A Mobile phone-based Safety and Life Support System for Elderly People

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Abstract—A mobile phone-based system has been developed to detect and transmit notification of elderly person daily-life emergency situations. The system employs a dual axis accelerometer, two low-power active filters, a low-power 8-bit single chip microcomputer, two mobile phones and a personal computer. The dual axis accelerometer measures body movements produced by respiration, posture changing, falling and activities. If the person's respiration is paused for 3 minutes, or if they are in an inactive state for 1 minute after falling, or for 64 minutes without previously falling, then the system automatically sends the person's location by e-mail. It also informs the patient's family by voice, via the mobile phone, of the emergency situation.

Keywords—Elderly person, Elderly person's location, Dual axis accelerometer, Fall, Comatose state, Mobile phone.

I. INTRODUCTION

Numerous types of daily living physical activity recording systems [1]-[7] have been developed for monitoring health conditions and living patterns; however, the sudden death of elderly people in daily life remains a serious problem worldwide. The causes are mainly cardiac and cerebral problems, which are induced by an unexpected cardiovascular incident, or a fall. To solve this problem, various devices such as push-button emergency necklace pendants and fall monitoring systems [8]-[9] have been developed. However, the pendant system is not effective when the elderly person suddenly becomes comatose, and the fall monitoring systems can not detect emergency situations caused by an unexpected sickness that does not cause a fall. Moreover, these systems cannot be used outside of the home.

In this study, the mobile phone-based safety and life support system, which is attached to the center of the abdomen with a waist band, detects the person's life-threatening physical condition from body movements produced by respiration, posture changing, walking and running. When the elderly person is in an emergency situation at home or away from home, the system automatically sends the elderly person's location by e-mail and informs the person's family by voice, via the mobile phone.

II. SYSTEM DESCRIPTION

Figure 1 shows the overall mobile phone-based safety and life support system. The system consists of a daily living activity recorder and a personal computer (PC) placed at home. They communicate via 2.4GHz low transmitting power mobile phones (PHS), which are incorporated in the daily living activity recorder and the PC. The daily living activity recorder attached to the elderly person’s abdomen measures body movements. Its low frequency components are mainly generated by respiration, while the high-frequency components reflect body movements produced by walking and running activities. The recorder detects the respiration interval and behavior. When an emergency situation is judged from the continuance of very small body movements, extinction of respiration and the larger acceleration forces due to a fall, the PHS in the daily living activity recorder is activated to make the telephone report and sends the emergency call code “HELP ME” to the PC. The PC prepares the elderly person’s location map from its stored data of PHS antenna locations. Numerous antennas, which were spaced every 100 m, are already installed by the telephone company now. The PHS
location is identified within 100 m from the receiving antenna ID, by the radio signal strength received by the antennas, or by transmission time from the mobile phone to the antennas. Latitude and longitude data of the location are downloaded from the mobile phone company. The PC sends the map to the elderly person’s family by internet mobile phone e-mail, and then informs them of the situation by voice.

Figure 2 shows the daily living activity recorder, which consists of a dual axis accelerometer (ADXL202E, Analog devices), a DC-DC step up/down converter, impedance converters, low and high pass filters, amplifiers, a low-power 8-bit single chip microcontroller MCT (PIC16F877, Microchip), a buzzer, a switch and a low transmitting power mobile phone PHSpc (P-in master, NTT DoCoMo).

The accelerometer is a complete acceleration measurement system on a single monolithic integrated circuit and has sensitive axes in the same plane as its silicon chip. The two sensitive axes are orthogonal to each other. The accelerometer can measure both static and dynamic acceleration forces simultaneously. The static acceleration force components, mainly generated by respiration, are detected by 0.3 Hz low-pass filters and then the slow acceleration magnitude is amplified by the 6 dB amplifiers.

The X and Y dynamic acceleration forces are detected by 0.1 Hz high-pass filters. The dynamic acceleration magnitude is obtained by adding the two vectors of the X and Y dynamic forces. When the elderly person falls down, then the acceleration magnitude indicates a very large ±12 m/s² acceleration for a short 600 ms period [1]. Body movements due to walking, running and posture change are of smaller acceleration magnitude than falls.

