Mobile-Internet-Based Healthcare, Public Safety and Home Welfare Services

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Abstract

Home assistant services have been growing up during the past years, and more elderly suffer from chronic diseases. This paper introduces the feasibility and benefits of health care, public safety and home welfare services for elderly monitoring using mobile internet network. Two key human-device issues are analyzed in the paper: usability and user acceptance. Moreover, the services are studied from the Chinese perspective.

KEYWORDS: Mobile Internet, home assistant services, usability , sensor.

1 Introduction

The percentage of elderly people in the world is increasing and this rise is putting pressure and demands on public services. The shortage of labor (nurses and doctors), as well as nursing home and hospital capacity, turn new home assistant services approach more attractive, including the creation of a new technological system infrastructure [14]. In China, the aging speed is predicted as "running into aging" . Meanwhile, health care is regarded more and more unaffordable as medical costs increase rapidly [23]. Thus, the Chinese government has to find an effective solution to deal with the elderly health care issues in advance.

Continua Health Alliance is an open industry coalition of health care and technology companies joining together in collaboration to improve the quality of personal health care [1]. Providing possibilities for independent living of aging people, personal fitness and chronic disease management are the ongoing research programs in the alliance.

Ambient intelligence sensor networks are one effective solution, which can offer the disabled and elderly people effective and scalable home assistant services. These sensor networks can be used to monitor people's surrounding environment and evaluate various abnormal activities [19].

The rest of the paper is structured as follows: Section 2 presents mobile-internet-based infrastructure, and related technological implementation in the system. Section 3 illustrates several scenarios in different usage categories. Section 4 describes the user acceptability and usability issues. Section 5 analyzes home assistant services R&D in China. Finally, a brief conclusion and the perspectives of mobile-based-internet usage are given in Section 6.

2 Mobile-Internet-based Platform Architecture

2.1 Ambient Intelligence

Ambient Intelligence is regarded as a new information technology in which people will live and work in smart environments, that can recognize user's requests and responses by visual recognition, including voices and gestures [15]. Various sensors are implanted into users' everyday objects like furniture, clothes, health equipment and household stuff, which can provide an intelligent way to communicate with each other or outside world via a mobile-internet network.

2.2 Local Area Sensor Network

2.2.1 Ubiquitous Sensors Introduction

Wearable Sensors: Wearable sensors can be attached to clothes, jewelry or separately wearable accessories, e.g. chest belt, wristband, etc. Sensor networks can distinguish the users' different activities, for instance, sitting, standing or movement [19]. Those continuous activities are captured by sensors, then they can be sent upon request to a physician, and the physiological parameters can be diagnosed by the monitoring software and doctors, if possible.

Environmental Sensors: Environmental sensors can be placed in home area or vehicles, rather than on users themselves. The ubiquitous sensors can observe users' actions or detect public safety threats, e.g. earthquake, thieves, etc [19].

Implanted Sensors: Implanted sensors are typically embedded under the skin. As their implementation is limited due to the bottlenecks of such technology, e.g. long-term power supply, it is treated as a sub-category of wearable sensors [19].

The survey shows that heart rate should be measured several times during the day to get proper data for analysis [6]. Heart rate monitoring sensor can be installed for monitoring that the heart rate stays at a certain and healthy level. Whenever detecting exceptional data, system should alarm immediately.

Movable Sensor Devices: The movable devices are inconvenient to be attached onto user's body, but small enough for user to carry about, e.g. blood-pressure meter, weighing-machine, etc. When user takes his/her daily measurement,

Figure 1: Stora Enso Pharma DDSi Package

the measurement data could be sent to the health care system via a network connection.

The pharmacy sensor can record the precise date & time when a pill is removed from the medicine box. An elderly person could also press an answer key which is embedded in the carton, to make a record how he or she feels and responds to the medical treatment. The carton can also sound a beeper to remind patients to take a pill . Fig. 1 illustrates a pharmacy DDSi medicine package model [3].

