International Journal of Pure and Applied Mathematics
Volume 116 No. 9 2017, 231-236
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue
ijpam.eu

A SMART PHONE-BASED POCKET FALL ACCIDENT DETECTION, POSITIONING AND RESCUE SYSTEM

K.P.Kaliyamurthie
Dean, Department of CSE,
Bharath University, Chennai-73.
kpkaliyamurthie@gmail.com

Abstract: Fall accident detection and recue system is a high achievement in the medical industry .It is based on environmental monitoring based or wearable sensor based system. But now in the era of modern world smart phone is acting as a sensor, based on novel algorithm as well as architecture for the fall accident detection and corresponding wide area rescue system based on a smart phone and the third generation (3G) networks. The angels obtained by electronic compass and waveform sequence of tri-axcial accelerometer on smart phone used as inputs while fall detection. Once a fall accident event is detected, the user's position can be acquired by the global positioning system (GPS) or the assisted GPS, and sent to the rescue center via the 3G communication network so that the user can get medical help immediately. With the proposed cascaded classification architecture, the computational burden and power consumption issue on the smart phone system can be alleviated.

Keywords: encompass, SVM, accelerometer, smart phone, GPS, fall detection.

1. Introduction

With the rapid development of science and technology in the medical field, the requirement of health quality is increased greatly, which promotes the classical "hospital centered healthcare" shift towards "hospital/home/person centered healthcare"[1].Tele-medicine [2,3] is a new medical model which offers remote disease diagnosis, treatment and health care by using remote communication technology and computer technology. Telemedicine system consists of three parts: the home terminal, the communication network and the monitoring center. However, telemedicine is not widely used in real life, for its client server is not well developed and still has many problems[4,5],such as the device cannot work continuously for a long time, it's not small and light enough so that the user may feel uncomfortable when using it.

Wearable telemedicine technology provides an effective solution to solve this problem and has become a new research hotspot. Medical sensors are embedded into watches or clothes to achieve a kind of non-instructive and noninvasive diagnosis and monitoring. As a remote medical monitoring terminal, wearable medical devices can be connected to the server of healthcare center through local area network, GPRS or Internet to transmit the real-time monitoring data [6-8]. As the aging of population in today's society, falls are one of the major health risks among the older community due to the increase in mortality, morbidity, disability, and frailty [9]. Falls and fall induced injuries account for over 80% of all injury-related hospital admissions among people over 65 [10].

Consequently, falls affect tens of millions of elderly throughout the world. For example, falls among the elderly cost the National Health Service more than ₤4.6 million per day according to a report by the Centre for Social Justice UK [11]. Therefore, the high incidences of falls, combined with their associated costs, make it imperative to develop a reliable and effective fall detection solution to provide remote medical help for the elderly [12]. Fall detection system, as a kind of wearable remote medical equipment, can monitor the user's daily activities, and will send feedback to the remote monitoring center. In the past, much research has gone into trying to find a solution to detect falls. Rimminen et al. [13] used a tri-axial accelerometer to set thresholds of acceleration and orientation of trunk through experiments to detect falls, which achieved an accuracy of 81%. Zigel [14] integrated a tri-axial accelerometer into a hearing aid device, and used thresholds for acceleration and velocity to judge whether a fall had occurred. The main problem was the use of only acceleration for fall detection led to many false positives. For instance, sitting down quickly produced similar vertical acceleration data. Tong, [15] developed a sensor with two orthogonally oriented accelerometers and used this sensor to monitor the inclination and inclination speed to detect falls. Though body orientation can improve the fall detection accuracy, using one single device can only monitor the body orientation. Sufficient posture information cannot be collected using this method. Cheng team [16] developed an airbag system to protect the hip when falling, just like the application of airbags in a car crash. To make sure that air was fully filled before a collision they applied a tri-axial accelerometer and gyroscope, then set accelerations and angular velocities thresholds using Support Vector Machine (SVM) methods to predict fall events. However, the accuracy and timeliness were not mentioned. Naranjo et al. [17] used hidden Markov model (HMM) and tri-axial accelerometer to detect and predict falls through analyzing the features of human motion series during fall processes. The exper- iment results showed that this method could predict falls in 200~400 ms before the impact and also accurately distinguish falls from other daily life activities.

However, the HMM λ and thresholds of the system were set based on the data samples of young people's simulated activities, the mathematical model and thresholds should be trained and reset based on the large real-world samples of the elders. Chen et al. [18] present a fall detection method based on one-class support vector machine in which a tri-axial accelerometer is used to capture the movement data of a human. This method needed specific activity patterns and computation, which was not appropriate for real-time and comfort fall detection. In sum, since outputs from accelerometer consist of not only body accelerations but also the gravity, the angle errors calculated from tri-axial acceleration maybe one of the reasons for misdetection of accelerometer based detection system.

