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Health Monitoring of Elderly in Independent and Assisted Living

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***Abstract*—This paper aims to present a comprehensive solution for health monitoring of elderly in independent and assisted living. One mandatory requirement is on the provision of suitable medical devices and apparatus for regular health monitoring and data measurements of the elderly. Then, a user-friendly interface would help the upload of health-related data and measurements to a web portal in the Internet, which would provide a database and management service. The paper also discusses on the development of a Responsive Health Monitoring System which would provide automated data analysis and response to the collected data. The system is designed to provide real-time response to the needs of the elderly, as well as the regular health evaluation. It can deal with both emergency and routine events round the clock, with knowledge-based coordination and management.**

Keywords- health monitoring; elder people; web portal; responsive system; telemedicine; automation

I. INTRODUCTION

In many cities of the world, the population is ageing. Take Hong Kong as an example [1], in 2008, the population of elderly persons aged above 65 is 12.6% (0.88 million) of the total population in Hong Kong. It is estimated that in 2016 and 2033, the percentage will increase to 14% and 27% respectively.

There are many different types of senior housing and care [2]. On one end of the scale, we can find independent living communities where the seniors have the maximum personal freedom in a lifestyle filled with recreational, educational and social activities. On the other end, we find skilled nursing facilities designed for seniors who are in need of 24-hour nursing care. Assisted living is often viewed as the best of both worlds. Residents have as much independence as they want with the knowledge that personal care and support services are available as required [3]. Table 1 would summarize the characteristics and level of major services that may be offered for three main types of senior housing.

Assisted living communities are booming in North America and Europe, and is becoming an international trend. It is a living arrangement that provides housing and personal care options and services [4] for folks who find it increasingly difficult to take care of their personal needs. From bathing and grooming to meal preparation and transportation services, those who live in an assisted living home are encouraged to do everything they can for themselves. However, those needs that cannot be met on their own will be taken care of.

One major concern for the assisted living communities is the lack of comprehensive health services provided in nursing homes. Very often, medication assistance and/or reminders are not provided, for the senior is supposed to take care of himself/herself to a certain degree.

	Independent Living	**Assisted Living**	**Skilled Nursing Care**
Level of Personal Freedom in the Environment	Level 5 Independent	Level 3 Medium	Level 1 Very limited
Level of Assistance on Daily Living Activities (dressing, personal care)	Level 1 No Assistance	Level 4 or 5 A lot or comprehensive Assistance	Level 5 Comprehensive Assistance
Level of Health Services	Level 1 None	Level 3 Medium	Level 5 Skilled Nursing
Level of Overall Personal Health	Level 5 Good	Level 3 Medium	Level 1 Poor
Level of Community Services (laundry, cleaning, etc.)	Level 2 Minimal or Medium	Level 4 or 5 Many	Level 5 Many
Level of Offered Community Activities (social events, outings, etc.)	Level 2 Few	Level 3 Medium	Level 2 Few

TABLE I. TYPES OF SENIOR HOUSING

II. REVIEW OF RELATED WORK

The idea of developing a remote health monitoring system can be found in many literatures ([5-9]). For example, in [10], the cell phone was suggested as the transmission device through which request for emergency service and health measurement data can be sent. Some early wireless health care monitoring systems were also described. Recently, an

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iPhone/iPad App called BPMonitor is developed for a user to input blood pressure measurement data. The data can be displayed and analyzed, or it can be transmitted to a medical health personnel.

An emergency support services for elderly citizens called Personal Emergency (PE) Link Service, also called "safety bell", was launched by the Senior Citizen Home Safety Association (**SCHSA**) in 1996 [11]. The service operates by connecting PE Link users through an advanced communication system to a 24-hour PE Link Centre. By pressing the main unit or the portable remote trigger device, a user can speak to an operator through the main unit at home. An operator would identify the needs of the caller and provide the necessary support services. A residential telephone line is needed for installing the service. Below is an analysis on the characteristics of the PE Link Service:

1. **Nature of the service**: The primary aim is towards the provision of **emergency** call service. The operator would try to confirm the nature of the call to determine on an appropriate action. In recent years, the service has been extended so that the user can press the PE link for accessing to the ancillary services which include providing social service information and referrals regarding home help services, emotion counselling, contacting family members and security functions, etc. However, this would cause considerable resources and deviate from the primary objective of PE link.

