ELMOS "Elderly Health Monitor System" as An Android Smartphone-Based Elderly Health Monitor Service

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Abstract

Elderly Health Monitor system named ELMOS as an android smartphone-based elderly health monitor service is essential in preventing elderly health problems, as well as providing a framework or basis for maintaining health awareness. This device comes with three functions which are sensing body temperature, heart rate and fall detection using Arduino. DS18B20 is used for the sense of body temperature. Body temperature could be a basic parameter for monitoring and identification human health. Heartbeat sensor was used for sensing heart rate. Accelerometer MPU 6050 was used to detect a senior citizen falling in real-time and to use the bluetooth communication to notify the administrator of such an event. *As a result, we found that the system can be used to measure physiological parameters, such as* body temperature, heart rate and fall detection.
Keywords: health, elderly, health monitor, *service, android*

1. Introduction

1.1 Background

The number of elderly people in Indonesia will soar in 2030. At that time, one of the seven Indonesian population aged more than 60 years. Despite having several risks, a surge of elderly people that had not been anticipated. This recent, we are starting to enter an aging population period where there is an increase in life expectancy followed by an increase in the number of elderly people. Indonesia experienced an increase in the number of elderly people from 18 million (7, 56%) in 2010, to 25, 9 million (9.7%), in 2019, and is expected to continue to increase to 48.2 million persons (15.77%) by 2035 (Badan Pusat Statistik , 2015).
The changes that occur in the elderly makes them more at risk to occur less attention to the elderly. Changes in the physical, biological and psychological disorders can cause physical or mental harm to them. The body becomes weak, susceptible to disease, anxiety, depression, reduced income. At the family who still adheres to the culture and put the elderly as a highly respected and appreciated, Assuming that the lack of attention to the elderly is considered as an act of unusual (Darmojo, 1999) .
Elderly people who live independently are exposed to a higher risk of falls. Besides that, fallingdown sometimes could cause a psychological and physiological injury that cause severe injury and even death if medical attention is not provided immediately. To reduce the risk of elderly people getting harm from fall, medical attention needs to be provided immediately.
Therefore, a reliable fall detection system will facilitate detect falls in older individuals and call the closest aid service to facilitate and support. The fall detection system has to be compelled to be user-friendly which suggests it's easier to be employed by the elderly people. The system additionally should not interfere and disturb activities of daily living (ADL) of elderly people. The system needs to be cost-effective and durable.

1.2 Problem Statement

In today's world, the use of wireless technology is being enhanced to meet the needs of remote control and monitoring. Remote patient monitoring (RPM) is a technology that helps us monitor elderly people even when the patient is not in the clinic or hospital. This can increase access to health services and facilities while reducing costs. Remote Patient Monitoring saves parents and doctors time, thereby increasing the efficiency and reliability of health services. Heart rate and body temperature are the main signs that are routinely measured by doctors after the arrival of the elderly.

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Elders who live independently have a high risk of falling and hurting themselves. Falling and becoming unconscious can be fatal because no one is aware of this falling event that can cause the faller to suffer a more severe injury. It is important to have a quick response and rescue time if a fall event occurs. There are several technologies out there to help detect falls in older people. One fall detection system uses a webcam to monitor the activity of elderly people and detect falls.
However, installation and operation costs are expensive and only applies to indoor environments. Currently available commercial fall detection systems require users to wear wireless emergency transmitters such as pendants, necklaces, or bracelets. There are some drawbacks to the device that can be used where elderly people tend to forget to use the device or cannot activate it after they become unconscious. Therefore, there is a need for devices that can monitor heart rate, body temperature and detect falling signals and send help automatically without pressing a button.

2. Material and Methods

This project was divided into 4 stages namely study of literature, system design and model, collection of tool and material, and tool making. By splitting into 4 different stages, the flow of the project was more organized and systematic.