As for gyroscope based fall detection system, most of the low-cost gyroscopes suffer from time varying zero shifts seriously, and make the system bring significant errors to the calculated angular acceleration and angular position through differential and integral operations. Hence, more and more researchers study on technology of combining tri-axial accelerometer with gyroscope to detect fall events accurately [19]. This paper is proposing a wearable fall detection method by using a mobile smart phone, and a custom vest integrated with tri-axial accelerometer and gyroscope to detect fall and issue alarm. The system incorporates an array of features, such as sending alerts, Short Message Service (SMS), and Global Positioning System (GPS) location for easy alerting and monitoring. Different from the research mentioned above, the system identifies falls using both acceleration and angular velocity. And this system can be applied to anyone, not only the elderly.

2. System architecture

The system Architecture is mainly composed of three blocks: the smart phone-based pocket fall accident detector, the coordination center, and the rescue center which is composed of the hospitals nearby or the first-aid stations.

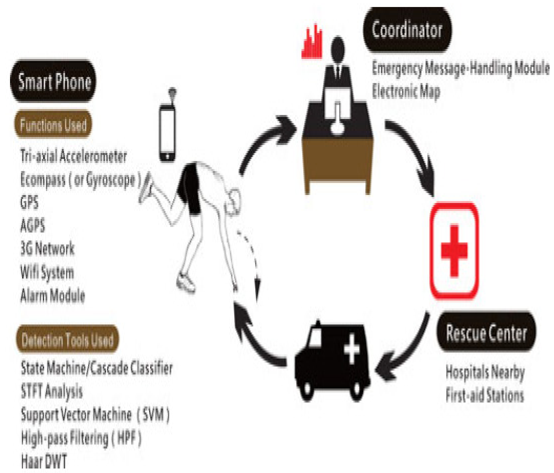


Figure 1 Architecture of Fall Accident Detection And Reuse System

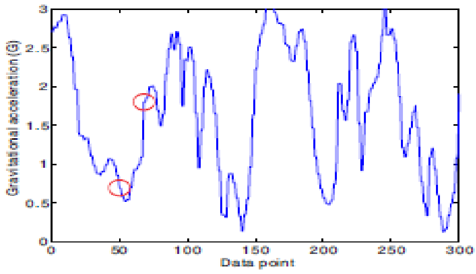
As can be seen in the part of smart phone-based pocket fall accident detector, the triaxial accelerometer and the encompass will be used to acquire the posture of motion activities for the elderly. In the proposed system, the inclusion of the encompass is to acquire the tilt angle, i.e., pitch, of the smart phone. This is because when the elderly is suffering a fall accident event, the smart phone in the user's pocket also tends to lie down, and the pitch angle is usually small[20].

Actually, the work of acquiring the pitch angle of the smart phone can also be accomplished by using a gyroscope that provides the angular acceleration information of the smart phone. However, the gyroscope is only available in higher grade smart phones. On the contrary, the encompass is available in most of the smart phones. Furthermore, the tilt angle (pitch angle) of the smart phone can be estimated by using the encompass in conjunction with the triaxial accelerometer[21,22]. We, therefore, decide to use the encompass for the estimation of pitch angle so that the proposed algorithm can be applied for most of the smart phone systems.

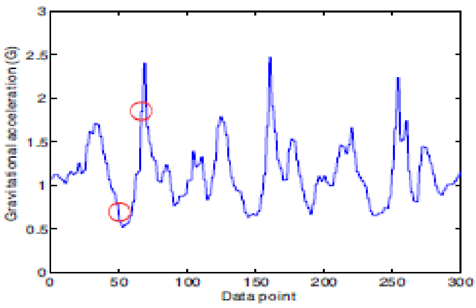
We also list in diagram the tools and algorithms that are used for the analysis and detection of a fall event. This is used in scenario of placing the smart phone-based fall accident detector in the pocket of the elderly.

As loud sound as a warning signal will be sent out once a fall accident event is detected, and then the longitude and latitude, i.e., the current position, of the elderly will be transmitted to the coordination center via the 3G network. The coordination center is composed of an emergency signal handling program module, which is used to receive the current position and important personal information of the elderly[23]. The received longitude and latitude can then be integrated and displayed with an electronic map, e.g., Google map.

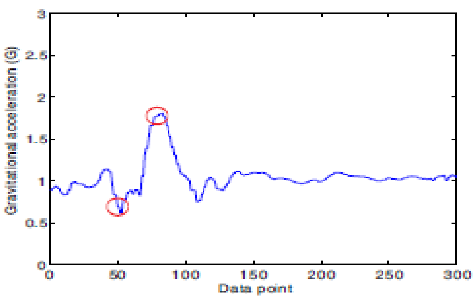
The predefined waveform is very important like running, walking, getting up and down stairs, like this wave is compared with the activity of users. Some example of wave form is predefined.



