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ACCELEROMETER–BASED HUMAN FALL DETECTION AND RESPONSE USING SMARTPHONES

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Abstract :- Unobserved human falls can be dangerous and can badly affect health. Falls can cause loss of independence and fear among the older people. In most fall events external support is essential to avoid major consequences. Thus, the ability to automatically detect these fall events could help minimising the response time and therefore prevents the victim from having serious injuries. This paper presents a smartphone based fall detection and response sending application which is based on the built-in accelerometer sensor and GPS module in the smartphones. The data from the accelerometer is continuously screened when the phone is in the user's belt or pocket. When a fall event is detected, the user's location is tracked and SMS and email notifications are sent to a set of contacts.

Keywords: Fall Detection, Smartphone, ADL, Accelerometer Sensor.

1. Introduction

Injuries occured due to falls are a huge problem among older generations and falls represents 40% of all injury deaths [1]. Falls are a great cause of fear and lack of confidence and independence among older people. Sometimes falls may even lead to death. Accidents due to falls can occur in everyday life during situations like: working in a construction site, going to any place like office, schools, colleges, shops, parks etc., a car accident, or going for a trip alone, or even when we are affected by any health problems like heart attacks, low blood sugar, low blood pressure, syncope (loss of consciousness due to lack of blood flow to the brain), neurologic syncope (loss of consciousness caused by a seizure, stroke, or transient ischemic attack) etc.

As the time delay between fall event and rescue time increases, the chance for death also increases. So a rapid response by directly reporting to care givers after the detection of a fall is very much important. Thus an efficient fall detection system with fall alert techniques including location and time in the alerts are very helpful.

More than one third of people aged over 65 years old falls each year [1]. Fall incidence is even more serious considering that worldwide the population is aging [2]. Falls are considered the main cause of fear and loss of independence among the elderly population [3]. The occurrence of simple to severe injuries cause not only the decrease of mobility and balance but also cause psychological damages. These factors increase the risk of falling resulting in fall recurrence, it has been discovered that previous fallers have a probability of two- thirds of falling again in the next year [3].

Fall detectors have been demonstrated to have direct impact on the reduction of fall fear. In fact, falls and fear of falling is not independent. An individual who is frequently falls appears to be fear of falling and this fear afterwards may increase the risk of suffering from a fall [4]. Fear of fall majorly negative impacts on the life quality of elderly which can cause depression, activities limitation, social interaction decreasing, falling, lower life quality. The relationship between automatic fall detection system and fall fear has been proved by Brownsel [5] et al. They conducted a study on elderly who experienced at least one fall in the previous six months. At the end of the experiment, people who wore the fall detector feel more confident and diminish the fear of fallen, as well as consider the detector had improved their safety.

The other important objective of a fall detector is to limit the time the elderly remains on the floor after falling. The period of laying on the floor after falling determines the severity of a fall because long lie may lead to hypothermia, dehydration and pressure sores [6,7]. This is extremely critical in case the person lives alone without any assistances from their families and neighbors. The ultimate goal of the detector system is to realize a fall event and manage to notify an assistant immediately.

These effects of fall injuries make this an important global health concern. Thus reliable fall detection and directly reporting to care givers are very essential to provide proper care and treatment and to increase the quality of living, especially among the elderly.

2. Literature review

Fu et al. [8] in 2008, presented a contrast vision system designed to detect accidental falls using a contrast vision sensor. The main feature used in this system for fall detection is change in illumination. The system will detect backward, forward and sideways falls. The performance of the system is declared as: 3 possible scenarios evaluated with positive results. Instantaneous motion vectors are evaluated and fall hazards are instantly reported with low computational efforts.

Zhang et al. [9] in 2012, proposed a privacy preserving automatic fall detection system using RGBD cameras. The features used for fall detection are: Deformation and person's height. Fall from chair and fall from standing are the different fall types considered. The system achieved an accuracy of 94%.

