A WSN healthcare monitoring system for elderly people in geriatric facilities

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Abstract. This paper investigates an enhanced WSN based monitoring system for elderly people in geriatric facilities. Apart from general physical monitoring functionalities, we explore the potential of using a wireless audio module to perform mental health monitoring. The telephone version of the mini mental status examination (T-MMSE) was adopted in the mental health monitoring and the RSSI (Received Signal Strength Indicator) localization algorithm was implemented in this system to track elderly people’s the real-time location and send alerts based on their inactivity/activity levels, movement history and entry into restricted zones. Experimental test was performed to evaluate the performance of the proposed system. With results obtained and studied, this work can be extended to perform detection and rehabilitation function for elderly people with mental illness. This kind of monitoring system would be expected to make an important impact on many application scenarios for geriatric facilities.

Keywords. Wireless sensor network, mental health monitoring, elderly people healthcare, RSSI localization

Introduction

The global aging crisis has created a great demand for advanced technologies for better elderly care. As people grow older, there is an increased risk of chronic illness strokes, falls, and other health problems. In addition mental illness is another important to be considered. Rovner et al found that 94% of a random sample of residents at a large, intermediate-care nursing home had mental disorders according to Diagnostic and Statistical Manual of Mental Disorders (DSM-III) criteria [1]. Furthermore, mental illness has higher prevalence in elderly people with chronic disease [2] and there is an increased healthcare cost and bad quality of life due to poorly treated mental illness [3].

It is essential for the elderly people with chronic physical or mental diseases to be monitored in a reliable and unobtrusive way. As an effective means in acquiring information, wireless sensor network (WSN) based systems are being increasingly proposed as the solution to provide better health monitoring services to elderly people. A number of WSN based health monitoring prototypes are in existence, and they are mainly focusing on providing physical and ambient monitoring for elderly people. Well known projects CodeBlue [4] and ReMoteCare [5] showed examples to provide vital sign monitoring and ambient monitoring respectively. Research has also been carried out in developing computer-aided tools for detection and treatment of mental disease.

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M. Chinman et al suggested that audio computer-assisted self-interviewing can facilitate data collection and has improved outcomes for a number of disorders [6]. Gowan et al. designed a Computer Interactive Reminiscence system that utilizes interactive multimedia (including audio, video, animation) to stimulate long-term memory to prompt verbal and non-verbal communication [7]. Nevertheless, these computer aided tools usually require a certain level of computer skills and companion by medical staff or family members, making it unsuitable for elderly people living independently in geriatric facilities or at home where long-time companion for each elderly person is difficult to achieve. To date there has been little work reported on WSN based physical and mental health monitoring system. The end devices which are light, small, energy-efficient and portable, can be spatially distributed to cover a large area where vital signs of the elderly people carrying the end device could be collected continuously. The audio module would allow limited number of the care staff to communicate with more elderly people to detect early signs of mental illness and, more than that, all conversations could be recorded and managed for further investigation. A widely used telephone version mental health scale such as telephone version of the mini mental status examination (T-MMSE) can also be used in the audio module to assess the elderly people’s mental status regularly. With the RSSI localization algorithm adopted and implemented, the real-time location of elderly people can be tracked and monitored to achieve a reliable and efficient system [8].

1. Methods

The architecture of the WSN healthcare monitoring system comprises of three key components: the end nodes, the sink node and the data monitoring centre. Each end node consists of a physical sensor module, a WSN module with RSSI localization and group communication functionalities allowing for multi-hop data transmission and an audio module enabling audio streaming and transmission. The sink node comprises a WSN module for communication with the end node and a serial port interface module over RS232/USB connection to the data monitoring centre to transmit the sensor data for further recording, processing and display, this being based on Graphic User Interface (GUI) software and database system. Figure 1 shows the architecture of WSN-based physical and mental health monitoring system.

