Fall Detection Prototype

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Abstract

The study in both fall detection and prevention have been increasingly important. There have been several different approaches for making a good system in both fields. This paper focuses on fall detection. Primarily it makes a suggestion for a fall detection system using a smartphone.

A prototype of the system will be based on Java and Google's Android System.

This paper is also a project report intended to be a part of a future master thesis in Fall Detection next Spring semester, 2011. It focuses on one aspect which is suggestion of a prototype to be further uses in the thesis' studies.

Contents

1 Introduction

While the prevention of fall is undoubtedly a big and important research field in health care, the study in detection of fall has in the past 3-4 years increased in magnitude and importance as well. This is because ultimately we cannot prevent all falls, but we can try to detect fall accidents and give a quick response and aid.

The study in both prevention and detection of falls is mainly focused but not limited to falls that occur to elderly people. Studies show that 1 out of 3 adults age 65 and older falls at least once a year. Falls can lead to moderate to severe injuries, such as hip fractures and head traumas, and can even increase the risk of early death. It can also result in psychological problems from fear of falling [1] [2]. Falls are also the leading cause of injury deaths among people 65 and older. Some of these deaths can be prevented with immediate medical attention, and thus a good fall detection system is important.

1.1 Topic Covered

This paper will discuss a suggestion of a fall detection system implemented on a smartphone. The prototype that we will make is tested with Samsung 1-9000 that has the Android 2.2 framework.

It is not in this paper's scope to discuss other methods or ways of fall detection nor fall prevention systems. We just want to show one approach which is with a mobile phone.

1.2 Keywords

fall detection, mobile phone, android, accelerometer

1.3 Why a Smartphone?

We have chosen to implement our system in a smartphone [1][2]. A smartphone is a very powerful device and includes a range of different sensors. The most notable one is the accelerometer. Smartphones are lightweight, highly portable and effectively make our fall detection system *pervasive*. Unlike commercial fall detection devices i.e. the panic button, smartphones can be used both indoors and outdoors. Almost everyone owns a mobile phone and increased popularity of smartphones is also observed. This will enable our system to reach more potential users than if

[1]For the purpose of this study the choice of the term *smartphone* and not *mobile phone* is deliberate. This to make a point that the system we expect to make demands a more powerful platform, i.e. a smartphone, than a traditional mobile phone.

[2]At this point we will not exclude that the system could also be deployable on less powerful mobile phones

the system is developed on a specially made hardware. Implementing the system in a smartphone combines the fall detection part of the system with the communication part, i.e., upon detecting a bad fall the system calls for help either through SMS, phone call, e-mail or combination of all. Further more smartphones offer the possibility of communicating with other devices if needed through e.g. *bluetooth*. Making our system location-aware either by using GPS or W-LAN or both is also feasible. Lastly our chosen OS platform is Android [3]. Applications made for Android can be cheaply made.

There are several different approaches of fall detections in terms of what kind of equipments and set-ups we could use. Using a smartphone with its integrated sensors (accelerometer, gyroscope, etc.) is only one of them. In most cases combining several equipments/sensors results in getting better performance of the developed system. For the purpose of this paper we envision our first system to just focus on plain fall detection. We will however open the idea for further development of the system by using additional device [4]. The possibilities and advantages of using the smartphone as our chosen platform as described in the previous paragraph will still be open although not a part of the first prototype of the system.

[3] `www.android.com`
[4] See section for future work later.

2 Related Work

The basis of this work are from the following scientific articles about exactly fall detection systems on a mobile phone [3], [4], [5] and [6]. The first three articles and their respective research group had the same approach in making a fall detection system - that is using a mobile phone. The mobile phones their system will be lunched on has to have a built-in 3D accelerometer since their system's algorithm is mostly based on acceleration change. Other similarities they have in common is using Android as their application framework. This is because Android is arguably the most developer-friendly operative system for mobile devices. Their UI might be different from each other but they share the same idea of giving their user a simple and easy to use interface. They also launch a service in the background that monitors change in the accelerometer. Based on the algorithm used and threshold levels either predefined or chosen by the user at start, the system will raise an alert that signifies fall. If an alert is raised, a time is given to the user to turn off the alert in case the user does not need any assistance or if it was not a fall after all. Not being able to do so will result in the system sending a SOS message.

