Fall Detection System for the Elderly People using the Earth's Gravity

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Abstract. *On population ageing, the major problems for elderly people are falls. These falls are the primary causes of injury, disability and accidental death. This article presents the development of the fall detection system for elderly people using the earth's gravity. The proposed system uses a built-in accelerometer sensor of the smart phone to detect the older people falls and notify the administrator of the corresponding falls in real time. The earth's gravity is used as a process of making choices by identifying a decision, gathering information, and assessing alternative resolutions. Samples of this research examination, obtained by a purposive sampling technique, were accounted from 30 sample examiners from both elderly and young persons with different weight. The experimental test-rig is a prototype application of fall detection on a smart phone. The statistical principles in terms of average and standard deviation were employed for the analysis. The evaluative results show that the proposed approach is desirable for the elderly people.*

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1. Introduction

On aging society, advanced development of medical terms and public health is higher tendency for increasing senior population; especially, the older people who have health problems such as physical deterioration and ailments, etc. Therefore, the seniors are the specific group of people who need high attentive care [1]. The major obstacles that need to be mentioned are the physical falling of the old people. This ultimately results in either casualties or being paralyzed. The physical falling is directly related to the issue of health in which the failure to spontaneous reaction. Unfortunately, this physical falling will subsequently result in high degree of injuries as well as deaths [2].

Nowadays, there are a number of technological developments regarding the facilitation of the elderly in many aspects. For example, the fall detection system bases on image analysis. The photos are taken from the scene, especially floors with different height/levels and stairs [3]. In addition, the fall detection system bases on image analysis can be notified the patients who cannot get back up after falling when they are alone [4]. This system is to determine the behavior of the elder movement. However the image analysis is not always feasible unless it comes from the surveillance area with the camera. Other disadvantage of this technique is distance. Since the most of undesirable situations are uneven illumination, scaling, rotating, viewpoint changing and other viewing situations etc.

Alternatively, the elderly's fall detection technique with acceleration detector (diagonal axis) is presented. This technique measures the rotating degree without limitation from area and distance as previously mentioned [5]. However, this technique is that it takes a lot of installation space and consumes relatively high power to operate. Therefore, the elderly people suffer from the equipment. Recently, the low power and accelerator sensor technique on the smart phone is proposed. This sensor detects the 3-axes direction [6]. The more change directions result in the high level of 3-axes direction. Therefore, there is the physical falling of the old people. However, this technique is undesirable for standing up slowly, lying down or sitting etc. These activities base on the Earth's gravity.

In this paper, the fall detection system for the elderly people using the Earth's gravity is introduced. The system is on a smart phone with simple human interaction, low power, conveniently portable and the real-time notification.

2. The Proposed Fall Detection System

2.1 System Realization

Fig. 1 shows the proposed fall detection system; where the system is relatively simple based on only three components of the commercial smart phone, i.e., an acceleration sensor, a processor and an alert module.

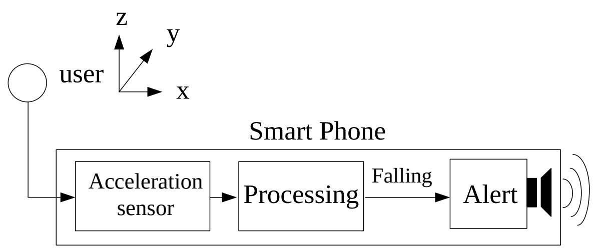

Fig. 1: Proposed system realization of fall detection

This newly developed device depends on the accelerator sensor of the smart phone. This sensor is either increasing or decreasing when moving from one point to another with swiftly changing acceleration. This sensor signifies also the status of bending or the condition of direction and accelerating [6].

The measuring of the 3-axes direction has many applications including automatic change of phone's screening result, shaking of cell phone for shuffling through songs, change from hibernation mode to working mode caused by small vibration and the newly developed application for measuring acceleration in horizontal axis during physical movement [7]. However, the use of 3-axes direction is undesirable for fall detection. Since, these directions cannot classify the fall and other activities such as stand up slowly, lying down or sitting etc. These activities base on the Earth's gravity.