![Figure 1. The architecture of WSN-based physical and mental health monitoring system.](image)

The system designed in this work consists of two key hardware components: the end node and the sink node. The end node carried by elderly people will be a portable platform which integrates the WSN module with the physical sensor module and the wireless audio module, which is illustrated schematically in Figure 2. The WSN module is consisted of a transceiver (CC2531, Texas Instruments Inc), an MCU (MSP430F5437, Texas Instruments Inc), a RSSI location engine and a power source for data processing and network communication. The physical sensor module includes...
a high precision temperature and humidity sensor (SHT15 - Digital Humidity Sensor (RH&T), Sensirion) and a reusable SpO2 pulse oximeter sensor with TI’s analog frontend (AFE4490SPO2, Texas Instruments Inc). The audio board is based on TI’s PurePath wireless Headset development kit. The sink node comprises the WSN module and the RS232/USB interface to collect the sensor data, which is then transmitted to the data monitoring centre for further recording, processing and display based on Graphic User Interface (GUI) software and database system.

2. Results

To evaluate the performance of system, an experimental system was set up as the network topology. The GUI software is design for care staff use shown in Figure 3. It will run on care staff’s PC or tablet as data monitoring centre to interact with the portable end node carried by elderly people. The data collected by the sink node can be displayed, processed and retrieved in the GUI software. Physical sensor data and real-time location information will be displayed and processed in the database system. Certain threshold will be set as emergency reminder. A mental disease management software is developed to perform detection and rehabilitation function for elderly people with mental illness. The end node carried by elderly people is shown in Figure 4.

ZigBee2007 is adopted in the WSN module to create a reliable, low-power network eligible for an intermediate to large geriatric facility supporting up to 50 nodes and maximum 10 hops. The transmission range can be over 80-meter point-to-point distance without obstacle, so a stable wireless channel could be realised in a general geriatric facility within one building.

2.1. Evaluation of the physical sensor module and the wireless audio module

The real-time data of high precision temperature sensor and SpO2 sensor on end node was collected, then processed and transmitted directly to sink node or via router
according to real environment condition. For example, change in distance and obstacle in the way may result in the change of connection route. All the end nodes are programmed and configured to monitor the sensing data and transmit this information to sink node where sensor data can be forwarded to the PC data monitoring centre over a standard RS232 connection shown in Figure 5.

![Figure 5. Sensor data displayed on the GUI software at the data monitoring centre.](image)

A mental health management software is developed to perform detection and rehabilitation function for elderly people with mental illness. The telephone version mini mental status examination (T-MMSE) will be pre-recorded and sent from monitoring centre to certain end nodes according to practical needs as shown in Figure 6. A certain time will be arranged between questions. All the answers by the elderly people will be collected and recorded in database system for professional analysis. This task could also be implemented in a real-time dialogue mode with professional present in monitoring centre. Everyday care staff can also talk to elderly people from monitoring centre to discover early signs of illness, the T-MMSE questions could be asked in a subtle way over a long period to avoid elderly people’s adverse attitude or nervousness towards it. This type of talk will also be recorded as audio file for retrieval and analysis. Reminiscence therapy for Alzheimer’s disease via audio (music, speech in an interactive way) could also be performed and managed in similar way.

![Figure 6. T-MMSE based on the end device designed and implemented.](image)

2.2. Evaluation of the RSSI location function

![Figure 7. Schematic diagram of the RSSI algorithm.](image)  ![Figure 8. GUI software designed for localization.](image)
The RSSI localization algorithm is adopted and implemented in the WSN module. The Location Engine which is integrated in the MCU of the targeted end node (blind node) enables the calculation of the distances with the reference nodes through the broadcasting and receiving of related RF signals as illustrated in Figure 7. All reference nodes have already been deployed and are assumed to know their own positions [8]. With the location information of the static reference nodes and RSSI values obtained, the estimated position information of the targeted end node which is carried by elderly people can be calculated and displayed in GUI software as shown in Figure 8.

3. Discussion

In this paper, the enhanced WSN-based physical and mental health monitoring system for elderly people in geriatric facilities is presented. ZigBee protocol and RSSI location algorithm were adopted in the WSN module to provide high flexibility, reliability and energy efficiency to meet the practical needs in medical community. A physical sensor module and a wireless audio module have been integrated to meet the needs of the medical monitoring for elderly care. The wireless network communication protocols and GUI software have been developed in this work to perform efficient display of the monitoring process through the end node carried by elderly people. The future work will include the integration of different physical sensors according to user’s needs. A sophisticated GUI software and database to display and manage the physical sensor data and audio data will be developed. Finally, system evaluations will be carried out in a geriatric facility in the UK and China.

References