By using body fat monitoring sensor, users can get their weight, body fat percentage, and body mass index from the sensor. It is not necessary to measure fat percentage very often, as couple of times a week is enough [6].

2.2.2 Local Wireless Connection

Two classes of sensor devices are categorized by different power usage and price requirements: Lowercase sensor radio nodes and wireless remote powered sensors [11]. Radio Frequency Identification (RFID) is a technology which can be used to store and retrieve data via a radio frequency from simple, often passive, devices. An RFID tag can have a sensor (or sensors) to monitor environmental or status parameters, for example for security and tamper detection. Passive RFID tags, which are only powered while in close proximity to a reader, are unable to continuously monitor the status of a sensor. Active RFID tags, which are constantly powered, are able to do continuous monitoring and record a sensing log to a memory. Furthermore, active RFID tags can power an internal real-time clock and apply an accurate time & date stamp to each recorded sensor value or event [5], e.g. for health care monitoring services.

Bluetooth is the standard radio technology for wireless personal area networks, e.g. for personal sensors [11]. It works between active devices over relatively short distances, mostly less than 10 m. Bluetooth is a nature technology and is considered safe and suitable for creating wireless personal sensor networks. There is a drawback for Bluetooth: its protocol stack might limit its development [17]. However, Bluetooth is still considered as the optimal approach to adapt to the sensor network at the present stage. Bluetooth is available in standard mobile phones & laptop computers.

2.2.3 Implementation

The ubiquitous sensors can be wirelessly connected, or attached to a mobile phone, which can send data through internet to a server for further diagnosis, if needed [14]. For example, an elderly person can push the emergency button on wristwatch for calling for help by sending an emergency message through network. [7].

3 Health care, Public Safety and Home Welfare Services Scenarios

Mr Smith was a 76 years old widower whose wife died a couple of years ago. He is now living by his own in a quiet villa in the middle of England. Recently, Mr Smith was diagnosed with a heart disease. Doctor convinces him to have a sensor implanted inside his body to take 24/7 wellness monitoring. His son Harry, who is too busy to take care of Mr Smith, worries about his father's health status and decides to have a home assistant services system installed. After consulting from several companies, Mr Harry delegates a company to install the Ambient Intelligence Monitoring System (AIMS), a mobile-internet-based smart context-aware platform at home [10]. This system can allow elderly to interact with surrounding objects.

The home assistant services company technician visits Mr Smith's house some day, installs some RFID tags, sensors and microcontrollers on surrounding objects in a ubiquitous manner, e.g. toilet, kitchen and bed in bedroom. The system communication software is also installed on Mr Smith's mobile phone, to generate data and send them to the remote server. Furthermore, he gives Mr Smith an emergency care watch and tells him the watch will record his daily performance data and he can press the button when emergency arises[10] [14]. A couple of days later, when Mr Smith visits the hospital for re-examination, the doctor gives him a smart medicine package and ask him to take the inside pill when the package is beeping to remind[3].

One day, Mr Smith goes out for shopping. He activates the security sensor in advance. Not long later, a burglar breaks into the house from the back window. AIMS detects the intrusion and actives the alarm rings and the burglar is scared to run away. When Mr Smith returns, AIMS identifies him and automatically disables the alarm. After a while, Mr Smith turns on TV to watch the live football broadcast. After his favorite team scores, AIMS detects a likely occurrence of the heart attack from Mr Smith's implanted sensor. The system activates the smart package, alarms Mr Smith via emergency care watch, to take the pill at once. Meanwhile, AIMS sends an alarm and forwards recent data to Mr Smith's doctor. The doctor will check the recent sensor data and then, make a diagnosis as soon[7].