The amplifier and high-pass filter outputs are fed into the MCT, which is an 8-bit CMOS RISC-like CPU with eight 10-bit analog converters. The outputs are converted to a 10-bit serial digital format every 0.02 seconds. If the elderly person falls into a comatose state, then the body movements produce very small dynamic acceleration forces and never exceed the 64 minutes continuance of the rest state [1]. The microcomputer judges this as an emergency situation from the small body movements recorded by the amplifiers. The judged emergency situation is informed to the PC via the PHS.

To enhance system reliability, the daily living activity recorder is powered by two batteries. A small coin 3V lithium battery(CR2477, Panasonic) drives the daily living activity recorder except the PHS and provides 10 days of continuous operation. A 3.6V lithium ion battery(PSP1F, Panasonic) drives the PHS, which requires 78.8 mA when transmitting the data. The 6.5 cm x 5.5 cm x 1.8 cm recorder weighs 56 grams.

Figure 3 shows the flowchart of the PC. When the PC receives the emergency call code, then the PC downloads the latitude and longitude data of the person’s location from the mobile phone company via internet. A map around the elderly person’s location is downloaded as a GIF file from a map company, which provides a free map, via internet. The map covers an area of 800 m x 800 m around the elderly person’s location. The elderly person’s location is indicated as a star symbol on the map as shown in Figure 3(b). The map data capacity is 5 kbytes. The emergency situation is informed automatically elderly person’s family via the voice modem [10], and then the map is sent automatically to the elderly person’s family by e-mail. If the family does not receive the emergency call, the PC sends voice information to other registered notification persons.

The family or registered notification person, who have an internet mobile phone, receive and know of the emergency situation by voice and watch the elderly person’s location displayed on the LCD as shown in Figure 3(b)
III. RESULTS AND DISCUSSION

The trials of the person location system, the communication time required to transmit an emergency situation and the 24-hour recording of the daily living activity were performed with the same system as shown in Figure 1. A family’s mobile phone used is an internet mobile phone (D502i, NTT DoCoMo), The PC used is a conventional Pentium 2 GHz Windows computer with 256 Mbyte memory, 80 GB HDD and a low transmitting power mobile phone PHSpc (P-in master, NTT DoCoMo).

Measurements of the location were performed by a normal age 22 male subject, who wore the daily living activity recorder on the center of the abdomen with a waist band. The subject stood at ten different places in Itsukaichi area of Hiroshima city and these locations all were identified on a 1/25000 scale map.

Figure 4 shows the distances from the identified locations to the detected locations. Although the distances were influenced the houses or buildings around the subjects, the system can detect a person’s location within 60 m.

At present, there is a highly accurate elderly person location device which uses the Earth satellite-based Global Positioning System (GPS). The accuracy of this person-locating system is within 10 meters, but it depends on its GPS receiver obtaining a strong signal, so the system does not function inside houses and other buildings. Since many elderly person falls occur in their house and buildings away from home, this limitation is serious. The developed system, when located within in the communication area of PHSpc, can detect the person's location both inside and outside of buildings, and inform health care personnel of the person's physical situation from data stored by the daily living activity recorder. The emergency call time from PHSpc to family was measured for 24 hours at intervals of one-hour to test if the call is influenced by communication system congestion. Figure 5(a) shows the transmission time from the PHS to the PHSpc. Maximum transmission time was 11.4 seconds, and minimum transmission time was 7.3 second. Figure 5(b) shows the preparation time of the elderly person’s location map. Maximum time was 45.9 seconds, and minimum time was 23.7 seconds. This time period mostly depends on the downloading time of the location data and map from the companies via internet. Figure 5(c) shows the e-mail and voice transmission time from the PC to the mobile phone of the family. Maximum transmission time was 20.2 seconds, and minimum transmission time was 9.7 seconds.

IV. CONCLUSION

The developed mobile-based phone safety and life support system can detect an emergency situation from recorded daily life activity and automatically inform the situation to family or
other registered person. The elderly person carries the daily living activity recorder only at their waist. Therefore, the system does not need any operation by the person and the small recorder does not become obstructive to daily life. Since the system also works well away from home, and in other buildings, it encourages elderly people to maintain a beneficial outside activity level, without undue uneasiness about their health condition.

The developed life-safety system is not only very applicable to elderly people living by themselves, but should also be found very useful for monitoring hospital patients and people in welfare facilities, especially wandering elderly persons.

REFERENCES


