The Elderly Care System

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Abstract. Population aging is an inevitable future trend. In the era of rapidly advancing technologies, using technology to enhance healthcare services, particularly in the care of older adults and assisting them to age successfully, is a need for urgent action. The purpose of this study is to build an Elderly Monitoring System using a wireless network or mobile network to set up a service platform for elderly care. This system platform integrates information technology into elderly healthcare to assist older adults living alone and enhance caregivers' care ability and thus, improving quality of life of older adults and caregivers. Continuous monitoring conditions for older adults or care recipients who do not need everyday medical assistance will help caregivers or family members to effectively monitor the conditions of older adults or care recipients, and thus, decreasing the sudden emergency conditions that may occur. The system also gives older adults or care recipients a sense of security while being respected. The paper test result shows that the devices used in the Elderly Monitoring System can send out alerts or distress signals in real time when detecting abnormal parameters. Also, the system can improve quality of elderly care and reduce the workload of caregivers.

Keywords: Home care, M2M communication, the elderly care, QoS

1 Introduction

Due to advances in contemporary medicine, the average life expectancy is expected to increase and an aging population is inevitable. The phenomenon of "senior-citizen and few-children" has been a remarkable fact of the changes in family structures in developed countries. According to the world health organization (WHO) definition, a country is defined as an "aging society" when the number of people aged 65 or older reaches 7% of its total population. It becomes an "aged society" when the elderly population reaches 14% or more and a "super-aged society" when they account for over 21%. According to the Council for Economic Planning and Development's population projections for Taiwan [1], the percentage of the population over the age of 65 accounted for 10% of the total population in 2007 and is expected to reach 20% by the year 2030. The number of older adults aged 65 or older would be up to 4.64 million. Taiwan has become the second most rapidly aging society in the world and its increase in speed of population aging is second only to Japan. To cope with the challenge of an aging society, the future need for healthcare services for the elderly will continue to increase and a large portion of social warfare resources will most likely be used in medical care and care service for older adults.

According to the estimate by the IEK of Industrial Technology Research Institute [2], the market scale of healthcare medical devices and healthcare service industry was in a size of NT$ 92 billion in 2006, and grew to NT$ 106.5 billion in 2007. The market includes the output value of NT$ 54 billion in the healthcare service industry, NT$ 28.35 billion on healthcare-related medical aids, NT$ 11.55 billion on home care supplies and medical furniture, and NT$ 12.6 billion on monitoring medical devices. The total output value is estimated to exceed NT$ 416.5 billion by the year of 2015.

In order to speed up the development of technological healthcare service system, the Ministry of Economic Affairs launched the U-Care program to encourage health care institutions to collaborate with information technology companies. The program was strongly supported by the healthcare and technology industries. The global home healthcare market and tele-healthcare market are in rapid growth and the demand for healthcare workers is expected to increase significantly. The U-Care program implemented a wireless physiological monitoring system to provide home care services for older adults with diabetes and hypertension. In institutional care, health care villages provide older adults with high quality of physical, psychological and spiritual care.