Mr Smith feels uncomfortable and goes to bed. When he lies on the bed, the pressure sensor of the bed is activated. After 20 minutes without any more activity, AIMS judges that Mr Smith has already fallen asleep and the system automatically switches to night alarm sensing around the house. Mr Smith wakes up at midnight and goes to fetch some food to eat in kitchen. His footsteps activate a sound sensor. The smart home system then checks if there is enough light for

movement in the house using light sensors. If there is not enough light, the lights on his routine course to kitchen are switched on. When he returns back to bed the lights are switched off automatically. Fig. 2 shows an Ambient Intelligence System scenario layout [14].

4 Usability & User Acceptance

The success of home assistant services for aging people depends critically on usability of the services and user acceptance by the target market – elderly themselves. Usability & user acceptance can be categorized by various factors: services cost, social isolation of the elderly, ethical impacts and user-centered interface design.

4.1 User Acceptance

4.1.1 Cost

Cost is one of the most significant factors when users choose to implement a home assistant services network. In a survey report, the participants indicated that their expected price is 4–10 Euros per month for such a home assistant services, but any increase above this price is met with a sharp decline in acceptance rates [13].

Cost is the most significant concern to the elderly. Elderly are a value sensitive user group who would like to use and buy such a system if they can afford it.

4.1.2 Social isolation

As people grow older, their social circles tend to diminish. The intelligent home assistant services are mainly based on artificial intelligence technology. Although this high-tech equipment may help the elderly to solve the cost and labor problems successfully, it would also diminish elderly's communication channel to outside world simultaneously. For example, making a face-to-face interview with doctor or nurse is a kind of social activity for the elderly. But when an elderly person has installed a home assistant services system, a doctor may make diagnosis via mobile internet remotely. Living alone, lack of emotional support and social support will make an elderly person feel more vulnerable than before.

Contact and keeping in touch with friends or relatives have a positive influence on the well-being and health of the elderly [12]. An increasing number of older people decide to participate more in social activities, e.g. courses at colleges or community activities, to raise a high quality of life.

4.2 Ethical Impacts

4.2.1 Freedom & Privacy

The fundamental ethical impact regarding to Ambient Intelligence is that, does it enhance human freedom or focus more on privacy protection. Privacy is considered as a very important factor by the elderly, but a survey states that when they need help they will ignore the privacy issues [19]. The response organization, e.g. hospital, can be trusted to monitor the user's daily activities and record the related data. The ambient intelligence system may help the elderly to gain more control due to more responsibility to their needs and intentions. For most of the elderly people, control over their well-being and contact with caregivers was important.

Designer may also make some restrictions to limit user's freedom to protect their privacy. The ubiquitous network can easily cause privacy threats by its ubiquity, invisibility, and sensing. The threats on privacy are so great due to the highly sensitive type of personal information, that is recorded and encoded [15]. They are either passive attacks or active attacks, for instance, listening and manipulating data on the system. The research shows that the elderly do not perceive privacy to be a significant concern [19]. Monitoring elderly at home will generate private data. However, elderly may believe that their medical data contains useless information to any malicious party. Thus, technicians need to indicate these privacy threats to their customers when installing the ubiquitous network.

4.2.2 Personal Safety

We do a lot of activities while living in our home. cleaning room, cooking in kitchen, go upstairs, etc. However, these easy tasks seem daunting to elderly people. Some accidents have high incidence rate for elderly at home. Falls are the most common and serious type of accidents for the elderly; they may fall on slippery floor, or fall down from stairs. The poor sense of smell leads to the elderly person too late to make emergency call in the case of fire. Moreover, the elderly's poor memory may result in a poisoning overdose of medicine [2]. When installing a home assistant services system, designers need to implement various domestic appliances to prevent most possible hidden dangers in home for elderly.

4.2.3 Information Security

Information security risks are identified by three categories: confidentiality, integrity, and availability. Protection of the information security in the ambient intelligence system is regarded difficult due to conflicts between communication entities [10].

