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A Survey of Wireless Sensor Networks for Home Healthcare Monitoring Application

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Abstract: In recent years, wireless sensor network technology has become mature. Working together with biomedical engineering, it has enormous potential benefits to improve the lifestyle of human especially for the elderly. This survey mainly focuses on two prototypes of home healthcare monitoring application: daily activities monitoring application and medical status monitoring application. It will present the requirement analysis which starts from the causes of chronic diseases. The paper also discusses challenges for current home healthcare monitoring application. At the last part of the survey, it will give the conclusion and future aspects.

1 INTRODUCTION

In recent decades, the elderly population increases continuously. There will be nearly 120 million people at the age 65 or more than 65 years old in 2050 (Kinsella and Philips, 2005). As a consequence of the population aging, the old people will have more possibility to suffer the difficulties from physical disability, health problem and cognitive impairment (Lee et al., 2010), which not only make the old people cannot live independently but also give them a huge economic burden. So, finding a good way to cure the chronic diseases and reduce the economic burden of the old people is an important issue.

However, working together with biomedical engineering, wireless sensor network technology has enormous potential benefits to improve the lifestyle of human especially for the elderly. The design consideration of WSN healthcare system provides new possibility to response to population aging.

This survey starts from the causes of chronic diseases and focus on the detail requirement in two prototypes of homecare monitoring application: daily activities monitoring application and medical status monitoring application. The paper also put forward the challenges for current healthcare monitoring application. At the last part of the survey, it will give the conclusion and future aspects.

2 PROTOTYPES OF HOME HEALTHCARE MONITORING APPLICATIONS

There are not many prototypes for healthcare monitoring application. According to the purposes of healthcare monitoring application, prototype can be generally divided into two categories: medical status monitoring applications and daily activities monitoring applications. The former is that using biomedical sensors such as blood pressure sensor, ECG sensor and heart rate sensor to monitor the physiological parameters of subjects in order to get users' health status. While the later one using mostly the environmental sensors to monitor the activities of daily living activities for the subjects. The following subsections will give examples of these two prototypes of home care monitoring system.

2.1 Medical Status Monitoring Applications

The home care monitoring application area, most of studies focus on medical status monitoring which collects the vital signs of subject in order to allow user to understand their health status and make caregivers easy to manage the medical information.

CodeBlue (Lab, 2008) is developed by Harvard Sensor Networks Lab which is a wireless sensor for

medical care application including both hardware platforms and software platforms. Wireless pulse oximeter sensor and wireless two-lead ECG sensor is used based on the TinyOS operating system, so that it is supported to monitor a variety of physiological parameters include heart rate (HR), oxygen saturation (SpO₂), and ECG data. The user can get their health status without going to the hospital. The software platforms support PDAs, PCs and other devices which make the user and caregiver to manage these medical data easily. CodeBlue system also supports indoor and outdoor location tracking, so that it can be used to identify user's location especially helpful for the people with cognitive disabilities.

With the development of biomedical sensor, there are a lot of physiological variables can be monitored. For example, in (Yang et al., 2010) (Morris et al., 2009), by using biochemical sensing techniques, a textile-based wearable biosensor can monitor pH and sodium (Na⁺) when the user wear it.

2.2 Daily Activities Monitoring Applications

Activities monitoring applications at first are mainly targeted for gerontology. The Geriatrics shows that with the increase of age, elderly body systems, such as nervous system and immune system will gradually decline (Wikipedia, 2012). The simple and inexpensive environment sensors are used to monitor the daily life of elderly. Such applications require the long-term monitoring, collecting and analyzing data to find out when a person begins to lose physical or mental ability, or discover the trends of chronic disease, so that it have the potential to prevent the elderly physical and mental illness.

There is a study in the Quality of Life Technology Center (QoLTC) of Carnegie Mellon University that using embedded sensors to monitoring observations of daily living (ODLs) to detect onset of Alzheimer's disease (Mellon, 2010). They proposed a new concept Observations of Daily Living, or ODLs which includes "patient-recorded feelings, thoughts, behaviours and environmental factors (Mellon, 2010)". They proposed a new concept Observations of daily living, or ODLs which include "patient-recorded feelings, thoughts, behaviours and environmental factors (Mellon, 2010)". And they put environment wireless sensors in about 50 old adults' house to monitor their daily activities in order to detect subtle changes in behaviour.

3 REQUIREMENT ANALYSIS FOR HOME HEALTHCARE MONITORING APPLICATION

Most of the healthcare system is designed for the elderly and the people who suffer from chronic disease. But when some researchers design the healthcare system, there is a problem that they did not give the motivations or reasons the physiological parameters or physical activities to be monitored. For example, the daily activity such as teeth-brushing or shaving (Ince et al., 2008) may not provide the useful information for the doctor. If the collected data have no effect to detect or cure the chronic disease, or if the collected data have less value to find out the activity patterns, there is no need to monitor these parameters. Therefore, this section provides requirement analysis which starts from the causes of chronic diseases and focus on what activities and physiological parameters which have more medical value for several chronic diseases.

"Table 1" shows the summary of all the user requirements analysis about the activities and physiological parameters to be monitored for chronically ill mentioned here. Researchers can use this table as a reference when they design health care system both for the medical status monitoring applications and the daily activities monitoring applications.