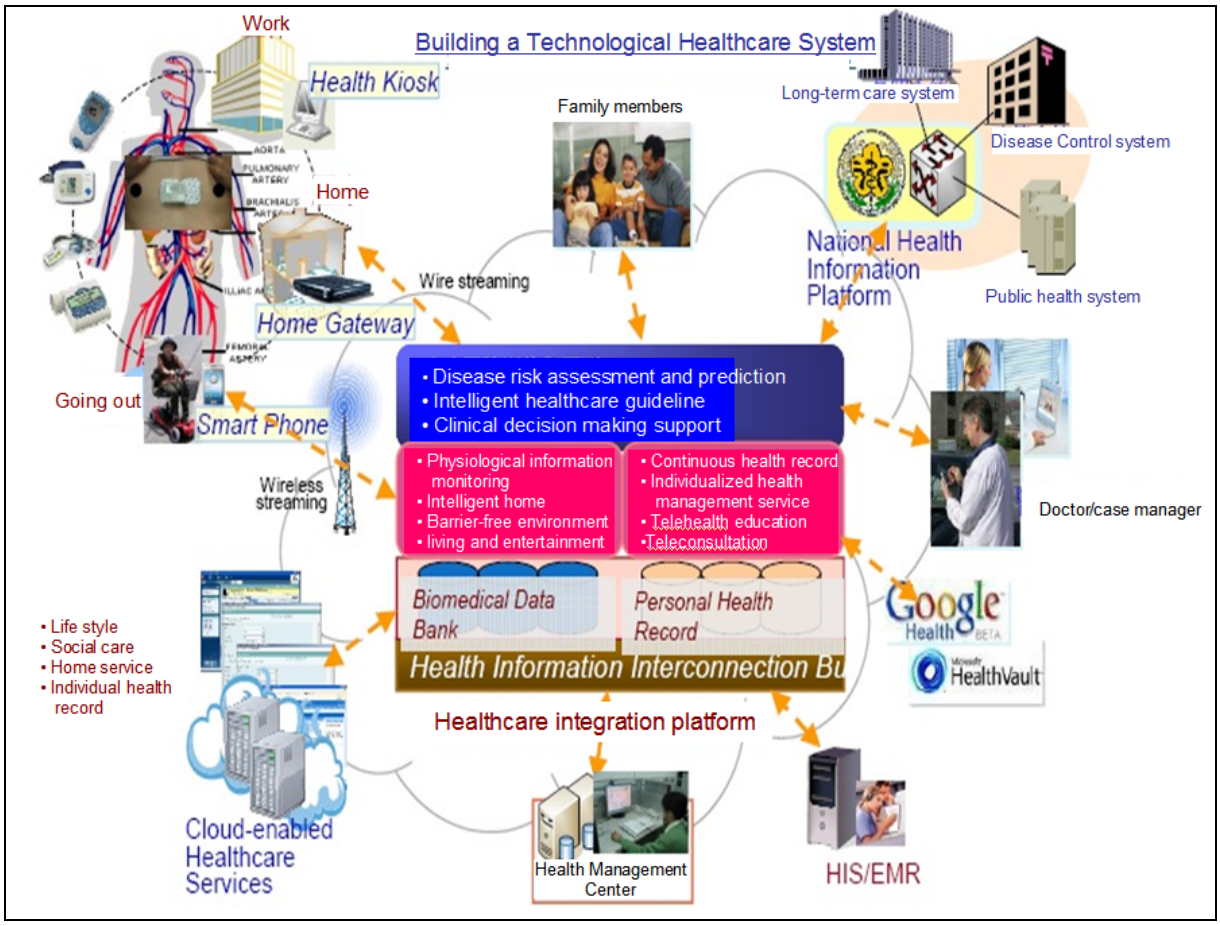

Fig. 1. Building a technological healthcare system by the Ministry of Economic Affairs

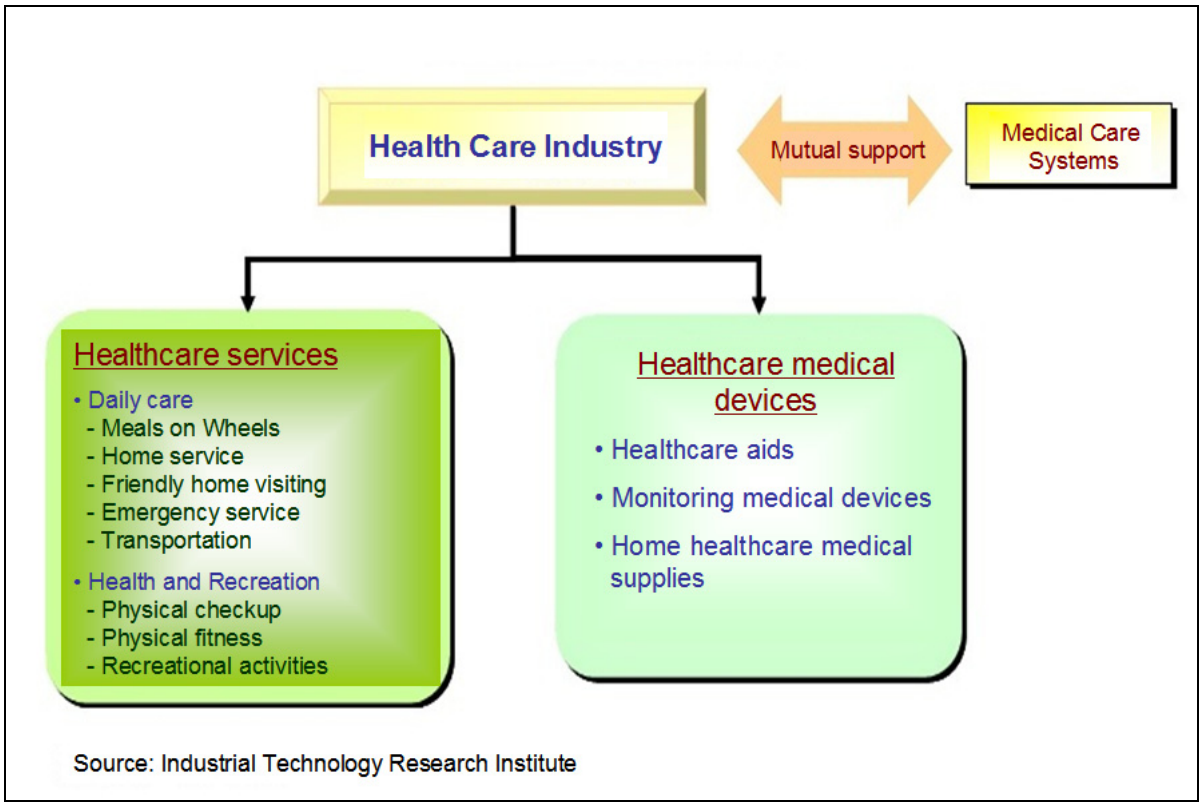

Fig. 2. Scope of Healthcare Industry

Based on the "IT enable Service Program" held by the Executive Yuan, Ministry of Economic Affairs [3] launched the "Innovative Technology Applications and Services Program" in 2006 to organize healthcare ser-