Mobile devices are considered as the most significant part in information security protection issues: mobile phones perform an important role in the system. Most of the data or information messages are exchanged via mobile phones, and once mobile phones are stolen or lost, all recorded data may be lost. In addition, limitation of the battery and interface capabilities are possible threats for system's availability, which may cause confidentiality and integrity problems. For example, an elderly person loses his mobile phone while shopping. Before long, the system detects an exceptional record and alarm the elderly person immediately. Unfortunately, the elderly person can not receive any warning message from the system because he has lost his mobile phone. Later when the doctor checks the exceptional record he can not make any diagnosis to the lost record do not be backed up. The case shows that the design flaw may also trigger system's vulnerability. Thus, the home assistant services system may need to make a backup plan to deal with emergencies.

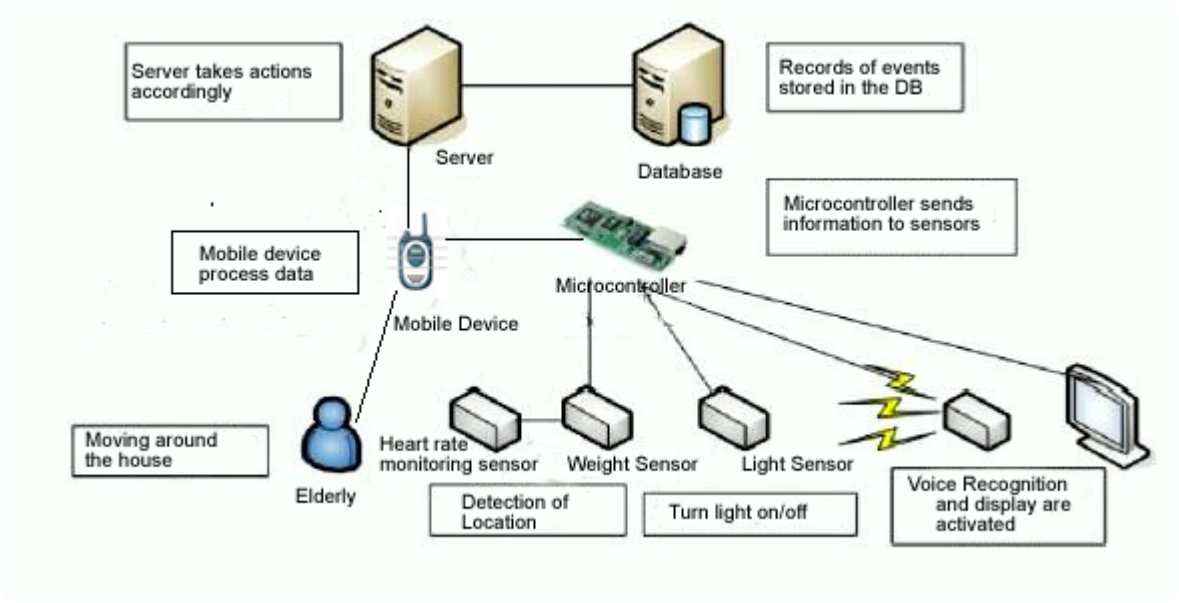

Figure 2: Ambient Intelligence System Layout

4.3 User-Centered Interface Design

4.3.1 Ease-of-Use

Ease-of-use is an important factor when considering user's usability in Information Communication Technology (ICT) network. The poor memory of the elderly makes them desire to have little control in the system. The interaction approach must be simple to use, such as a single button or speech recognition.

There are multiple categories for Home Assistant Services devices usage and management in the home:

Easy-to-Understand: Whenever the elderly person asks for help from the system, the background of the user can not impede their ability to interact with the system [22]. For example, both the expert and novice can freely use a new home assistant services system by reading the user manual, if the manual is well-written.

Automatic Association: The well-known "Plug & Play" implements automatic association function. System has artificial intelligence so that user does not need to operate the system manually [22].

