A Low-Cost Community Healthcare Kiosk

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***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. It currently supports monitoring ECG, blood pressure, temperature, blood oxygen saturation and weight. 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 telemedicine 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.

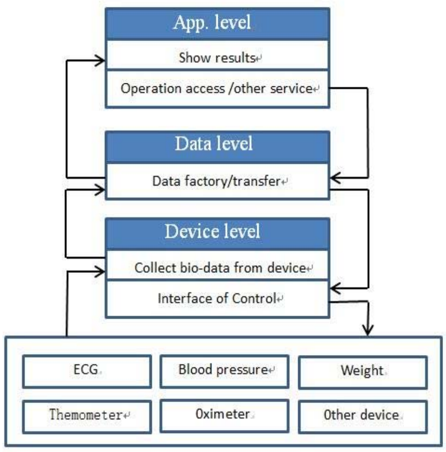

Figure 1. The three-level healthcare architecture.

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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.

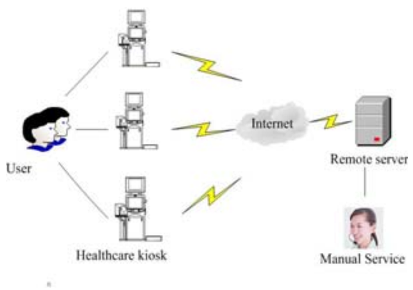

Figure 2. Architecture of the kiosk

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.

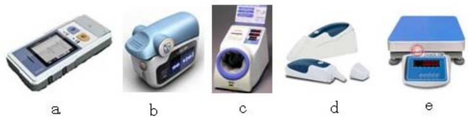

Figure 3. Monitoring devices

Figure 3(a) is the ECG, a single-lead based embedded system. There are also three stainless clips .Standard Lead II configuration offered for ease of use. The measurement results can be sent out via USB (Universal Serial Bus).

Figure 3(b) is the oximeter, a finger-clipping optical oxygen saturation meter. It will start automatically when a user presses the start button and puts a finger into the monitoring aperture. USB port is also used to transfer data.

Figure 3(c) is the Blood Pressure (BP) monitor, an optional automatic Blood Pressure measurement instrument for kiosk use. Compared to the upper arm BP instruments, it's more robust, durable and easy to use. Users don't need to understand much professional operation, it will automatically inflate and measure the pressure numbers. However, it is a little bit expensive and requires users sitting perfectly otherwise the results would not be guaranteed. It is also available for designers to replace it with a lower-cost upper arm BP. Currently it uses Serial Port to transfer data.

Figure 3(d) is the thermometer, an infra-red forehead temperature meter. It is non-contact and easy to use. The kiosk in this paper just fixes it at a proper height and users just need to let their foreheads approaching to it within a limited distance. The result will be automatically achieved and transferred out by a USB port.

Figure 3(e) is the weighting scale, which is an industrial scale with a stronger shell model for durable public use. It also has data transferring interface via USB port.

C. Integration

1) Hardware Integration

The kiosk integrates several biological devices and connects them to an industrial computer with plentiful external ports. is supposed to support only the authorized people in most circumstances, so it has a user identification reader by default. For easy use, a touch screen is installed to input and output data and another LCD screen is prepared by default to display some educational videos or user-specific multimedia (such as advertisement) .

The detailed design of the kiosk is illustrated in Figure 4. The number 1 points to the advertisement LCD screen; 2 is the thermometer; 3 is sterilizing place; 4 is the touch screen; 5 is the ECG; 6 is the oximeter; 7 is the user identification reader; 8 is the weight scale; and 9 is the Blood Pressure.

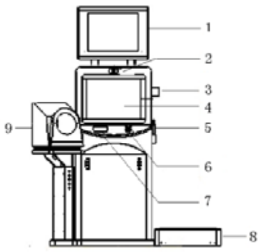

Figure 4. Design of the kiosk

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 defines.

TABLE I. THE COMMON DATA FORMAT

2Bytes	**1Byte**	**1Byte**	**1Byte**	**1Byte**	**n Bytes**
Header	Len	Mod. No.	command	Response	Data body

TABLE II. DATA FORMATS FOR DEVICES IN KIOSK

Device	**Module Number**	**Command**	**Response**	**n**
ECG	0xff	0x01 for name 0x03 for start 0x04 for stop 0x05 for read	0 for OK 1 for Error	Length of ECG data
BP	0x30	0x59 for stop 0x44 for Cross-border 0x52 for start	0x54 for waiting 0x50 for stop	16
Oximeter	0xf9	0x03 for start 0x04 for stop 0x05 for read	0x0b	11
Thermometer	0x30	0x01 for start 0x02 for close 0x03 for test 0x04 for stop 0x05 for read	1 for OK 2 for Error	11
Weight	0xf6	0x08 for start 0x09 for reset 0x0a for stop	0x0a for OK 0x0b for Error	10

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.

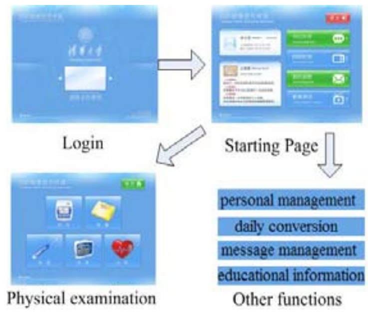

Figure 5. Interface and functions of the software

All measuring operations are guided by the pictures and movies on screen and necessary voice notification are offered too. Users don't have to pay much attention to each device for all the controlling commands to the devices are issued by the system. The only thing for user to do is acting as the screen tells, e.g. put up the electrodes, hold out fingers, step onto weighting scale, etc. For a trial user, one can also login the system by clicking the "trial" icon. All functions will work well except for the data discarded.

c) Interface to Server

The application for healthcare kiosk is based on the internet, which has manual service interface. It looks more like a browser based office automation application. There is login access for doctors and administrators; they can browse their patients' biological records and give corresponding advice through the system. Different educational message both in media and other forms are also distributed through the system.

For a public infrastructure, securing personal data is very 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 the 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.

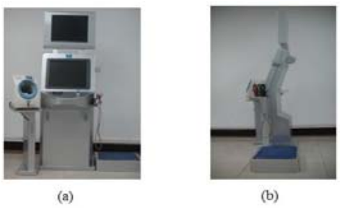

Figure 6. Appearance of the community healthcare kiosk

The server is developed as a web server supporting a telemedicine browser/web system. Figure 7 shows its browser side interface. Doctors or service stuff can use this to tract the records of users and trigger a event or session with specific users via emails, calls and short messages. Currently there are no built-in analysis algorithms or data mining modules in the server side, and all data recognition and analysis are based on personal professional knowledge.

The cost of the integration of the biological devices to the kiosk is low by using the existing data ports of the devices and the computer. The most cost of the kiosk is taken to set up the steel model and buy the peripheral devices, which is relatively low though.

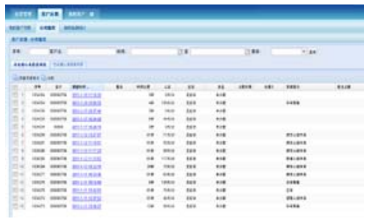

Figure 7. Browser interface of the server application

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.

Recently there are about 100 tests, most are done by students and teachers. Table III is a summary of test results.

TABLE III. TEST RESULTS

Test result		Percentage
Success		80%
Failure	Users' lack of familiar about the whole operation	9%
	Software's lack of consistency with hardware	2%
	Crashes after long-time working	2%
	Interface loose or disengage	3%
	The relative standard deviation of the results	4%

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.

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