So far we have mentioned the similarities and basic framework of these systems. There are however some differences between them. Firstly the exact algorithm for detecting fall and setting-up the appropriate threshold level can be different. Although [3] did not give their exact algorithm for calculating the acceleration change, they still inform of doing so. To make up for *false positives* alerts, i.e. alerts that are falsely triggered, their system also measures the orientation of the user. If the system detects that when a signal pattern matching a fall starts from a vertical position and ends in a horizontal position then it can assume that the fall is real. The assumption is that the user is standing before a fall occurs and lying after it occurs. This adds an additional check for real falls, but ultimately there are other falls that does not match this pattern. The system also offers for the user to adjust the sensitivity level.

In [5] they use Discrete Wavelet Transform for their fall detection algorithm. In addition to this they also implement a Location Manager to the system so that it is aware of the location of the user in case a message is sent asking for assistance. This will be specially useful when the user is unconscious and is unable to confirm his status.

The approach of [4] is much similar to [3], but unlike [3] they give a better explanation on how their algorithm works. They use the following 2 equations: 1. Calculates the total acceleration from both x-, y- and z-axis, 2. Calculates the orientation from the mobile's orientation sensor. Like the previous approach, it assumes that both sudden acceleration/deacceleration and change of body orientation is a sign for fall.

$$|A_T| = \sqrt{|A_X|^2 + |A_Y|^2 + |A_Z|^2}$$

$$|A_V| = |A_X \sin\theta_Z + A_Y \sin\theta_Y - A_Z \cos\theta_Y \cos\theta_Z|.$$

In addition [4] has an additional feature. It offers the user the possibility of using an additional accessory, which in this case is a magnet, for better performance. Like in the previous article, having this extra functionality will give another check for if a fall is real, reducing false positives. What it does is it measures the magnetic field between the mobile phone (granted that it has a magnetic field sensors) and the magnet accessory. When the accessory is placed on the user's left knee while the mobile phone is situated at the user's right pocket it measures a certain magnetic force. This force is different from when the user is doing normal daily activities to when the user has fallen.

Although [6] does not use a mobile phone as it's choice of device, its algorithm results in better performance and less false positives. It also measures the user's body orientation but *also* the transitions that happen in between and not only the start and end position/orientation of the body. It does so by using a gyroscope which is able to measure a body's movement more precisely. A gyroscope together with a tri-axial accelerometer can measure 6 degree freedom of movement - which translates to whatever kind of movement humans can do.

Mobile phones specially smartphones offer a lot more for better enhancement of these systems. Just the possibility of adding additional devices/accessories via bluetooth or IRDA like in [4] gives room for better improvement. The devices being produced now are also becoming more powerful in terms of integrated sensors, processing power and storage space. One can use the integrated microphone for additional sound verification - for example detecting a loud noise from fall impact. This is also true for the camera.

There are other literatures studying how one can accurately measure falls and what other type of approaches we could do in terms of set-up and algorithms. This will be discussed in another report beside this one [7].

3 Suggested Fall Detection System

Our first prototype will follow the framework used by the research groups in chapter 2. One problem of existing systems - also the ones previously mentioned - is that they do not take into account that users of the system might be different from each other. This means that a fall signal from an old person might be different from a fall signal from a younger patient suffering from an epilepsy. Also monitoring a user that has some neuro-degenerative disease and usually stays at home might be different from monitoring a cyclist or a hiker or even just a normal user walking on slippery roads. There is not a good enough study for how many kinds of fall there are and to differentiate between falls done by different group of people. This will all be addressed in [7].

In our prototype we offer users to make their own profile based on their height, weight and age. This way the system will be tailored for each individual. In addition, possible other options like having a disease that has falling as a symptom or side-effect can also be added. This will be in the setup page which will meet the user every time the application is started. Further the user can adjust the sensitivity level of the system depending on how active the user will be on that day or specific time. In the set-up page, the user also registers which persons to contact and how to contact them (SMS, e-mail, phone call, etc.). Finally, a delay timer can be set-up. Automatic location-awareness can also be turned on. In future prototypes where additional accessories might be added and used setting them up will also be part of this page.

After setting up the user profile, the system can then start and run on the background so that the user can use other functionalities of the phone. The system should offer the user a default setting to use if the user forgets or just does not want to set up a profile. Technically, setting up the system should only happen once per user if the user does not need to change its sensitivity level.