vices in order to provide the newly emerging industries with development opportunities. The Department of Industrial Technology (DOIT) estimates that the healthcare industry will reach an annual growth rate of 17% and its output value is expected to reach NT$ 221.5 billion in 2015. The DOIT indicated that the "Innovative Technology Applications and Services Program" has been added to the industrial development package in the "Economic Development Vision for 2015 First-Stage Three-Year Sprint Program." In the face of the future trend toward population aging, having fewer children and "health promotion" and "disease management", Taiwan government encourages medical care institutions to collaborate with technology enterprises to develop innovative business models and build a technological healthcare system (Fig. 1) [4]. This type of collaboration will promote medical equipment industry and applications of information communication technology. The development of innovative healthcare services will interoperate with the long-term care system organized by the Ministry of the Interior and the medical care system organized by the Department of Health, Executive Yuan, Taiwan. The DOIT indicated that changes in population structure will result in more senior citizen and fewer children while an increase in chronic disease. Thus, the application of technology in healthcare services will develop innovative business models and provide comprehensive care services. It will also promote the scope of applied technological services. Healthcare industry includes two major categories: healthcare services and healthcare medical devices (Fig. 2) [5]. In some cases, dietary supplements are also included.

To cope with the growing elderly population, healthcare service needs in Taiwan should be transformed to make both treatment and care equally important. With this view, the Taiwan government has listed the healthcare industry as one of the six emerging industries in Taiwan. Healthcare service models should be changed because there are fewer children, a growing aging population, chronic diseases on the rise and extremely limited healthcare resources.

Machine to machine (M2M) communication module will become one of the best options for future healthcare applications because of its capability in implementing tele-health services and monitoring of health conditions in real time. M2M communication [6][7][8] refers to machine to machine communication that allows any device or machine to connect to a network, through wired and wireless communication systems for data transmission. For example, the soil moisture sensor in the rice field will send out an event when detecting a specific soil dryness level. The farm monitoring system receives the information and uses that information to turn on the automatic watering system to provide enough water to irrigate crops. The scope of M2M application includes using a device to receive an event from a sensor and that event is transmitted to an applied system via the Internet and then converted to relevant information. Due to advanced computer and network technology, there is a wide range of information being transmitted across the World Wide Web. M2M communication is offering more functions and getting more reliable. The work that used to be done by a large workforce can now be processed automatically. The workload of workers can be effectively reduced.

The action that everyone needs to take early on in their life is to manage his/her own health and have a good financial plan. From the healthcare professional perspective, the main issues that healthcare professionals should think about are: how to prepare the geriatric healthcare providers as soon as possible; how to establish more elderly care facilities; how to implement workable home care services for the elderly; how to extend the scope of healthcare services; how to establish the manpower bank for senior services; and how to disseminate elderly healthcare knowledge.

Population aging is an inevitable future trend. In the era of rapidly advancing technologies, how to use technology to enhance healthcare, particularly in the care of older people, is a need for urgent action. There are applications of technology in healthcare such as electronic medicine, Electronic Patient Record System, multimedia medical image database, implantable sensors for detecting if an individual with heart disease is having a heart attack, the Guardian Angel Emergency Response system, healthcare beds for the elderly, alarm devices, etc. According to the world health organization statistics, the developed countries are likely to have aging population. The medical device market related to chronic cardiovascular disease, respiratory disease, ophthalmology and urinary system is growing rapidly. Most current medical devices using pressure sensors for medical monitoring or treatment are non-invasive devices. However, in recent years, many innovative implantable devices have been developed with the intention for long term monitoring of patients. In the future, integration of information technology in healthcare of the elderly could significantly improve healthcare providers' ability to monitor the conditions of older adults.

The purpose of this study was to build a healthcare system, the Elderly Monitoring System, to protect the elderly or disabled families to have stable daily life. The Elderly Monitoring System can reduce the necessity to travel back and forth to hospitals and the amount of healthcare to be done in hospitals, particularly for those care recipients who do not need everyday medical assistance. This system enables patients to receive comprehensive healthcare services within their homes and to maintain a good quality of life. It can also assist older adults living alone and family caregivers to improve their care ability and quality of life and thus, making older adults and care recipients feel secure while being respected. The rest of the paper is organized as follows: Section Two describes the proposed system architecture. The implementation and the test results are addressed in Section Three and, Section Four concludes the work and recommends for future work.

