33rd Annual International Conference of the IEEE EMBS
Boston, Massachusetts USA, August 30 - September 3, 2011

A new safety support system for wandering elderly persons

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***Abstract*—We have developed a new mobile phone-based safety support system for transmitting information of a wandering elderly person's location and the environmental sounds around that person. The system consists of a wearable sensor and a conventional desktop PC with Internet access acting as the server computer. The wearable sensor, which is attached behind the neck of the elderly person's shirt, is composed of a low transmitting power mobile phone (W-SIM), a small microphone and a one chip microcontroller. The wandering elderly person's location is identified within 100 m from the mobile phone company's antenna ID via the W-SIM. The caregiver sets the elderly person's movement area by specialized computer software. When the elderly person goes out of the area, the sensor automatically records the environmental sound around the wandering elderly person for the presumption of the person's situation with the small microphone. The W-SIM sends both the wandering elderly person's location and the environmental sound to the server computer. The server computer informs automatically the caregiver by the e-mail. The caregiver can monitor the sound and the map of the wandering person's location via Internet. The sound enables the presumption of an accurate location and the situation of the wandering elderly person.**

I. Introduction

IN Japan, the 2010 population of elderly people over the age of sixty-five was about twenty-nine million, according to an analysis by the Japanese ministry of internal affairs and communications. Elderly people with dementia number two million and are expected to reach 3.5 million by 2030 [1], [2]. Dementia is a long-term and progressive disease, and a normal lifestyle becomes difficult. They have many behavior disorders such as wandering, poor verbal communication and being uncooperative [3], [4]. Their wandering behavior is a major cause of death, so it is an especially serious problem for caregivers. It is therefore very important to monitor the wanderer's location and situation.

Numerous location detection systems have been developed [5]-[10]. At present, there is a highly accurate elderly person location device which uses the Earth satellite-based Global Positioning System (GPS) [11], [12]. The W-SIM system also can be used to detect the person's location. Numerous antennas, spaced every 100 m, are already installed by the telephone company. The location is identified within 100 m from the mobile phone company's antenna ID. The accuracy of the W-SIM system is considerably less than the GPS system; however, the GPS system cannot detect locations inside houses, other buildings, shopping arcades, underground shopping malls and in vehicles such as a car, bus or train [13]-[16].

The developed wearable sensor employed the W-SIM can detect the person's location both inside and outside of buildings, and send the location to the server computer by the W-SIM. Also the wearable sensor can record the environmental sound around the wandering elderly person. This sound can be used to identify the accurate wandering elderly person's location and prevent an emergency situation, such as an accident.

When the elderly person goes out of the area set in the sensor, the sensor automatically sends both the wandering elderly person's location and the environmental sound to the server computer. The computer informs the caregiver by the e-mail. The caregiver can monitor the sound and the map of the wandering person's location via Internet. The sound enables the presumption of an accurate location and the situation of the wandering elderly person.

II. System Description

Figure 1 shows the overall mobile-phone based safety support system. It consists of a wearable sensor, a conventional desktop PC acting as the server computer, and with Internet access. The wearable sensor, which is composed of a low transmitting power mobile phone (W-SIM), a small microphone and a one chip microcontroller, is attached behind the neck of the elderly person's shirt. The W-SIM detects the elderly person's location within 100 m from the mobile phone company's antenna ID. The W-SIM receives the latitude and longitude data of the location from the mobile phone company via Internet in ten minute intervals, and then the data are stored by the microcontroller. When the elderly person goes out of the area set in the microcontroller, the sensor records the environmental sound around the wandering elderly person. Both the wandering elderly person's location and the

M Manuscript received April 11, 2011.

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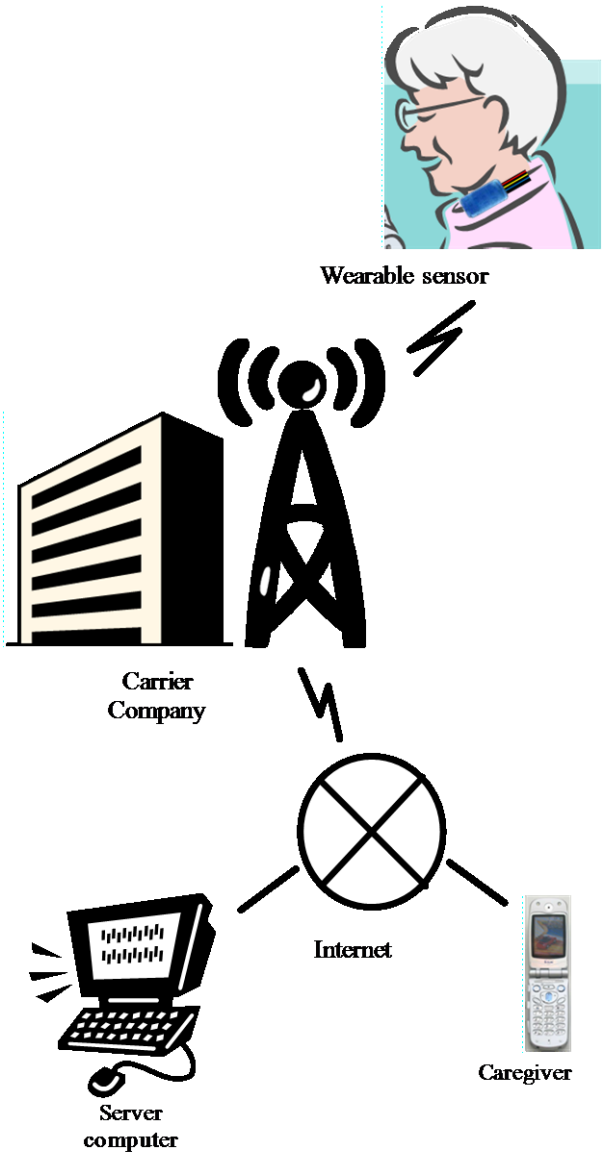