Intuitive Operation: The operation illustrates sensible and natural sequencing of device operations [22]. The services will be labeled by their priority beforehand. When user sends multiple task requests, system would automatically make a task sequence to finish the work. For example, an elderly person can take his/her weight and body fat percentage measurement concurrently, but taking the medicine must be on next phase.

Attention Free: It means that elderly do not need to be imposed by any unnecessary awareness issues[19], e.g. an voice instruction prompts the elderly person to press a key to ask for help.

4.3.2 Conceptual Difficulties

People's cognitive context, which involves the patient's objective thoughts, are closely related to their education levels [12]. Low level of knowledge and memory decay make them feel that it is too difficult to handle these modern electronic home assistant equipment correctly. Therefore, hiring a nurserymaid to take care of the elderly becomes the most realistic solution at the present stage in China.

A survey shows that the elderly may pay more attention to the technology usage, to conduct what has largely been a social exercise, and they tend to be forgetful, stubborn and conservative [19]. For instance, if an elderly person believes that the technology should be for emergencies only, he/she will strongly resist to incorporate the technology in daily use. Users may believe that the technology has and only has one functionality: activate it when in case of emergency.

4.4 Benefits

4.4.1 Cost Saving

A survey shows that the mean health services cost for hospital at home care was roughly half that of inpatient care [8]. Compared to hospital health care, the home assistant services can save an increasing amount of money. However, the elderly may not have the ability to afford all the home assistant services cost. Whenever an elderly person perceives the home assistant services system to be optional, he/she may generally be less willing to pay for that, or turn to ask for financial help from relatives. Most of the elderly express a strong desire that either family or government can offset the cost of the system [19]. The elderly people are reluctant to buy a high-cost performance system so the government

may need to design a mechanism to make home care services more affordable.

4.4.2 Independent Living

In western countries, the majority of the elderly prefer to live an independent and autonomous life [12]. They prefer to live independently in their own homes. Moving to an institution is regarded as a negative behavior. In their mind, home is a place with good memories where they spend a lot of their time. Their living environment demands will increase and change with age [4]. When they suffer an increasing number of chronical illnesses, it is much more difficult for them to continue independent living or they need to require for home assistant services help.

Elderly people are often reluctant to ask for help due to their self–reliance. They believe that they can ask for it when necessary [19]. As a matter of fact, the elderly may lack the ability to determine a emergency, which may lead to forgetting to call for help or to press the emergency button, or having the emergency device out of reach.

5 Home Assistant Services in China

A rapidly aging population continues to stretch the ability of families to provide support for the elderly. Despite the fact that China's present population is relatively "young" with only 11 percent considered elderly (those aged 60 and over), the United Nations projects that the proportion of elderly will increase to about 28 percent in 2040, by which time over a quarter of the world's elderly population will live in China [9].

5.1 Services Requirement

In most of the developed countries, the major payer is either the government (for example, The Social Insurance Institution of Finland (KELA) in the Finland) or a medical insurance company. Compare with that, China has a different payer environment. The expansion of the health care market economy in China over the past two decades has resulted in a shift away from government-funded health care to the self-pay sector (consumer expenditure on health care), and over 50% of health care bills are paid for out of pocket. The self-pay health care expenditure is estimated to increase from 2% to 3% of GDP in the next 10 years [21]. The patients or their children are the major payers for health care services; affordability is therefore a key determinant of patient access.

5.2 Status Analysis

From technology point-of-view, in China, the health care services system market is dominated by world-famous enterprises. The mobile internet health care technologies are mainly implemented in hospitals due to the cost of the equipment and services. In addition, the shortage of professional health care assistant institutions and personnel is an urgent problem that must to be solved in the near future [9].

From the user point-of-view, the Chinese family traditionally has been viewed as a close-knit social network from which its members derived support, security, and a means for meeting their needs. The Chinese elderly were cared for by their families [20]. Compared with precision instruments, the elderly person prefers to believe neighbors and friends. Neighbors and friends were clearly less important caregivers than family members. But at certain key moments their help could be quite important. Given the close proximity in which people in urban China live, neighbors are almost always available on short notice in case of an emergency. There are many stories of calling on a neighbor in the middle of the night when a parent or spouse suddenly fell ill [20].