2 System Architecture

The proposed system architecture for the Elderly Monitoring System is shown in Fig. 3. Fig. 4 demonstrates the functional framework of the Elderly Monitoring System. The system is an application of information technology to improve quality of home healthcare service. It uses a Service-Oriented Architecture (SOA) based Service Home Gateway (SHG) as the core infrastructure [9]. After building wireless networks and mobile networks, sensors and devices are used to transmit and control information through wireless for continuous monitoring senior's vitals, and even reporting older adults conditions via a mobile phone to caregivers or family members. The system helps caregivers or family members effectively monitor the conditions of older adults and thus, reducing the sudden emergency conditions that may occur to older adults.

The Elderly Monitoring System is based on the framework of applying wireless and internet technology via remote to receive feedback from physiological monitoring of a patient. Through implementing of information technology, the system provides new modes of remote home health care and service applications, such as eHealthcare, mHealthcare and interactive medical robots. Based on the new model of home healthcare, applying technology such as wireless, the internet, IT, medical device sensors, and physiological data acquisition in tele-health and incorporating them with home healthcare and hospital resources can establish a foundation for further the research in tele-health and home healthcare monitoring systems.

The Elderly Monitoring System uses the SOA based Service Home Gateway (SHG) as the core infrastructure. Through a wired or wireless network, SHG is connected to a Arduino control board [10] that synthesizes physiological inputs by various types of healthcare devices that measures blood pressure, pulse rate, blood glucose, body weight, body lipids, body temperature, electrocardiography, peak flow readings, blood oxygen level and electroencephalography, or to monitor the image of senior safety and safety movements. Data is then transmitted back to the SHG system for analysis and stored as a database in the health monitoring and healthcare system for family members and doctors to view on computers or other intelligent handheld devices. It uses intelligent handheld devices to achieve the real-time delivery of healthcare information. If abnormal physiological parameters occur, the system will alert healthcare professionals to take an appropriate decision accordingly. The system can improve quality of care for the elderly and reduce the workload of caregivers, and that will have a positive impact on assisting older adults to age successfully in long term care.