Fig. 1. The overall of mobile-phone based safety support system.

environmental sound are sent to the server computer automatically.

The server computer receives the latitude and longitude data of the location from the W-SIM via Internet, and then the data are stored by the server computer and automatically informs the caregiver by the e-mail. The caregiver can monitor the sound and the map of the wandering person's location via Internet.

Figure 2 shows the block diagram of the system. The sensor is composed of a low transmitting power mobile phone W-SIM (Altel, RX430AL), a small microphone (Panasonic, WM-E13UY), an amplifier (Texas Instruments, OPA336) and a one chip microcontroller (Microchip, PIC32MX695F512H). The W-SIM size is 50 mm x 30 mm x 5 mm, and the weight is 10g. This W-SIM receives the latitude and longitude data of the location from the mobile phone company's antenna ID. These data are stored by the microcontroller.

The 1 gm microphone size is 5 mm x 1 mm, diameter and

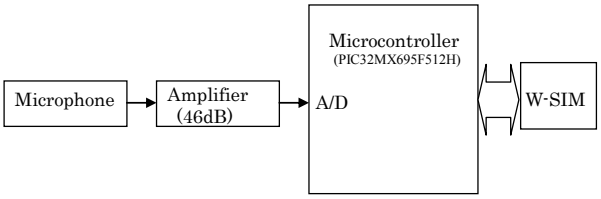

Fig. 2. The block diagram of the wearable sensor.

thickness. The recorded sound is amplified 43 dB, fed to a 32-bit RISC microcontroller with 16-channel analog to digital converters (A/D) and sampled at 8000 Hz. The sampled data is stored by the microcontroller. The stored data are sent to the server computer by the W-SIM.

Figure 3 shows the wearable sensor flow chart. The elderly person's movement area is set to the microcontroller by the

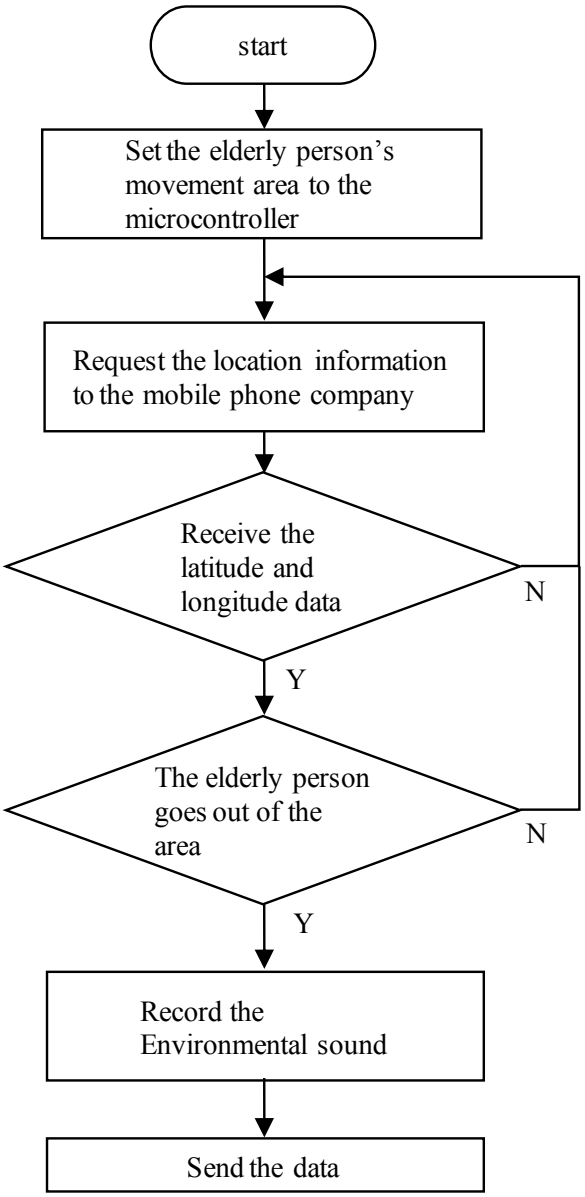

Fig. 3. The wearable sensor flow chart.

server computer via Internet. The W-SIM receives the latitude and longitude data of the location from the mobile phone company via Internet in ten minute intervals. The microcontroller checks whether these data are within the area set in the microcontroller. When the elderly person goes out of the area, the A/D converter starts to sample the environmental sound around elderly person and stores the sound to the microcontroller.