Experiments should be conducted to find out what type of thresholds to set up for the different group of users. This is also what is lacking with the previous studies. We feel that there has not been a thorough enough studies in data gathering. Again this will be addressed in [7] - a proper user profiling.

When a fall occurs the system will sound an alert and give the user a time to respond (15 seconds for example) in case the fall was not serious or true after all. If the user does not turn off the alert, the system will call for help.

So far in this prototype, we will use the same algorithm for detecting fall as [4]. This is because this is easy to implement. How we will manage to make this better and the system as a whole will be an ongoing study. What essentially is being monitored are acceleration/deacceleration change and orientation change.

Also at this point we have not done our own experiments to gather sufficient data to set-up threshold levels. This means that we will just rely on the studied research articles and their suggested threshold levels to start with. Also although the prototype offers the users to make their own profile so that it will be tailored specifically for each user, the prototype as of now does not make any difference to any user - so it is only using a default specification. This is again because of lack of data for now.

The design will likely to change in the future as well. For now we just keep a bare minimal design - taking into consideration that targeted platforms are mobile devices with touch screen interfaces.

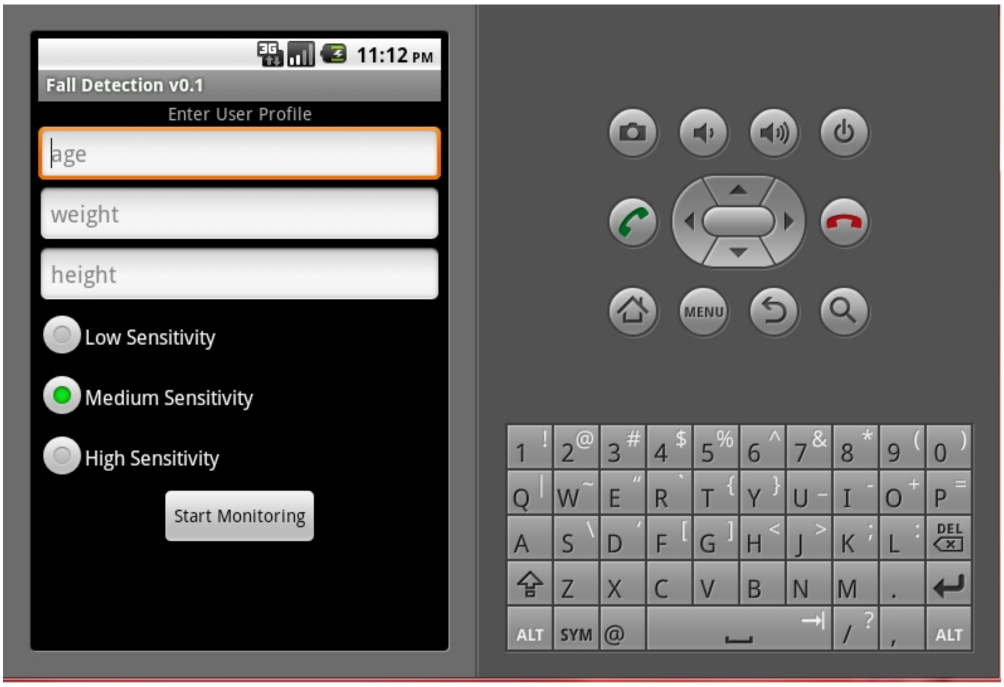

Figure 1: First Prototype

4 Conclusion, Future Work and Author's Notes

The first prototype is not at all complex and hard to implement. It serves as a basis of a bigger study in fall detection system. It does however explain the framework and backbone to which a more robust reliable functioning system will be built upon.

It has been planned that our chosen platform are smartphones but we will not disregard the possibility of deploying the system to be used on normal mobile phones to reach more potential users. The use of Android framework is pretty much decided, but with today's trend of launching application on different OS we will have it on the back of our mind to possibly develop the system in Nokia's Symbian and Apple's iOS as well.

The evaluation of the prototype has also not been done yet. We assume that it is far from complete and gives some false readings. How one does typically evaluate such systems is covered and discussed in [7].

Notes

I got some troubles making and putting up images of the prototype into that is why I only managed to have this one image.

All knowledge in programming come from the course Mobile Phone Programming or else are self-taught.

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