5.3 Community Healthcare Center (CHC) System in China

In China, individual home assistant services are still unaffordable to the majority of Chinese families. Community is regarded as the primary living environment in which Chinese government can establish a base CHC) [18]. In one city, hundreds of CHCs mix with government hospitals construct a large health care network. As a matter of fact, CHC acts as an interactive medium between patients and hospital. To the lower level, CHC takes people's health care as the task of the serving center, family as the serving unit, community as the serving confine [18]. It can take a long-term monitoring for individual chronic illness patients or elderly inside community with low-cost services. Elderly or patients can access the CHC by mobile phone, using the low cost Short Message Service (SMS) to exchanges information with CHC. To the upper level, CHC makes an effective connection to the nearby hospitals via internet, sharing medical information or acquiring diagnosis from CHC network.

5.4 Trends in China

The number of people under 25 years of age is predicted to decline 47%, from 437 million in 2007 to 297 million in 2026. Within the next decade, 25% of the population will be over 60 years of age [21]. This is the significant target segment for home assistant services in the near future. We can easily predict that China has a large growth potential in home assistant services market in the near future.

In addition, Chinese government may invest increasing number of labour and capital to establish a professional home assistant services network, to meet the requirement of the fast growing market.

6 Conclusion & Further Challenges

The design of Ambient Intelligence home assistant services, which is based on a value sensitive principle relates to the following segments: privacy, freedom, universal usability, moral responsibility and user acceptance, etc. The products or services should be accepted by the majority of the target segment, e.g. elderly people or chronical illness patients. Both novices and experts can easily learn how to freely use the system. Moreover, the services should be designed as a standardized interface capable to specialized user. [12] [10].

For an elderly person, independent living relates to both social and health care [4]. Many older people may suffer from chronic sickness, physical or cognitive impairment. Thus, the home assistant services have a big challenge regarding the best equilibrium point between health and social care to achieve elderly people's demands.

In order to reduce health care costs and promote independent living, the home assistant services system could encourage patients to play a more important role in the ambient environment [22]. Regardless of whether the system develops with artificial intelligence, human-device interaction is still desirable. Especially elderly people need automatic association services.

In contrast to western countries, Chinese government suffers from population problem in health care services. A successful home assistant services mechanism in western countries may not feasible in China due to the population and citizens' education level. Thus, Chinese government trends to exploit high technologies for low-cost and qualitative health care services. The new system can deliver multi-level, multi-dimensional health care services to urban and rural citizens [16].

Chinese government proposes to migrate to a new health care system with a four-layer architecture: personal, home, community and hospital (PHCH system) [16]. The implementation of the system could lower health care expenditures and make the health care services more affordable to Chinese citizens. Moreover, the new system can really relieve the burden of the hospitals and enable Chinese people to seek early medical care. Community health care services would play a important role in the system.

In the future, device intelligence, automatic association, and intuitive human-device interfaces can simplify user's operating skills. In order to reduce health care cost and independent living, elderly people will be encouraged to interact with the home assistant services system in a user-friendly manner. The next generation home assistant services system should concentrate on artificial intelligence technology. The sensing intelligence can monitor human's well-being, the communication intelligences will make elderly person more interactive with outside world, and emotional intelligence can enhance system more intelligent to understand users' thought.

References

[1] Continua Health Alliance. http://www.continuaalliance.org/index.html.

[2] Home Safety For The Elderly – How to Prevent Accidents in The Home. http://www.home-security-action.co.uk/home-safety-for-the-elderly.html.

[3] Stora Enso Pharma DDSi . http://81.209.16.38/WebRoot/549653/Pharma_right.aspx?id=1005230.

[4] i2010: Independent Living for The Ageing Society. Technical report, Europe Commision, 2008.