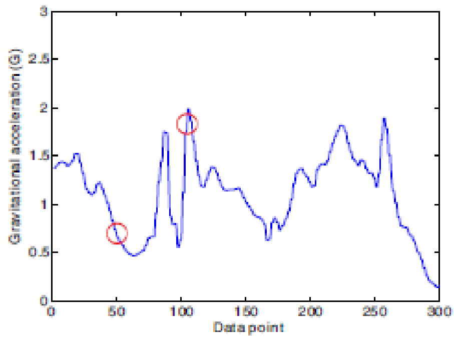
(a) Run



(b) Walk



(c) Sit down



(d) Go upstairs

3. Proposed system

We propose in this paper a pocket-based fall accident detector that uses a smart phone as the platform of the system. the global positioning system (GPS) or the assisted GPS will be used to acquire the user's current position, and the longitude and latitude will be sent to the coordination center via the third generation (3G) communication network if a fall accident event is detected. This way, the coordination center can know the user's position exactly. Moreover, the detailed position can also be shown on the screen of the coordination center with electronic maps[24], e.g., Google map, so that the user can get medical help immediately. Meanwhile, the system will send out a loud sound as a warning signal so that people nearby can notice this fall accident event and provide assistance to the user immediately. With the proposed algorithm and architecture, the computational and the power consumption burden can be quite alleviated since we check each fall accident feature sequentially and reset to the initial state once any one of the feature in the state machine is not verified. Since we also use the angle acquired by the electronic compass to assist in discriminating a fall down event, the user just put the smart phone in their pocket, which is easy to carry with. Moreover, the proposed system can locate the user and communicate with the coordination center in a wide area as long as the 3G network is available, which facilitates the daily activities of the elderly.

Advantages: The system identifies falls using both acceleration and angular velocity. The result is positive detection and more accrued. Using GPS co ordinates it conveys the location to medical coordinator. Medical coordinator easily find nearby hospitals using these GPS coordinates. And this system can be applied to anyone, not only the elderly.

4. Implementation

Novel algorithm as well as architecture for the fall accident detection and corresponding wide area rescue system based on a smart phone and the third generation (3G) networks. To realize the fall detection algorithm, the angles acquired by the electronic compass (encompass) and the waveform sequence of the tri-axial accelerometer on the smart phone are used as the system inputs. The acquired signals are then used to generate an ordered feature sequence and then examined in a sequential manner by the proposed cascade classifier for recognition purpose. Once the corresponding feature is verified by the classifier at current state, it can proceed to next state; otherwise, the system will reset to the initial state and wait for the appearance of another feature sequence.

Once a fall accident event is detected, the user's position can be acquired by the global positioning system (GPS) or the assisted GPS (A-GPS), and sent to the rescue center via the3G communication network so that the user can get medical help immediately. With the proposed cascaded classification architecture, the computational burden and power consumption issue on the smart phone system can be alleviated. Moreover, as we will see in the experiment that a distinguished fall accident detection accuracy up to 92% on the sensitivity and 99.75% on the specificity can be obtained when a set of 450 test actions in nine different kinds of activities are estimated by using the proposed cascaded classifier, which justifies the superiority of the proposed algorithm.

4.1 Customize The Basic Information:

Initially the user needs to enter some personal information such as name, email, phone number and location. The purpose of entering the personal details is to help the user to be identified the control rooms if the user meets any emergency situation. The information provided by user is stored in server of Medical center.

4.2 Monitoring Accelerometer:

Accelerometers measure linear acceleration and tilt angle. Single and multi-axis accelerometers detect the combined magnitude and direction of linear, rotational and gravitational acceleration. They can be used to provide limited motion sensing functionality. For example, a device with an accelerometer can detect rotation from vertical to horizontal state in a fixed location. As a result, accelerometers are primarily used for simple motion sensing applications in consumer devices such as changing the screen of a mobile device from portrait to landscape orientation.

4.3 Triggering Of Alarm:

As soon as the motion is detected after shaking the device, an alarm is programmed to be triggered and a countdown for one minute is started. This delay before sending the message is induced where the user can either choose to disable the alert message from getting delivered by entering the disarm code or if the situation is severe the user can yell out a code word which is immediately recognized by the application and send the alert message to the chosen contact immediately. If none of the actions is performed, the message gets delivered after one minute. It is understood that the user is unable to reach the mobile or has fainted due to health issues

4.4 Alert Message with Location Information:

An alert message is delivered to the trusted medical coordinator with the location information including the latitudinal and longitudinal details.

4.5 Emergency List:

Emergency Information module consists of emergency list of the each user who are the using Android application. This information is collected from user mobile. It contains the information of user (i.e) user id, name, email, phone number, location, latitude, longitude. These information are stored in emergency table. The admin can view the location information in map. The emergency information was implemented in a PC server, which was connected to the Internet and could be accessed via web browsers. The server can emulate the trajectories of mobile nodes and display their traces on the map.

4.6 Communicating Rescue Centre:

The medical coordinator finds the nearest hospital by using latitude and longitude which is sent by user. Coordinator make call to the nearest hospital to take an immediate action.

5. Conclusion

This paper deals with smart phone-based pocket fall accident detection system. The fall detection algorithm is realized with the proposed state machine that investigates the features in a sequential manner. Once the corresponding feature is verified by the current state, it can proceed to next state; otherwise, the system resets to the initial state and waiting for the appearance of another feature sequence. To speed up the efficiency of classification process, the early states are composed of simple and important features that allow a large number of negative samples to be quickly excluded from being regarded as a fall event. Those complex features are then placed in later states.

The future work will further focus on to solve the computational and power consumption burden of the system and also to take effort to improve efficiency and speed.

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