The stored environmental sound and person's location data are sent automatically to the server computer by the W-SIM.

Figure 4 shows the flow chart of the server computer. The server computer receives the elderly person's location information and the sound from the wearable sensor carried by the elderly person. The map of the elderly person's location is downloaded from a map company via the Internet, and then the elderly person's location is marked on the map. The server computer automatically informs the caregiver by e-mail. The caregiver can monitor the sound and the map of the wandering person's location via Internet.

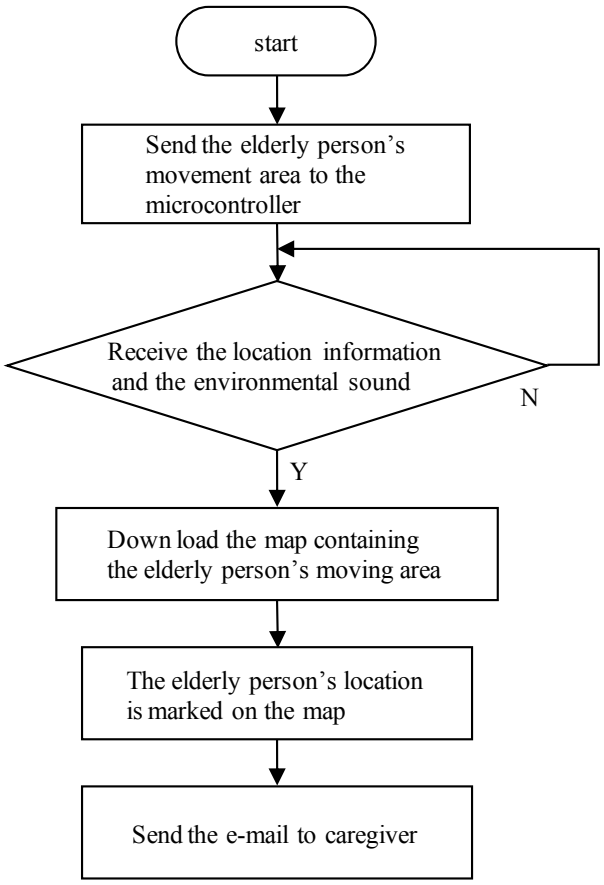

Fig. 4. The server computer flow chart.

III. Results & Conclusion

In trials of the system, the environmental sounds in various locations such as the vicinity of railway track, heavy-traffic road, light-traffic road, supermarket, and park nearby Hiroshima Institute of Technology in the Itsukaichi area, as shown in Figure 5, were recorded with the system for 15 seconds, and then the recorded sound is divided into 1, 3, 5, 10, and 15 second intervals.

Fig. 5. The locations recorded the environmental sound.

Experimentation was performed normal age 20-22 male 9 subjects. They heard all of the divided sounds and identified the subject's locations in almost every situation.

Table 1 shows the ratio correctly identified by the divided sound in various locations.

All locations except the park were identified 100% from the 15-second sounds; however, the park was 78%. The reason for this was that the park was very quiet because there were neither children nor other people present. These results indicate that a characteristic sound can presume the location.

TABLE I
THE RATIO CORRECTLY IDENTIFIED BY THE DIVIDED SOUND IN VARIOUS LOCATIONS

Time [s]	Heavy traffic road	Light traffic road	Park	Supermarket	Vicinity of railway road
1	44%	44%	0%	33%	56%
3	67%	67%	11%	44%	100%
5	100%	89%	56%	78%	100%
10	100%	100%	78%	89%	100%
15	100%	100%	78%	100%	100%

However, it is very difficult to recognize an exact location by only its sound.

The developed system can get the location and the sound simultaneously. So these data enable the recognition of the accurate location. The server computer displayed the downloaded map corresponding to the subject's location as shown in Figure 5. The subject's location is displayed within 100m on the map; however, the accuracy of the location is considerably less than the GPS system.

So they heard the sounds for 10 seconds after recognizing the subject's location on the map. As a result, the location was

identified 100% by using both the location and the environmental sound. Moreover, the wandering elderly person's voice is recorded in the environmental sound. Therefore, the sound enables the presumption of the wandering elderly person's situation. When the person has an unexpected accident, the caregiver can immediately send help or emergency support.

The system is not only applicable to wandering elderly patients, but would also be very useful for monitoring children and elderly people living alone.

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