Bourke et al. [10] in 2007, done an investigation into the ability to discriminate between falls and Activities of Daily Living (ADL). The detection technique is TBM using information from the impact. The system designed is able to detect backward falls, forward falls and lateral falls left and right, obtained with legs straight. The fall detection system with accelerometer sensor is placed at trunk or thigh. For trunk SP is 100% and for thigh SP is 83.3%.

Li et al. [11] presented a fall detection system which uses both accelerometers and gyroscopes in the year 2009. It is a TBM analyzing the posture and the intensity of the activity. The system considers, sideways, forward, backward and vertical falls and falling on stairs and fall against walls ending with a sitting position, as a fall event. The device should be worn at chest or thigh. It got an SP of 92% and SE of 91%.

Shan et al. [12] conducted an investigation of a pre-impact fall detector in 2010. The MLM including, a discriminant checking apply to the time based statistical features to select the characteristics, and Support Vector Machine is used for performing fall recognition. The fall types includes: lateral falls left and right, forward falls and backward falls. The fall detector must be placed at the waist. The obtained SP and SE is 100%.
Lee et al. [13] performed a study on the sensitivity and specificity of fall detection system using mobile phone technology in the year 2012. Fall detection is done through TBM considering the impact. Backwards, forwards, lateral right and lateral left fall events are considered for fall detection. The system achieved SP of 81% and SE of 77%. The motion signals received by the phone are compared with the motion signals recorded by an independent accelerometer.

3. Proposed Work

This paper presents a fall detection system which has been developed for the smart- phones, having the Android operating system. When a body is moving, many types of data can be generated using different built-in sensors in the smartphone. But in this application, we use only the data collected from the accelerometer sensor for detecting fall events. This is because, acceleration is considered as one of the most suitable data type for the purpose of fall detection. The reason behind this consideration is that a body acceleration maintains a strong relationship with the force exerting on that body, according to physical laws, and when there is a fall, the exerting force will be changed accordingly. This transitive relationship between a body fall and its acceleration explains for the reason to apply acceleration data for fall detection. Furthermore, accelerometer is a popular sensor type and accelerometer sensor is the most optimized sensor regarding battery usage and it provides also the most informative data for fall detection. It is found on most smart phones nowadays. (Figure 1) shows the image of accelerometer sensor.

Figure 1. Accelerometer Sensor

3.1. Smartphone Application

The application runs as a background task in the smartphone having Android operating system in order to screen all the user's movements searching for fall events. When a fall is detected, a sound alarm will be produced inorder to draw the user's attention and the application will display a message on the screen automatically asking for whether to report the fall to the care givers or not. The message will be displayed for 10 seconds and meanwhile the user can cancel the broadcasting of fall by pressing the 'NO' button in the case when a false fall event is detected by the application or when the user is able to recover from the fall, to avoid further complications. In all the other cases, the system will automatically send fall alerts to the care givers after the delay time of 10 seconds is completed. The system will send fall alerts via SMS and email notifications to a previously configured set of contacts for a quick response and rapid aid. These messages include the time of the fall and the user's current location, with the google map view of the location.

3.2. Battery Usage

The battery usage by the app should be in an efficient way since the application is continuously running throughout the day as a background task in the smartphone inorder to search for a fall event. Keeping this in mind, we use only the data collected from the accelerometer sensor for the fall detection even though there is availability of other sensors in the smartphone. The accelerometer sensor is the most optimized sensor regarding battery usage and it provides also the most informative data for fall detection. For providing an extra care on the battery usage, the accelerometer sampling frequency is reduced to 4 Hz when the user is not moving or not standing. Otherwise accelerometer sampling frequency is set to 67 Hz, to use the sensor in a high accuracy way.

3.3. Fall Detection Algorithm

The system will first check whether the user is moving or not. This will be considered as the Stationary state of the user. Whenever the user starts moving or the phone is detecting a relevant change in acceleration the state will change to Moving state. In the Moving state, the system will check whether a fall is detected. This is done by checking whether a severe decrease in acceleration is occurred. In this stage, if a fall is detected, the user will be in the Falling state.