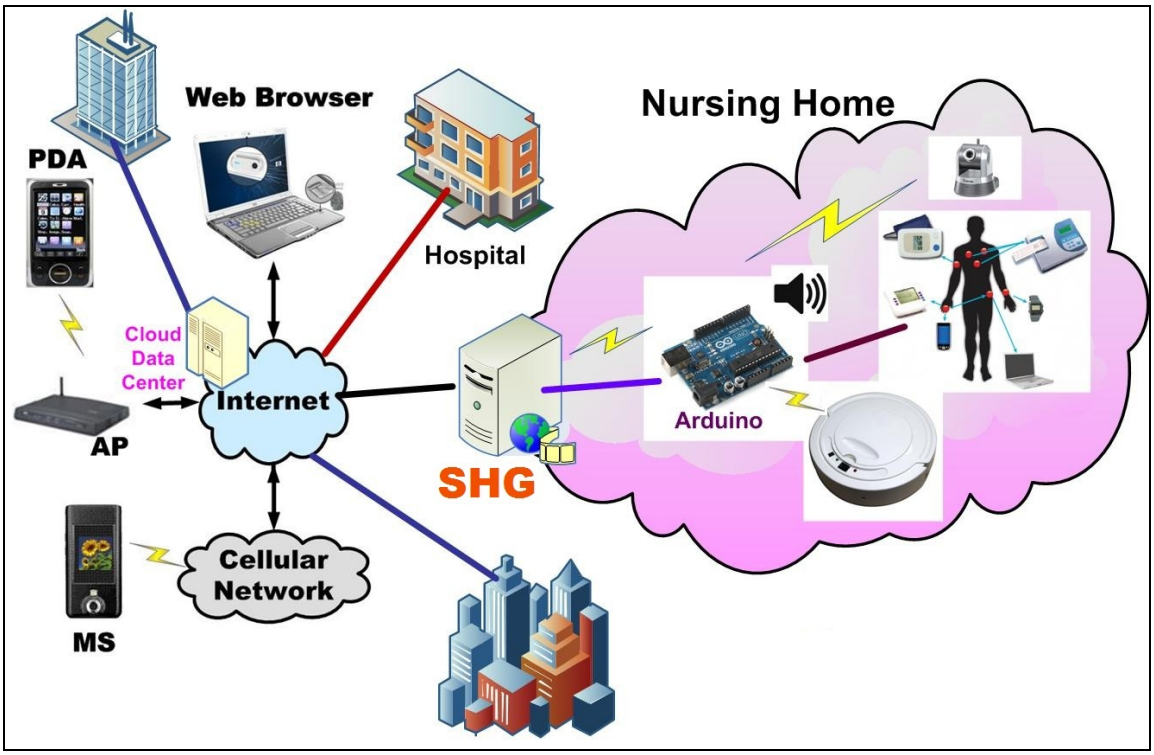

Fig. 3. The Elderly Monitoring System architecture

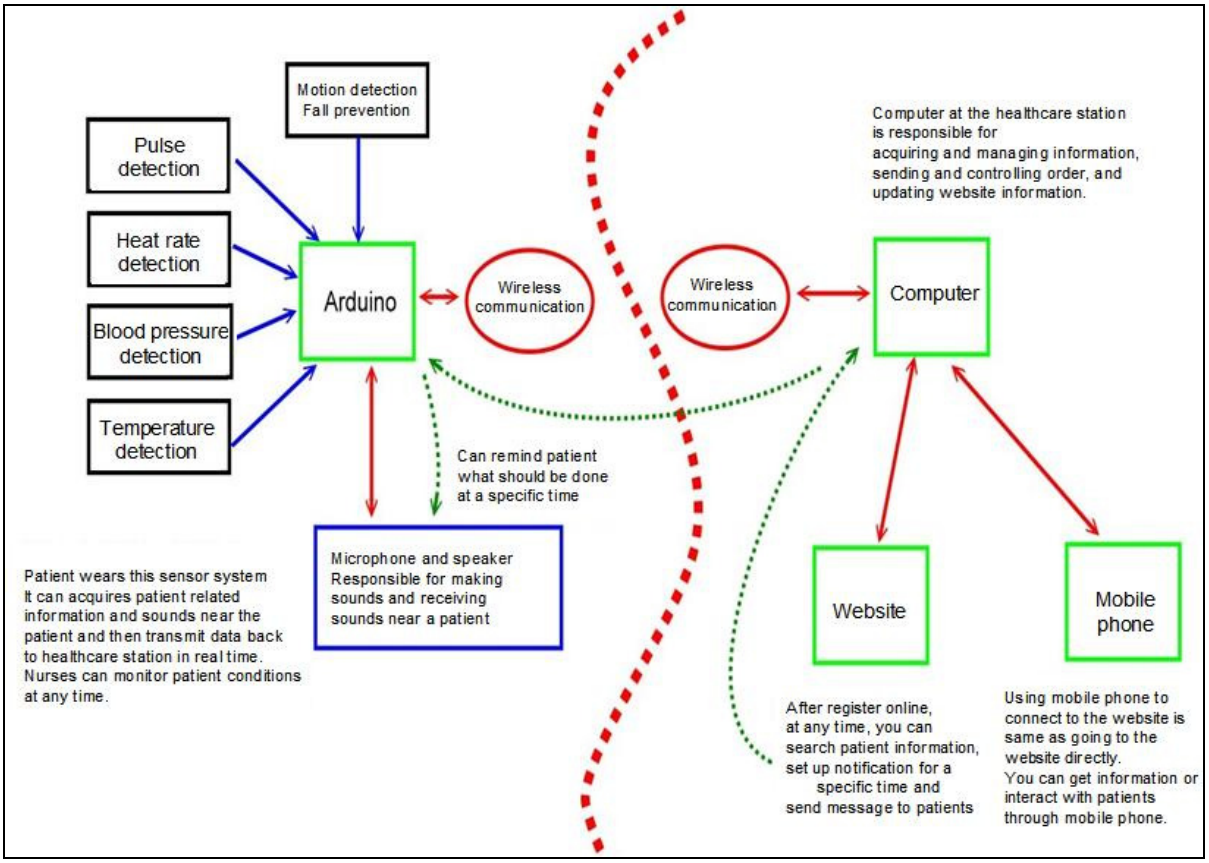

Fig. 4. The functional framework of the Elderly Monitoring System

3 System Implementation and Results

Fig. 4 shows the functional framework of the proposed Elderly Monitoring System and Fig. 5 demonstrates the physical prototype architecture design. Below is a brief description of the items in Fig. 5.

1. Temperature sensor: for measuring body temperature of a patient. It has a sensitivity of 0.1 degree and its response time is less than 0.1 second and thus, it can immediately detect the change of body temperature of a patient. The physical function of this part can be configured to transmit the body temperature of a patient to the monitoring computer every few seconds and to determine whether a temperature crosses the line to being dangerous for the patient. A tolerable temperature range can be configured according to the conditions of the elderly (patient). For example, a patient may be having hypothermia when his/her body temperature drops to below 35 degree and having hypothermia when his/her body temperature increases to above 38 degree. Consequently, healthcare professionals can monitor a patient's temperature in real time and provide appropriate and timely care.
2. Pulse sensor: a finger sensor clipped to the finger for measuring heat rate. It is based on the theory that pulsatile blood flow in arteries can produce a weak electric current. The measurement of electric current moves up at the moment the heart beats, which is the same time a contraction is taking place in the heart. On the other hand, the electric current measured is relatively low when the heart is in the diastole phase. A diagram illustrating the measured pulse readings makes it easier to assess the conditions of the pulses. The pulse rate is relatively slow while in a steady sitting state and increases after exercise. The fluctuation of pulses can clearly be noticed in the diagram. The pulse monitoring can set up to a certain range of monitoring for a patient in advance. The system will periodically transmit back the patient's pulse rate and send out alarm messages when the pulse rate is above or below the normal range. Because it takes time to calculate pulse rate, the system is unable to send an immediate transmission. Thus, setting the transmission time between 5-20 seconds can ensure the accuracy of data received.
3. Human Motion Sensor: consists of a fast response Tri-Axis accelerometer and a Tri-Axis electronic compass. It can rapidly detect motion in the elderly or the individual carrying the device. It's able to detect body movement when in a stationary position, while walking, sitting, standing, lying or falling. Also it compares various motion databases to detect current motion of an individual carrying the device. Its main

feature is to detect potentially dangerous body motions, such as falls and accidental slips. The sensor will then send out an alarm message for immediate medical assistance.