[5] Active and Passive RFID: Two Distinct But Complementary, Technologies for Real-Time Supply Chain Visibility. http://www.autoid.org/2002_Documents/sc31_wg4/docs_501-520/520_18000-7_WhitePaper.pdf.

[6] A. Ahtinen, A. Lehtiniemi, and J. Hakkila. User Perceptions on Interacting with Mobile Fitness Devices. In *3rd International Workshop on Pervasive Mobile Interaction*, pages 89–111, 2007.

[7] T. Broens, A. van Halteren, M. van Sinderen, and K. Wac. Towards an Application Framework For Context-Aware m-health Applications. *International Journal of Internet Protocol Technology*, 2:109 – 116, 2007.

[8] J. W. Felix Ram. Hospital at Home for Patients with Acute Exacerbations of Chronic Obstructive Pulmonary Disease: Systematic Review of Evidence. 2007.

[9] B. Gill. China's Health Care and Pension Challenges. *New York Times*, 2006.

[10] V. Ikonen, E. Kaasinen, M. Niemela, and J. Leikas. Ethical Guidelines for Mobile-Centric Ambient Intelligence. Technical report, VTT, 2008.

[11] I. Jantunen, H. Laine, P. Huuskonen, D. Trossen, and V. Ermolov. Smart Sensor Architecture for Mobile-Terminal-Centric Ambient Intelligence. *Sensors and Actuators A: Physical*, pages 352–360, 2008.

[12] N. Malanowksi, R. Ozcivelek, and M. Cabrera. Active Ageing and Independent Living Services: The Role of Information and Communication Technology. Technical report, Europe Commisions, 2008.

[13] M. Mikkonen, S. Vayrynen, V. Ikonen, and M. Heikkila. User and Concept Studies as Tools in Developing Mobile Communication Services for the Elderly. *Pesonal and Ubiquitous Computing*, 6:113–124, 2002.

[14] M.W.Raad and L.T.Yang. A Ubiquitous Smart Home for Elderly. In *Advances in Medical, Signal and Information Processing, 4th IET International Conference on*, pages 1–4, July 2008.

[15] B. Philip. Freedom and Privacy in Ambient Intelligence. *Ethics and Inf. Technol.*, 7(3):157–166, 2005.

[16] C. Poon and Y. Zhang. Perspectives on High Technologies for Low-Cost Healthcare. *Engineering in Medicine and Biology Magazine, IEEE*, pages 42–47, 2008.

[17] A. Rodzevski, J. Forsberg, and I. Kruzela. Wireless Sensor Network with Bluetooth. In *Smart Objects Conference*, 2003.

[18] T. Shen, J. Shi, and Z. Yan. The Design of Communicty EHR System Based on PDA. In *International Conference on Complex Medical Engineering*, pages 42–47, 2007.

[19] R. Steele, C. Secombe, and W. Brookes. Using Wireless Sensor Networks for Aged Care: The Patient's Perspective. In *Pervasive Health Conference and Workshops*, pages 1–10, Nov 2006.

[20] L. Wang and J. W. Schneider. Home Care For The Chronically Ill Elderly In China: The Family Sickbed In TianJin. *Journal of Cross-Cultural Gerontology*, pages 331–348, Oct 1993.

[21] S. Ward. Demographic Factors in the Chinese Healthcare Market. *Nature Reviews Drug Discovery*, May 2008.

[22] J. Yao, S. Simmons, and S. Warren. Ease of Use Considerations for Wearable Point-of-Care Devices in Home Environments. In *Prodeedings of the 1st Distributed Diagnosis and Home Healthcare (D2H2) Conference*, pages 8–11, April 2006.

[23] J. Zhu, L. Gao, and X. Zhang. A Health Monitoring System Based on Pocket PC for Community Aging Residents. *Bioinformatics and Biomedical Engineering*, pages 1391–1394, May 2008.