Design and Implementation of a Fall Detection Monitor System with a Voice Interaction Function for Smartphones

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***Abstract* -- In this paper a smartphone fall detection system featuring a three-axis accelerometer sensor with a voice interaction function is presented. The value, measured by the three-axis accelerometer sensor, is sent to the program. It is then calculated and compared to the fall characteristics. When a fall is detected, the voice function asks whether the user needs help. If the fall is not serious, the user can cancel this emergency notification by means of either the voice interaction function or the touch panel. Otherwise the smartphone would automatically send out an emergency signal to the help center to request assistance for the user.**

I. Introduction

The features used to detect falls can usually be divided into three types: 1. image recognition [1], 2. voiceprint and vibration recognition [2], and 3. traditional devices [3]. Recently, a typical smartphone contains a variety of sensors. By using those sensors, a smartphone can be used to detect changes in external characteristics, and then convert them to voltage signals for fall detection [4].

A three-axis accelerometer sensor is used in the design to detect and analyze the acceleration values when monitoring the occurrence of a fall. Combined with both TTS (TextToSpeech) and speech recognition, this design allows the user to notify a help center if there is indeed an accident. The smartphone would ask if the user needs help, and allow the user to respond to the question either by speaking to the phone or by pressing a designated area on the screen. In addition, with this design based on the fall detection the smartphone can make calls, and send an SMS (Short Message Service) with an address converted from the GPS (Global Positioning System) latitude and longitude data. Fig. 1 shows the operation environment of our design. If the APPs keep the GPS always on has affects the battery, therefore through the GPS location the update frequency is prolonged to reduce the power consumption of the battery in this design.

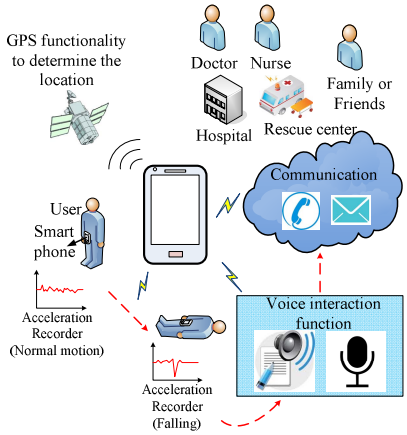


Fig. 1. The operation environment of our design.

II. Fall Monitoring Algorithm

Fig. 2 shows the acceleration waveform produced as a result of a fall. The resulting acceleration waveform analysis from the fall can be divided into three characteristic values.

1. Initial value

When the smartphone location is established, there would be a gravitational force close to $9.81\ \mathrm{m/s^2}$, or 1g exerted on the phone.

2. Impact threshold

When a fall occurs, the three-axis accelerometer sensor, which detects a dramatic change because of the change of the human body center of gravity, it will produce an acceleration of gravity. From the result of our repeated tests, the threshold value is set at $17.64\ \mathrm{m/s^2}$. Approximately 1.8 g is considered to be a reasonable threshold value.

3. Measured value

If the body does not maintain a standing position after a fall occurs, the phone would either be flipped or fall down etc., thus changing its center of gravity.

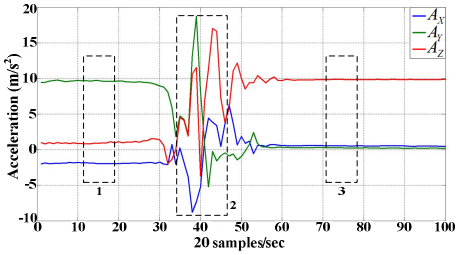


Fig. 2. Falling acceleration waveform.

Fig. 3 shows the fall detection flowchart. When the three-axis accelerometer sensor is turned on, it will analyze the acceleration values in real time. The first step calculates the composition acceleration and sends the result to the composition force. The second step, which detects whether there is any other movement within a period of two seconds, is used to filter other activities. The third step is a comparison both of the initial and of the measured values to determine whether the user's center of gravity has changed.

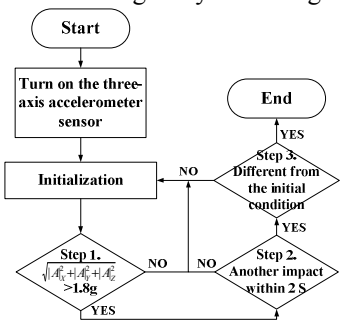


Fig. 3. The fall detection flowchart.