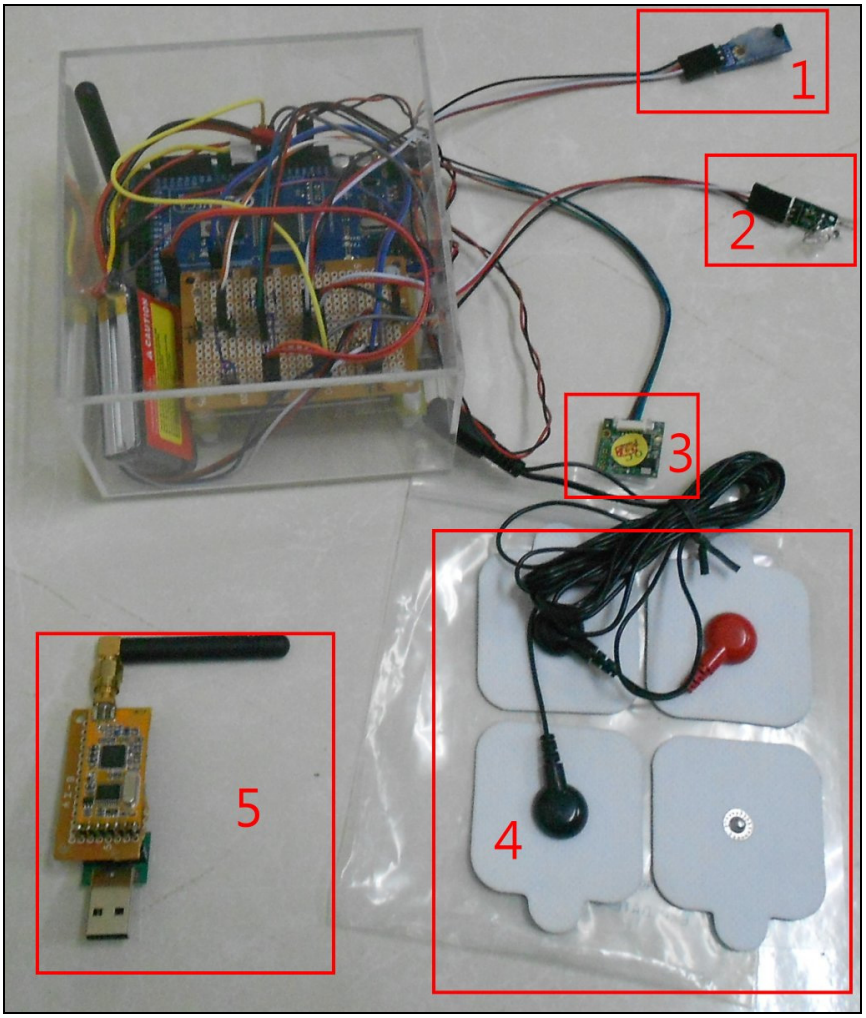

Fig. 5. The physical prototype architecture of the Elderly Monitoring System

4. Concerning Heartbeats: Heart rate is measured by using a more sophisticated sensor than that of measuring pulse. The number 4 sensor patches show in Fig. 5 needs to be attached to the heart area to receive heart beat signals. This same theory applies to the pulse sensor that detects electric current produced by heart beats. The heartbeats and calculation of heart rates are represented in a live graphical visual feed.
5. A wireless mode is used to connect to the monitoring computer for data transmission. It has a 1.5 km wireless range and can cover any hospital or nursing home area. It can also be used to reach a further distance. However, the device with a longer wireless range has a stronger electromagnetic emission and can cause health issues. It is particularly harmful to patients with heart disease with electronic life sustaining devices. This is the one part of the proposed Elderly Monitoring System that has a strong electromagnetic emission. Thus, for practical application, the device will only be powered when transmitting data and its power is off when not in use. This approach can prevent the wireless mode from producing harmful electromagnetic emissions.

The UI interface of the Elderly Monitoring System is shown in Fig. 6; Interface Settings is illustrated in Fig. 7, and Fig. 8 presents the warning interface of the Elderly Monitoring System.