2. **Technology**: The PE link depends on fixed telephone line. With the availability of many lightweight mobile phones in the market (some less than 90g), the current hardware setup of PE link has many limitations. PaperPhone, a bendable mobile phone that is extremely lightweight, will appear in the market very soon.

3. **Human Resources** : An operator is needed to pick up every call and to determine its nature, in addition to the screening out of false alarms. SCHSA is also providing a more comprehensive service which include tele-health link, post-discharge tele-health advice, transmission of personal record to hospital in emergency, as well health advice hotline. This would also cause considerable manpower in the provision of those services.

In the next section, a modern health monitoring system and emergency handling system is described. The modern system can provide similar services to the one described above, but it has the following features:

1. **Automated handling of emergency call** : The fall sensor also has a panic button which is similar to the remote trigger provided by the PE link. Every incoming emergency call can first be handled automatically by the web portal and a set of confirmation procedures can be performed without a human operator. After a quick screening by the system, the operator can then determine the appropriate action to follow up.

2. The system is for **both health monitoring as well as for emergency service**. It is also designed for the user to upload health measurement data so that wireless health care monitoring can be carried out. The latest Interent technology will be used to provide a user-friendly interface for the users. Through the **web portal**, information related to health and social service can be provided. This would greatly reduce the manpower required in handling phone call via the PE link.

3. The system makes use of **WiFi or 3G** for communications and transmission of health data. With the use of WiFi/3G, the user would not be fixed to within an area or a range when using the service. The location information can also be automatically determined by the mobile device. In a retirement community or housing estate, the WiFi network is probably free and shared among many users.

4. Knowledge-based techniques and machine learning methods are used to process the health measurement data to look for unusual signs or trends in the database. This provides another level of automation which would lead to a high quality health monitoring system.

III. TECHNOLOGY FOR AUTOMATED HEALTH MONITORING

With the use of frontier technology, this paper aims to present a comprehensive solution for health monitoring of elderly people in independent and assisted living. Next, we discuss the detailed objectives of the development.

A. Provision of Basic Equipment

A preliminary requirement is to provide a set of medical devices and apparatus to the elderly for proper health monitoring. The medical devices could include thermometer, blood pressure monitor, blood gluco meter, scale, oximeter with heart rate monitor etc. A fall sensor is also provided. An Application software (App) is being developed for use in an Android tablet which can receive a signal from the fall sensor. The signal is sent via Bluebooth from the fall sensor. On receiving the emergency signal, the App would send the information to a web portal via WiFi /3G. The elderly can also upload his medical health data to a web portal via the tablet PC device on a regular basis. Figure 1 shows an Android tablet with App to receive the emergency signal or health data for uploading.

Figure 1. Android tablet with App to receive emergency signal or health data for uploading

B. Health Monitoring Web Portal

The next development is a web portal for health monitoring of the elderly. It would include the setup of a database and the development of the user interfaces for secured but easy access by the elderly, his family members or health monitoring personnel. This would provide an advanced remote network health monitoring and management service.

The webserver has a database for the storage and management of the health data. Through the website, an elder can login to review his personal health record. His family members can also examine his health record to find out his health condition. In addition, health monitoring personnel, nurses and doctors can also check on the health condition of the elder so as to provide the best medical care possible. Figure 2 shows the development of the web portal.