Once in the Falling state, the system will check whether the user is able to recover from the fall or not. This is done by producing a sound alarm inorder to draw the user's attention and the application will display a message on the screen automatically asking for whether to report the fall to the care givers or not. The message will be displayed for 10 seconds and meanwhile the user can cancel the broadcasting of fall by pressing the 'NO' button in the case when a false fall event is detected by the application or when the user is able to recover from the fall, to avoid further complications. In all the other cases, the system will automatically send fall alerts to the care givers after the delay time of 10 seconds is completed. This is because, even after the completion of some delay time, the user still cannot move his hands to cancel the fall broadcasting, will indicate a chance that the user is either in an unconscious stage or has been met with some serious injuries. The system will send fall alerts, via SMS and email notifications, to a previously configured set of contacts for a quick response and rapid aid.

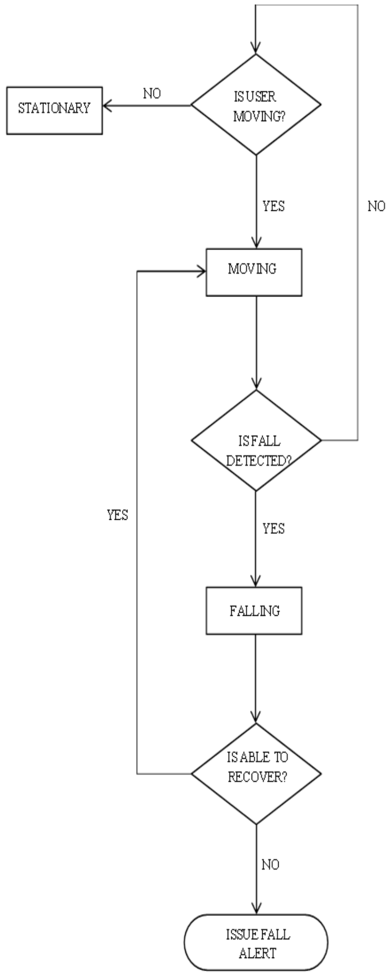

Figure 2. Graphical Representation of Fall Detection Algorithm

If the user is able to recover from the fall, he will be again put in the Moving state and again the system will search for another fall event. (Figure 2) shows the graphical representation of fall detection algorithm.

4. Results

After performing different tests, it is found that the proposed system can efficiently detect falls and is able to send accurate location of the user where the fall is occurred. The system have a very less probability of detecting or reporting false fall events because of the provision of cancelling the fall broadcasting by providing a convenient delay time. The proposed system is capable of sending alerts more faster, using the communication and localization features which are in-built in the smartphones.

The battery usage by the app is in an efficient way. Since the application is continuously running throughout the day as a background task in the smartphone in order to search for a fall event, we use only the data collected from the accelerometer sensor for the fall detection even though there is availability of other sensors in the smartphone. The accelerometer sensor is the most optimized sensor regarding battery usage and it provides also the most informative data for fall detection. For providing an extra care on the battery usage, the accelerometer sampling frequency is reduced to 4 Hz when the user is not moving or not standing. Otherwise accelerometer sampling frequency is set to 67 Hz, to use the sensor in a high accuracy way. This additional feature of reducing the sampling frequency can increase the battery life.

5. Conclusion

This paper presents a smartphone based fall detection system using the built-in accelerometer sensor in the smartphone. The use of smartphones for detecting falls have the advantage of not carrying additional wearables or sensors by the users and minimized cost by not buying any extra wearables. The system is able to track the location information of the user where the fall event is occurred. The system can send the details of the fall along with the time and the location information to a previously configured set of contacts, via email and SMS, whenever the user is met with a fall. The proposed system is capable of sending alerts more faster, using the communication and localization features which are in-built in the smartphones.

The proposed system is only based on the data provided by the accelerometer sensor in the smartphone, and will not use the data provided by other sensors in the smartphone since accelerometer sensor is the most optimized sensor regarding battery usage and it provides the most informative data for fall detection. In future the usage of other sensors and their contributions in fall detection can be considered.

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