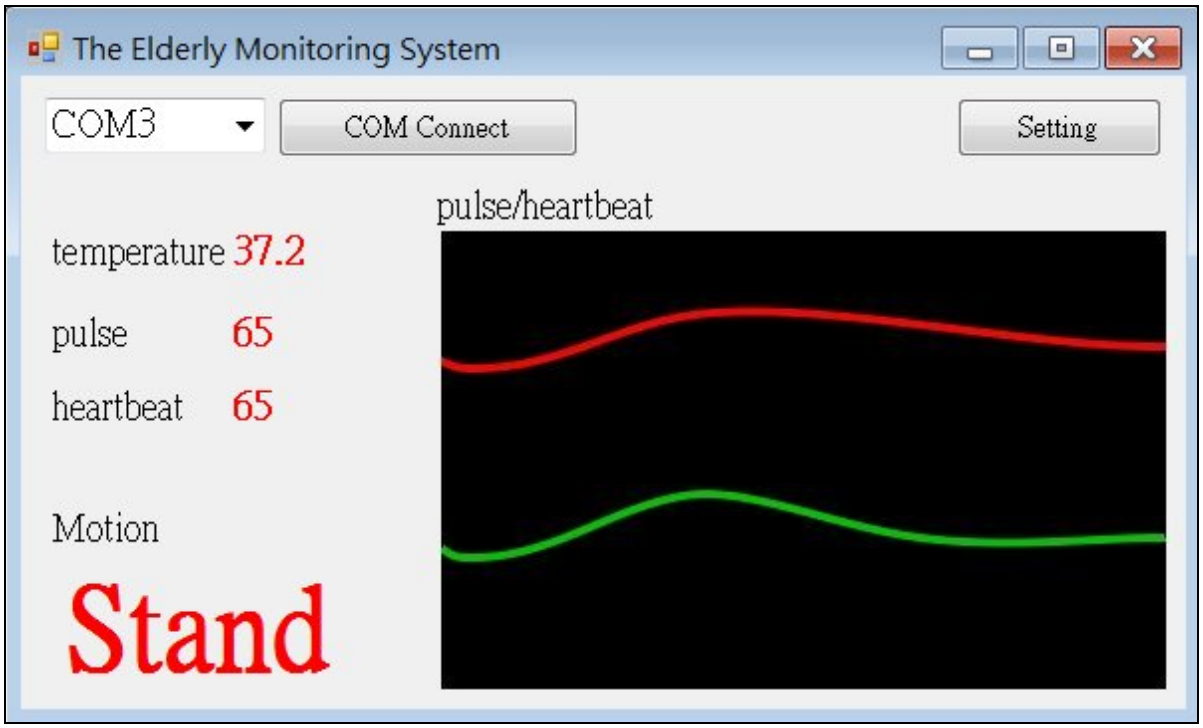

Fig. 6. UI interface of the Elderly Monitoring System

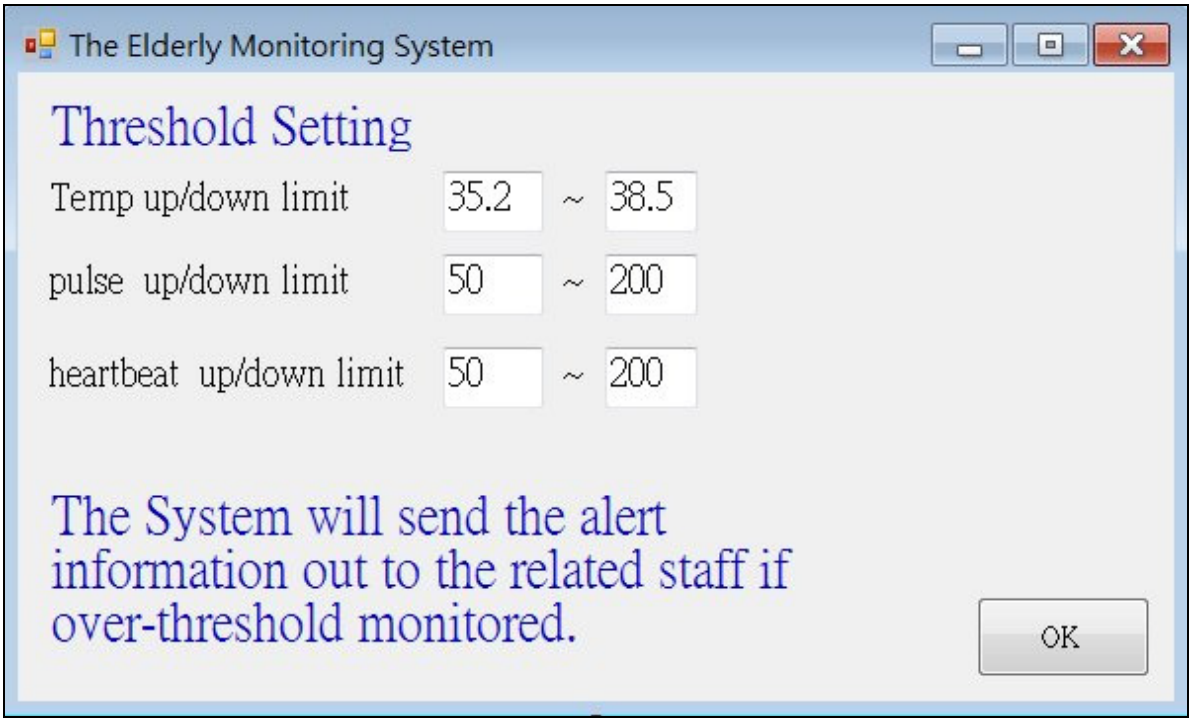

Fig. 7. Setting interface of the Elderly Monitoring System

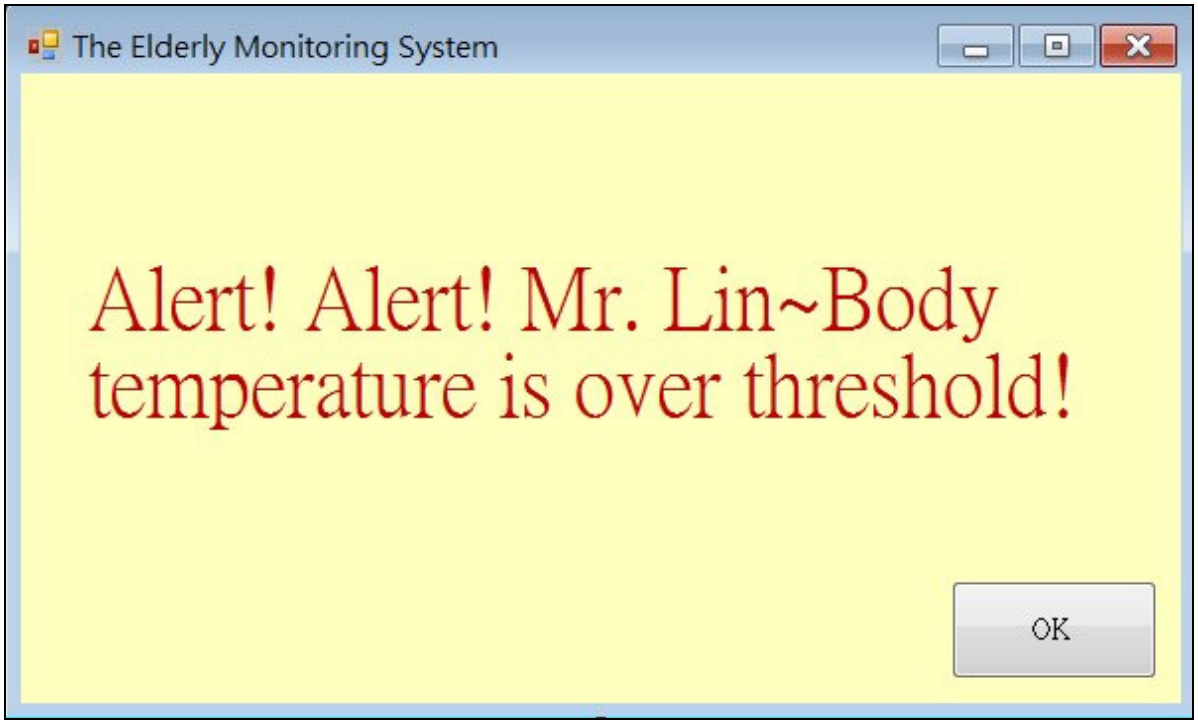

Fig. 8. Warning interface of the Elderly Monitoring System

4 Conclusions and Recommendations

In reviewing the result of this research, implementation of the Elderly Monitoring System can reduce the necessity to travel back and forth to hospitals and the amount of health care to be done in the hospitals, particularly for those patients or older adults who don't need everyday medical assistance. This system enables patients to have comprehensive healthcare services in their homes and to maintain a quality of everyday life. It can also assist older adults living alone and family caregivers to improve their care ability and quality of life and thus, making older adults and care recipients feel comfortable while being respected.

In the future when there is financial support, the prototype of the Elderly Monitoring System developed in this study could be made into an actual product and one day could be reduced to the size of a watch and put into mass production. However, making the system into the size of a watch could result in the necessity of regular replacement of batteries and less time for use for the system. We recommend making the system to be the size of a cell phone with replacement batteries, to extend the use of the system and to be directly strapped to the waist. We believe this would simplify the complicated management process and reduce the workload of care providers.

The Elderly Monitoring System is a framework for the application of wireless and internet technology for remote physiological monitoring. Through implementation of information technology, the system provides M2M, sensors, new modes of remote home health care and service applications. Based on the new model of home healthcare, applying technology such as wireless, IT, medical device sensors, physiological data acquisition in tele-health, incorporating home healthcare and hospital resources, can establish a foundation for future applications for tele-health and home healthcare monitoring systems.

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