make the whole integration work well. In this case we design a common data format as Table I shows. The first two bytes are the message header, and the next byte describes the data’s length. The 3rd byte shows the ID number of the module which is employed to distinguish the devices. The command to the device is organized in the 4th byte and the response type from the device is the 5th byte. All the rest data body will be formulated in the last n bytes. For example, the thermometer used in this kiosk, a data format of “55 aa 03 30 01 34” means “let it get the temperature and return”, in which 03 is the data length; 30 is the thermometer module ID; 01 means to measure; no response byte is needed in this command message. If the thermometer performs normally, it will return another data message like “55 aa 04 30 01 01 36”, which means “the temperature of 36 ℃ is returned as response”.

Different devices will have different module numbers, commands, responses and n values as Table II defines.

<table>
<thead>
<tr>
<th>Device</th>
<th>Module Number</th>
<th>Command</th>
<th>Response</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>0xff</td>
<td>0x01 for name</td>
<td>0 for OK</td>
<td>Length of ECG data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x03 for start</td>
<td>1 for Error</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x04 for stop</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x05 for read</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BP</td>
<td>0x30</td>
<td>0x59 for stop</td>
<td>0x34 for waiting</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x44 for Cross-border</td>
<td>0x50 for stop</td>
<td></td>
</tr>
</tbody>
</table>

b) User Interface

The software is developed on the Windows XP and has graphical user interface (GUI) as Figure 5 shows. Anyone can make a health examination through this system by simple clicks on the screen or just waiting for the automatic system reactions. As Figure 5 illustrates, for a regular user, he can swipe his ID card and login to the system automatically. The system will present five functional entries, i.e. personal information management, biological status examination, daily conversation, message management and educational information. The kiosk also supports the historical data query and some preliminary statistics. All the data will automatically upload to the remote server when the network works well; otherwise the data will be archived locally with encryption and resume uploading when the network recovers.

For a public infrastructure, securing personal data is very important.
important especially for biological data and personal information. Taking this into account, there are two methods to keep privacy protected and make the data safe in the kiosk design. First, all data will not be archived without encryption on the local machine, and they will be removed automatically after certain-time invalidation (e.g. the network keeps down for a certain time). Second, only the user ID is required to identify or record in the system, and all other personal information like name and contact information will not appear in the kiosk and are maintained directly by the remote trusted third party service provider. For community users, this kind of service can even be provided anonymously. Finally, all the data transfer to the server are compliant with 128-bit encrypted https protocol to make sure the data safe in the data path of internet.

IV. IMPLEMENTATION AND TRIALS

Recently, two healthcare kiosks and a dedicated server for the telemedicine system have been developed. The kiosk is shown in Figure 6 (a is the front view and b is the side view). There is a stainless steel model to integrate and protect all the devices. There are two screens, the upper one is the LCD screen which is designed for public education media broadcasting; the other is the touch screen for user interactive operation. The altitude level of the Blood Pressure on the left side can be adjusted. The ECG offers a set of stainless clips for easy use marked red, blue, black, which can be seen clearly in Figure 6(b). The Weight scale just lays on the ground as the dark blue platform on the right side shows. The Oximeter lays on the front panel under the touch screen, beside which there is an IC card reader for user identification. The infrared thermometer is right above the touch screen and under the top screen. By defining the specific communication protocol as described above, the kiosk can receive and process biological data from different devices. There are also some reserved interfaces in case there should be other devices to integrate.

The server is developed as a web server supporting a telemedicine browser/web system. Figure 7 shows its browser side interface. Doctors or service staff can use this to tract the records of users and trigger an event or session with specific users via emails, calls and short messages. Currently there are about 100 tests, most are done by students and teachers. Table III is a summary of test results.

Since the kiosk uses some professional biological devices, people may need assistance at first-time use. It is very easy to learn how to use for average people with preliminary education backgrounds. For the community of aged people, professional assistance is suggested.

TABLE III. TEST RESULTS

<table>
<thead>
<tr>
<th>Test result</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>80%</td>
</tr>
<tr>
<td>Users’ lack of familiar about the whole operation</td>
<td>9%</td>
</tr>
<tr>
<td>Software’s lack of consistency with hardware</td>
<td>2%</td>
</tr>
<tr>
<td>Crashes after long-time working</td>
<td>2%</td>
</tr>
<tr>
<td>Interface loose or disengage</td>
<td>3%</td>
</tr>
<tr>
<td>The relative standard deviation of the results</td>
<td>4%</td>
</tr>
</tbody>
</table>

V. CONCLUSION & FUTURE WORK

The current version of the healthcare kiosk serves as a useful prototype for low-cost community healthcare analyses. It offers the basic biological data measurements and supports extensions on both kiosk side and service side based on a client server architecture. However, the usability and robustness of the system are not guaranteed according to the initial trials. In future work, real community trials will be deployed and more testing results will be collected and analyzed. Based on them, the usability and robustness of the system will be improved further. At the same time, more environment-friendly profile design of the kiosk will be taken into account.

REFERENCES