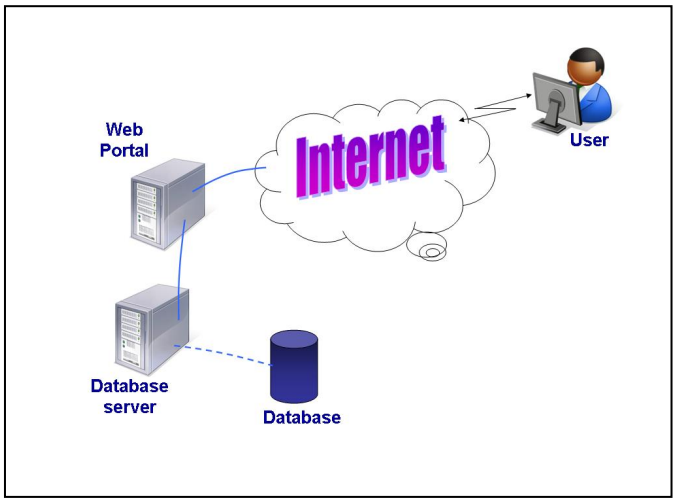

Figure 2. The web portal

C. Responsive Health Monitoring System

With the use of the health record in the database, trend analysis will be carried out to examine for unusual pattern or trend of the health data or measurements. A knowledge base will be developed based on the experience of expert nursing personnel. In the emergency situation of receiving a fall sensor signal, automated response will be carried out immediately for verification of the alarm. When needed, automated message can be dispatched to the emergency team or ambulance.

The idea on the development of a Responsive Health Monitoring System originated from **Responsive Process Management (RPM)** [12] in the IT industry. The technology emphasizes on the real-time responsiveness to operational conditions and events. The system is based on the following:

(a) Real-time visibility across its entire process environment

(b) Continuous analysis of operationally-relevant data

(c) Real-time agility in process execution

The system's operational process is automated or semi-automated. Where appropriate, the process execution would trigger operator participation to leverage on real-time operational intelligence. One importance criterion of the system is on the processing of events on the arrival of an emergency signal from a fall sensor. The system can also carry out analysis of the health data on the elderly.

The analysis of the health data can be carried out based on knowledge-based and expert system techniques developed from AI research. Rules for execution by an inference mechanism of an automation program are developed. The rules are extracted from the expertise/experience of the health professionals. The rules would describe the range values of the health data that requires constant monitoring. In addition, the data trends (speed of increasing or decreasing) are also important indicators which require careful monitoring by the program. Figure 3 shows the responsive health monitoring system.

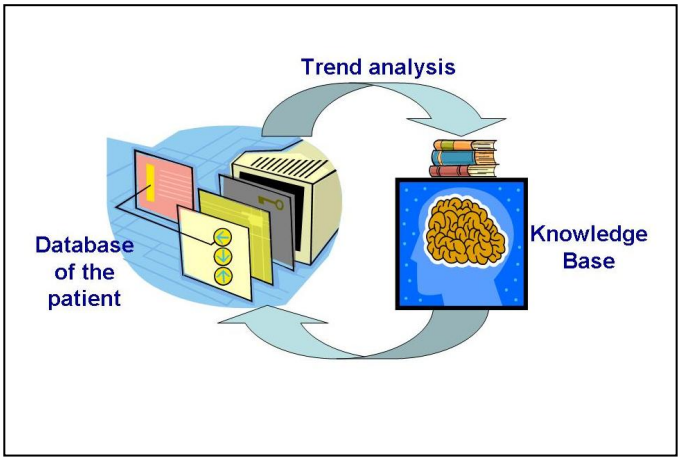

Figure 3. The responsible health monitoring system

The overall idea of the development is shown in Figure 4 below.