III. VOICE INTERACTION FUNCTION

The voice interaction function is divided into two parts: one for the TTS, and the other for speech recognition. The smartphone can ask the user to respond to the question within 20 seconds in order for the system to determine that the fall is not serious. Fig. 4 shows the voice interaction function sequence [5].

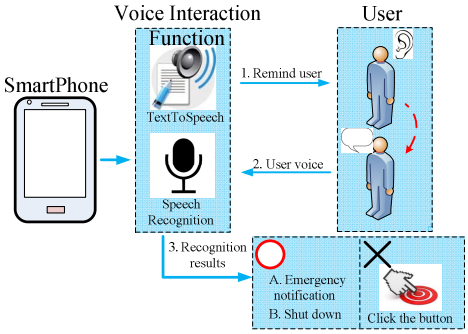


Fig. 4. The voice interaction function sequence.

1. TextToSpeech (TTS)

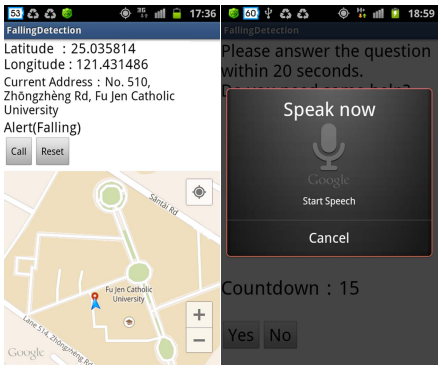
By utilizing smartphones with the TTS function, we can either reduce false positives or confirm that no injury has taken place, and thus prevent any waste of emergency resources. Through the TTS feature, the smartphone can achieve a better human-computer interaction.

2. Speech Recognition

Many smartphones have a built-in voice recognition function that contains pre-processing, feature extraction, decoding, and also both a language model and recognition model. Our design uses this feature to further control the APPs function by analyzing, recognizing and converting the user's voice into text to provide the interactive function.

IV. EXPERIMENTAL RESULTS AND COMPARISON

Fig. 5 (a) shows the user interface on which the smartphone records both the latitude and longitude and converts the data into an actual address. At first the APPs, if it detects that a fall accident has occurred, will immediately start the voice interaction function shown in Fig. 5 (b) to ask the user either to respond verbally or to use the touch panel to cancel the fall detection. When the mobile data network is turned off, the APPs will not be able to retrieve the address from the GPS coordinates. But the APPs still can attach the GPS coordinates to send the SMS content to the recipient.



(a) (b)

Fig. 5. This design's user interface.

There are several designs that can detect falls, but those designs can only be used indoors [1-2]. If we want to include a suitable outdoor design, there will be an increase in the system cost. Table I shows a comparison of our design with others.

TABLE I

COMPARISON OF OUR DESIGN WITH OTHERS

Detection method	Image recognition [1]	Voiceprint vibration recognition [2]	Our design by acceleration detection and by use of voice interaction function
Convenience	Low	Low	High
Outdoor	No	No	Yes
Cost	High	High	Low
GPS function	No	No	Yes
Voice function	No	No	Yes

Table II shows the experimental results of the voice interaction function. The experiment uses three testers who speak two keywords of two languages to determine whether or not the two keywords of either language would activate the emergency notification. Each keyword of both languages was tried 100 times. This design obtained an average accuracy rate of 97% by utilizing the voice interaction function which detects whether a fall had taken place.

TABLE II

EXPERIMENTAL RESULTS

Tester	English keyword "Yes"	English keyword "No"	Chinese keyword "Yes"	Chinese keyword "No"
1	100	92	100	100
2	100	95	98	96
3	99	100	99	98

V. CONCLUSION

In this paper we use the three-axis accelerometer sensor contained in a smartphone to design and implement a fall detection monitor system. In addition, we use the voice interaction function to detect and resolve any false alarm. When recognizing the need for help, the smartphone can automatically send a SMS containing the actual address converted from the latitude and longitude data and at the same time make a call to a family member, a friend or an emergency center. By providing a user response function, it can effectively reduce the waste of emergency and medical resources.

REFERENCE

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