3.1 Diabetes

For the people who have diabetes, they always have high blood glucose level and produce the classical symptoms of polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger). Beside of these three symptoms, there are other sign of diabetes: constant hunger, unexplained weight loss, flu-like symptoms, including weakness and fatigue, blurred vision and slow healing of cuts or bruises. From WHO diabetes criteria, if the one whose fasting glucose is over 125 mg/dl and 2 hour glucose is at or above 200 mg/dl, he or she can be diagnosed with diabetes.

3.2 Cardiovascular Disease

Cardiovascular disease is related with heart or blood vascular disease. The two main causes are high blood pressure and high blood cholesterol. Other important risk factors are diabetes, tobacco use, poor nutrition, and overweight and obesity. There are

three means to diagnosis cardiovascular disease that are blood tests, electrophysiology and medical imaging. However, blood tests are minimally invasive and medical imaging is expensive and only work in hospital, so the better approach is to measure the Electrocardiogram (ECG). At the same time, blood pressure and heart rate monitoring are also necessary.

3.3 Epilepsy

Epilepsy is a chronic neurological disease which can occur anytime so that the detection of seizures is important. Figure 1 shows an electroencephalogram (EEG) that contains EEG signal and Epileptic seizure EEG signal. This figure tells us that it can use EEG to monitor seizures.

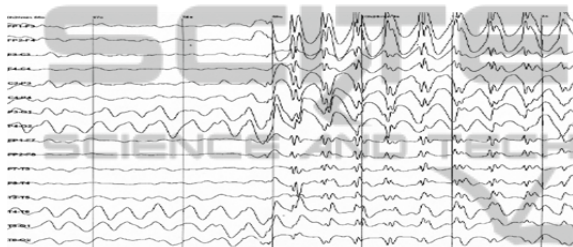


Figure 1: Normal EEG signal and Epileptic seizure EEG signal (Lange, 2005).

3.4 Alzheimer's Disease

Alzheimer's disease (AD), also called senile dementia, has symptoms such as confusion, irritability and aggression, mood swings, language breakdown; long-term memory loss and senses decline. At present, the early detection of Alzheimer's disease is monitoring the movement pattern.

3.5 Obesity

Obesity is caused by excessive intake of energy from food but not getting enough physical activity. As the consequence of obesity, it may lead to diabetes, heart disease high blood pressure and sleep and respiratory problems. Bad habits may lead to chronic disease. So it is important to monitor the daily behaviours which for obesity are diet, physical activity, alcohol and tobacco use and medicine intaking.

Table 1: Requirements analysis about the activities and physiological parameters to be monitored for chronically ill.

Disease	Activities to be monitored	Physiological parameters to be monitored
Diabetes	Quantity of water intaking	Blood glucose
	Quantity and frequency of eating	Blood pressure
	Quantity of smoking	Cholesterol
	Frequency of urination	Body weight
	Medicine intaking	Vision
Cardiovascular Disease	Alcohol consumption	ECG
	Tobacco cessation	Blood cholesterol
	Daily activity of moderate to vigorous exercise	Blood pressure
	Emotional stress in day to day life	Body weight
Epilepsy	Bradykinesia	EEG
	Idiosyncratic motions	ECG
Alzheimer's disease	Quantity of smoking	Blood glucose
		Blood pressure
		Cholesterol

4 CHALLENGES OF THE CURRENT HOME HEALTHCARE MONITORING APPLICATION

When we get the benefit from the wireless sensor network healthcare applications, we also face many challenges. This section presents the challenges and problems for current home healthcare monitoring applications. In this survey, the challenges and current problems are discussed from both the user and developer sides.

4.1 User Level Challenges

For the elderly who suffer from chronic disease, they prefer non-invasive measurement sensor rather than minimally invasive measurement sensor. For example, the most popular way to measure blood glucose is pricking the finger and getting some blood, then using blood glucose monitors to get the blood glucose level. But most of the users don't want this minimally invasive measurement. So, to

solve this problem, developer needs to find a better way of measuring.

For the caregiver, the health care application should be easy-to-learn and easy-to-operate. This problem becomes one of the reasons of the failure of Google health. The healthcare data type of Google health is too complex to use, so that users are deterred by the burden of data entry. So make the healthcare application easy-to-use is very important.

For healthcare professional, the different areas of experts may have different requirements. Vascular doctor has said that have the requirement of blood flow sensor. Because cells or tissues necrosis caused by inadequate blood flow. So his patients have to amputees at this situation. Therefore, there is still much developing space for WSN healthcare system. Developer had better to find out the current needs before they start the research.

4.2 Developer Level Challenges

The most important issue at the developer lever is that the biomedical sensors are directly in contact with the human body, which is different from any other common sensors. However, most of the WSN healthcare systems is still under research and develop in laboratories (Ren and Meng, 2006). So, they cannot be directly applied to the healthcare system because of the biological effects that may arise. So, check out whether the biological effects have any effect for human body is an important task for developer.

The healthcare application is better to have high interoperability. For example, different kind of sensor may use different communication protocol which is hard to work together in one system. Sometimes, an application may design its own communication protocol lead to the problem that researcher development platform cannot unify. Therefore, it is necessary to develop middleware to improve system interoperability.

5 CONCLUSIONS AND FUTURE ASPECTS

The paper presented a detail requirement analysis starting from the causes of chronic diseases and made a summary about five typical chronic diseases and analyzed the user requirement and gave results at "Table 1" that show the user requirement about the activities and physiological parameters to be monitored for chronic disease. This survey discussed

the challenges from both user and developer side. In the future, finding a good way to solve these problems will make the WSN healthcare system works better to improve people's lifestyles.

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