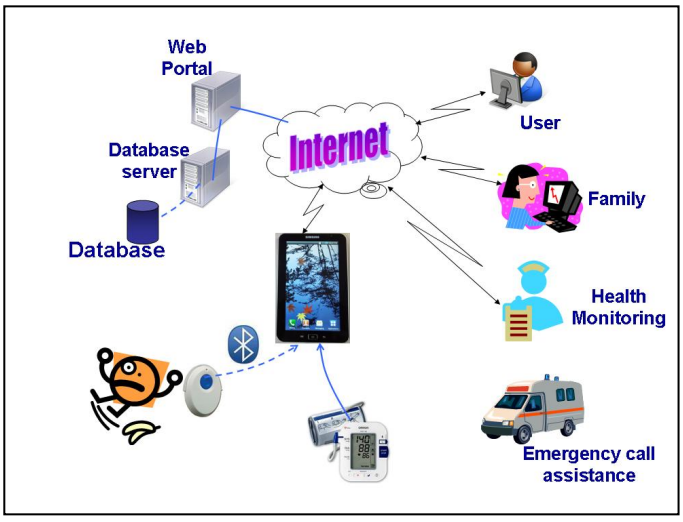

Figure 4. A health monitoring system for elderly

IV. ADVANCED HEALTH CARE MONITORING

The health monitoring system shown in Figure 4 is being developed. The advanced system has the following innovative features:

A. Automated response to emergency call

The process flow is described in Figure 5.

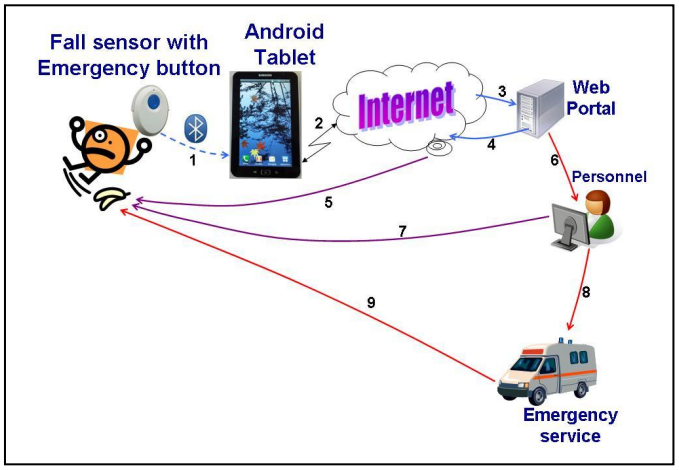

Figure 5. Process flow of the health monitoring system

The meanings of the items 1 to 9 are given below:

1. Signal Activation and received by tablet.

2&3. Upload to Internet and portal via WiFi/3G.

4&5. Automated phone call or message to tablet for confirmation.

6&7. Notice to personnel and confirmation.

8&9. Emergency call for assistance and dispatch of vehicle, or other assistance.

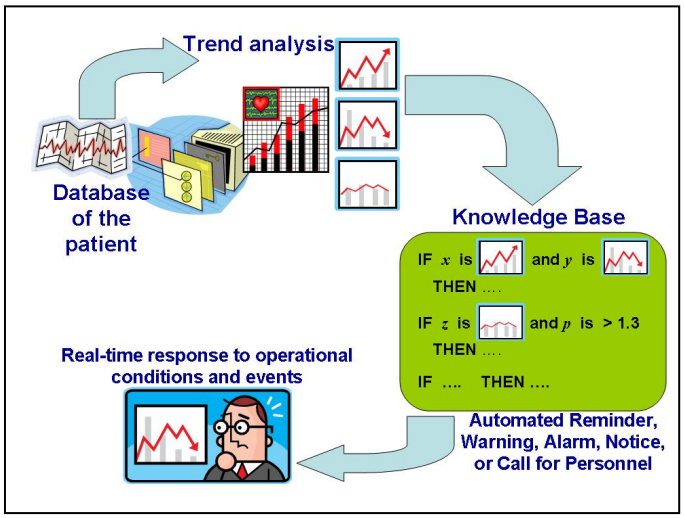

Figure 6. Knowledge base of the health monitoring system

B. Responsive Health Monitoring System

The advanced system has a knowledge base for automated monitoring of the health data of the elderly (Figure 6). On the detection of any abnormalities, warnings or alarms will be sent to the relevant health professionals for confirmation.

V. CONCLUSIONS

One major concern for elderly living independently or in assisted living communities is the lack of comprehensive health services provided in nursing homes. Very often, only very minimal medication assistance and/or reminders are given. In this paper, an advanced health monitoring system based on the use of frontier technology is discussed, with the aim of providing a high level of professional care and health monitoring service for the elder people.

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