Normally, the Newton's second law states that the rate of changing momentum of a body over time is directly proportional to the force applied, and occurs in the same direction of the applied force. For objects and systems with constant mass, the second law can be re-stated in terms of an object's acceleration. Therefore, the physical falling of the old people can be also an object's acceleration over the Earth's gravity [7]. This data acceleration is the input of processor to decision and alert.

2.2 Application Realization

As mention earlier, the physical falling of the old people can be also an object's acceleration over the Earth's gravity. Therefore, the application realization is design and

Fig. 2 : Proposed application realization of fall detection

development of the elderly's fall detection by the object's acceleration. The reference acceleration is Earth's gravity. The fall criteria are an object's acceleration greater than Earth's gravity (9.80665 m/s^2). The application is in order to facilitate the elderly whenever the accidents take place with immediate response action. The simple process of application realization for all detection is described as follow:

Step 1: Read the data values from the accelerator sensor on smart phone. These data are the value of the 3-axes direction.
Step 2: Determine the acceleration. This acceleration can be determined by simple equation.
Step 3: Comparison between the acceleration and Earth's gravity. If the acceleration is less than Earth's gravity then go to step 1.
Step 4: Event records and real time notify.

Fig. 2 shows proposed application realization of fall detection where the application is simple human interaction, low power, conveniently portable and the real-time notification. It is relatively simple based on three screens, i.e. start screen, evident screen and report screen. Firstly, the start screen consists of storage system, reset button and stop alerting, emergency button, check gravity button and log out. Secondly, the evident screen consisted of detection of falls among the elderly, previous menu button and gravitational button. Finally, the report screen consisted of the failure elderly name, previous menu button, presented status, status in text format, gravity values and back button.

2.3 Functional Testing

The proposed fall detection system for the elderly people using the Earth's gravity was tested by the sample of 30 in the Surin Technical College, Surin province, Thailand. Fig. 3 illustrates the selected group of populations for this testing. Samples of this testing, obtained by a purposive sampling technique. These samples were the people who had different weight. There were three main criteria of the functional testing. The first criteria included standing and falling rapidly on the mattress in the whole body manner and put in an order the amount of weight of sample groups from the lowest to the highest. The second criteria includes sitting and falling rapidly on the mattress in the whole body manner and put in an order the amount of weight of sample groups from the lowest to the highest. Finally, the third criteria included standing and jumping rapidly on the mattress in the whole body manner and put in an order the amount of weight of sample groups from the lowest to the highest.

As mention earlier, the fall detection of an elderly on smart phone selected the groups of sampled participants from the seniors to the person with difference in weight, total of 30 people. The data from functional testing were analyzed and processed for results to determine efficiency of the detection system through use of the smart phone.

3. Experimental Results

3.1 Experimental Setup

Fig. 1 shows the proposed system realization of fall The selected group of population.

Fig. 3: the selected group of population for functional testing in this research

1) The experimental results of the elderly's fall by method of earth gravity had the final outcome in the measurement of gravity taking place and stopping immediately during short span of time in order to determine the condition of falling in the elderly and simultaneously sending out alerts for further help whenever the fall happens. The final results as follows:

Fig. 4: Testing of system where the elderly or average person stand and fall rapidly on the mattress in a whole body fashion

Fig. 5: Testing of alerting system where the elderly or average person stand and fall rapidly on the mattress in a whole body fashion

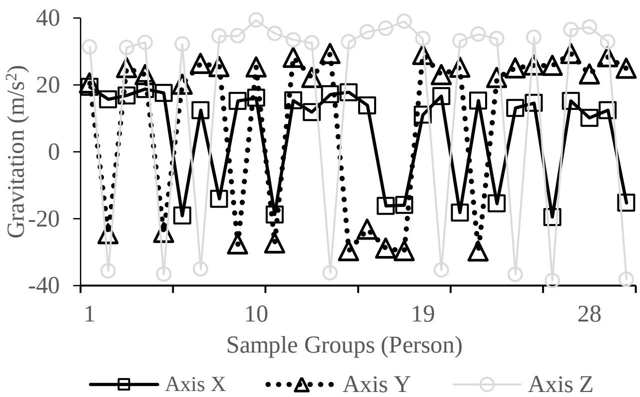

Fig. 6: Experimental results obtained from the first functional testing

From the first experiment, by the method of having the elderly and average person stand and fall on the mattress with a swift manner with the whole body, suggests that out of 20 males and 10 females taking the test with age's allocation in three intervals; 16-25 years old, 26-30 and more than 30 years old had the x-axis gravitational value of 5.7 m/s^2, y-axis equals 9.11 m/s^2 and z-value equivalent to 16.08 m/s^2. Average value of all three axes was equivalent to 10.59 m/s^2.

2) The experimental results of the elderly's fall detection system by means of gravitational value measurement, Second Time, where the elderly and average weighted persons were asked to stand and sit in an immediate manner, which had the results as follows:

Fig. 7: Testing of system where the elderly or average person stand and sit rapidly on the mattress in a whole body fashion

Fig. 8: Testing of alerting system where the elderly or average person stand and sit rapidly on the mattress in a whole body fashion

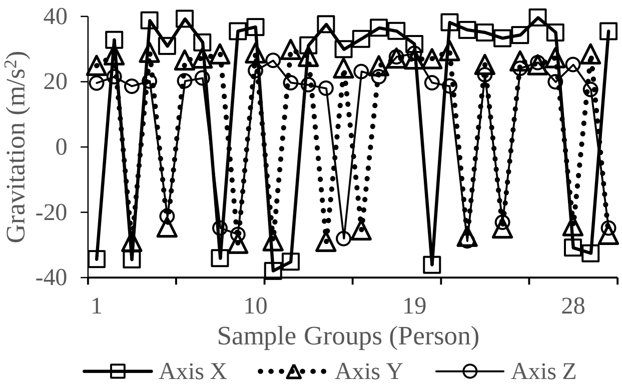

Fig. 9: Experimental results obtained from the second functional testing

From the second experiment, by the method of having the elderly and average weighted persons stand and sit on the mattress with a swift manner with the whole body, suggests that out of 20 males and 10 females taking the test with age's allocation in three intervals; 16-25 years old, 26-30 and more than 30 years old had the x-axis gravitational value of 16.8 m/s^2, y-axis equals 9.61 m/s^2 and z-value equivalent to 11.07 m/s^2. Average value of all three axes was equivalent to 12.51 m/s^2.

3) The experimental results of the elderly's fall detection system by means of gravitational value measurement, Third Time, where the elderly and average person are asked to stand and jump in an immediate manner has the results as follow:

Fig.10: Testing of system where the elderly or average person stand and jump rapidly on the mattress in a whole body fashion

Fig. 11: Testing of alerting system where the elderly or average person stand and jump rapidly on the mattress in a whole body fashion

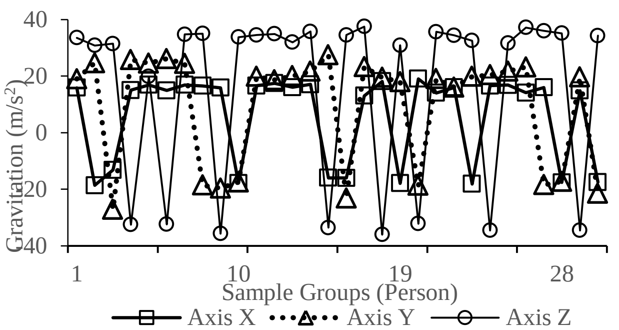

Fig. 12: Experimental results obtained from the second functional testing

From the third experiment, by the method of having the elderly and average person stand and jump on the mattress with a swift manner with the whole body, suggested that out of 20 males and 10 females taking the test with age's allocation in three intervals; 16-25 years old, 26-30 and more than 30 years old had the x-axis gravitational value of 6.46 m/s^2, y-axis equals 9.35 m/s^2 and z-value equivalent to 15.95 m/s^2. Average value of all three axes was equivalent to 10.59 m/s^2.

Experiment	Average Value	Standard Deviation
1	10.59	6.79
2	12.51	4.33
3	10.59	6.20

Table 1 Average value of experimental results for fall detection of elderly

From the experimental results, the findings suggested that the gravity value was dependent on the characteristics of the accident when the elderly persons encounter the fall. Therefore, the researchers had measured the cavity and all three axes in order to eliminate the limitation of the smart phones' position. From the experiment, it consisted of 20 males and 10 females taking the test with age's allocation in three intervals; 16-25 years old, 26-30 and more than 30 years old had the mean x-axis gravitational value of 10.59 m/s2, mean y-axis equals 12.51 m/s^2 and mean z-value equivalent to 12.51 m/s^2. Average value of all three axes was equivalent to 10.59 m/s^2. From their evaluation of body mass index (BMI) which affected the falling of the elderly persons through the use of earth's gravity [9].

BMI/ Gravity	Gravity	Below Standard	Normal	Over weight	Fat	Obesity
Gravity	1	0.201	-0.225	-0.463	-0.603	0.901
Below Standard		1	-0.576	-0.448	-0.491	0.637
Normal			1	0.272	0.839	-0.638
Over weight				1	0.164	-0.123
Fat					1	-0.463
Obesity						1

Table 2 coefficient values between body mass index and gravity

From the table, it is found at the coefficient number between gravity and body mass index below standard, gravity and body mass index at standard level, gravity and body mass index above standard, gravity and body mass index for overweight and gravity and body mass index for obesity had no significant value or any direct correlation between the two values. Thus, the level of body mass index had no correlation with number of earth's gravity for the reason that gravity which happened and stopped immediately was dependent on the behavior of falling body of the elderly or accident which took place during that period of time. The result of alerting system for the elderly's fall detection through the use of gravity could be drawn the conclusions from all the 3 functional tests; The first experiment had the elderly and average weighted persons stand and fall on the mattress in an immediate action with the whole body, the second experiment had the elderly and average weighted persons sit and fall on the mattress in an immediate manner and experiment three has the elderly and average weighted persons stand and jump on the mattress in an immediate action. Throughout the whole experiment there was a notification of alerting system as the below table [4].

Experiment	Alerts/ Time	Percentage	No Alerts/ Time	Percentage
1	29	96.67	1	3.33
2	28	93.33	2	6.67
3	30	100	-	0

Table 3 Summarized number of alert notifications for elderly's fall detection system

From Table 3, the system had detected the falling of the elderly, 29 alert notifications, in the first experiment one, with one no alert. The alert is calculated to be 96.67% and no alert 3.33%. The second experiment had 28 alert notifications and two no alerts, accounting for 93.33% and 6.67% for no alerts. The third experiment has the total of 30 alert notifications, calculated to be 100%. This is thus concluded that characteristics of elder's fall were dependent on the condition of the accident which took place and stopped immediately in the short span of time.

4. Conclusions

1. From the experiment of alert efficiency, system has detected the falling of the elderly, 29 alert notifications, in the first experiment one with one no alert. The alert was calculated to be 96.67% and no alert 3.33%. The second experiment had 28 alert notifications with two no alerts, accounting for 93.33% and 6.67% for no alerts. The third experiment had the total of 30 alert notifications, calculated to be 100%. This is thus concluded that characteristic of elder's fall depends on the condition of the accident which took place and stopped immediately in the short span of time. Whenever an elderly suffers from the fall accident, it can be suggested that, Alert notification can be made in order to inform as associated persons.

2. From the experimental results, the findings suggest that this gravity value was dependent on the characteristics of the accidents when the elderly encountered the fall. Therefore, the researchers had measured the cavity and all three axes in order to eliminate the limitation of the smartphones' position. From the experiment, there were 20 males and 10 females taking the test with age's allocation in three intervals; 16-25 years old, 26-30 and more than 30 years old had the mean x-axis gravitational value of 10.59 m/s^2, mean y-axis equals 12.51 m/s^2 and mean z-value equivalent to 12.51 m/s^2. Average value of all three axes was equivalent to 10.59 m/s^2, while the average of all age intervals was equal to 11.23 m/s^2.

3. It is found that coefficient number between gravity and body mass index below standard, gravity and body mass index at standard level, gravity and body mass index above standard, gravity and body mass index for overweight and gravity and body mass index for obesity had no significant value or any direct correlation between the two values. Thus, the level of body mass index had no correlation with number of earth's gravity for the reason that gravity which happened and stopped immediately was dependent on the behavior of the falling body of the elderly persons or accident which take place during that period of time.

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Biographies

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