2.1. Study of Literature

Heartbeat ,body temperature and falling down are the major medical problems that faced by the elderly people. Heart rate refers to how many times a heart contracts and relaxes in a unit of time (usually per minute). Heart rate varies for different age groups. For a human adult of age 18 or more years, a normal resting heart rate is around 72 beats per minute (bpm). If the heart rate is lower than the normal heart rate, it is an indication of a condition known as bradycardia and if the heart rate is higher than the normal heart rate, it is an indication of a condition known as tachycardia.
Like heart rate, normal body temperature also varies from person to person and changes throughout the day. The body temperature is lowest in the early morning and highest in the early evening. The normal body temperature is about 37° C or 98.6 ° F. However, it can be as low as 36.1° C (97°F) in the early morning and as high as 37.2° C (99° F) and still be considered normal. Thus, the normal range for body temperature is 97 to 100 degrees Fahrenheit or 36.1 to 37.8 degrees Celsius. Temperature can be measured by using different types of sensors. These sensors come in different forms such as thermocouples, thermistors, resistance temperature detectors (RTD), and integrated circuit (IC) sensors
The consequences of falling may be fatal if there is no immediate medical attention provided. Hiring nurse and caregivers may be the best option to constantly monitor and support activities of daily living (ADL) of elderly people, but the cost would be very expensive. Moreover, it is difficult for the caregivers to constantly observe and assist elderly people all the time. Falling event among the elderly people may occur when the caregivers are not around to supervise which lead to the issue of reliability. Therefore, an intelligent fall detection system that is reliable and cost effective must be considered as an option to assist elderly people all the time. Falling event among the elderly people may occur when the caregivers are not around to supervise which lead to the issue of reliability. Therefore, an elderly health monitoring system that can reliably monitor heart rate, body temperature and smart fall detection should be an option to assist elderly people.
Some previous studies regarding this project are as follows : first, research about System Architecture Of A Wireless Body Area Sensor Network For Ubiquitous Health Monitoring. Recent technological advances in sensors, low-power microelectronics and miniaturization, and wireless networking enabled the design and proliferation of wireless sensor networks capable of autonomously monitoring and controlling environments. One of the most promising applications of sensor networks is for human health monitoring. A number of tiny wireless sensors, strategically placed on the human body, create a wireless body area network that can monitor various vital signs, providing real-time feedback to the user and medical personnel. The wireless body area networks promise to revolutionize health monitoring. However, designers of such systems face a number of challenging tasks, as they need to address often quite conflicting requirements for size, operating time, precision, and reliability. In this paper we present hardware and software architecture of a working wireless sensor network system for ambulatory health status monitoring. The system consists of multiple sensor nodes that monitor body motion and heart activity, a network coordinator, and a personal server running on a personal digital assistant or a personal computer (Otto, Milenković, Sanders, & Jovano, 2005).

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Further research about Heart Rate Monitoring System Using Finger Tip Through Arduino and Processing Software . This research provided systematic evidence of Biomedical engineering (BME) combines the design and problem solving skill of engineering with medical and biological sciences to improve patient's health care and the quality of life of individuals. Cardiovascular disease is one of the major causes of untimely deaths in world, heart beat readings are by far the only viable diagnostic tool that could promote early detection of cardiac events.By using this we can measure ones heart rate through fingertip.This paper focuses on the heart rate monitoring and alert which is able to monitor the heart beat rate condition of patient. The system determines the heart beat rate per minute and then sends short message service (SMS) alert to the mobile phone. It is portable and cost effective. It is a very efficient system and very easy to handle and thus provides great flexibility and serves as a great improvement over other conventional monitoring and alert systems. (Mallick & Patro, 2016)

Further research about LabVIEW based Abnormal Muscular Movement and Fall Detection using MEMS Accelerometer during the Occurrence of Seizure .The manifestation of seizure in patients can be in the form of abnormal muscular movement occurring at the extremities and it can cause sudden fall to the patients which can lead to injuries. MEMS accelerometer MPU6050 is used to acquire the signals from the extremities to detect abnormal movements and sudden fall. The signals are received through an interfacing device named Arduino Uno and are processed using LabVIEW software. The Wavelet transform is used for detecting the changes in movement of the extremity and a thresholding technique is used for seizure detection and fall detection. Once a seizure or fall is detected then a message is sent to the caretaker through GSM. MEMS sensor MPU6050 proves to be an effective tool for detection of seizure. It is more compact and easy to fx in the extremities. Te cost of the components used is also economical. It can be made wireless and designed in the form of wrist watches. Wavelet transform is an effective time frequency domain analysis tool which gives a faster response when compared to STFT. Tresholding is the major concept used in this work. Activity detection, fall detection and seizure detection are all based on Tresholding technique. In activity detection the value of the wavelet coefcient is considered. If the wavelet coeffcient exceeds a threshold limit it is considered as activity. Fall is detected by fxing a threshold of the difference between the present and past sample. Seizure is detected by calculating the mode of the frequency of the signal that is obtained from the sensor. If the mode value falls within in a certain range and remains in the range for certain amount of time then it is considered to be a seizure. When fall or seizure is detected a message is passed to the care taker through GSM. (Prince, Hemamalini, & Rajkumar, ad, 2014)

Other research discusses A GPRS-based Wrist Type Pulse Wave and Body Temperature Monitor for Children Healthcare . A GPRS-based wrist type pulse wave and body temperature monitor for children healthcare is presented in the article. The device, which detect the pulse wave signal and temperature signal of children and send the data to the server as well as the cell phone of their parents, enable the parents to find out their children's conditions in real time. The device has the advantages of high stability, wearable, low power consumption, high anti-jamming ability and seldom region limit because of GPRS. Conclusion of this journal we can easily tell that the wrist type monitor has reached our prearranged goals. The new monitor fully makes use of GPRS network so the cost of the device has been decreased significantly. With the help of the novel monitor faced to children, the present condition of children healthcare will have been improved increasingly. In addition, children are accessible to the proper help when they are suffered from some kind of accidents or sickness. As more and more attention will give to the fitness and security of children, the product would have a brilliant future definitely. (Chen, Han, Wu, Wu, & Zhou, 2008)

The last study discusses the Wireless Patch Sensor for Remote Monitoring of Heart Rate, Respiration, Activity, and Falls . Unobtrusive continuous monitoring of important vital signs and activity metrics has the potential to provide remote health monitoring, at-home screening, and rapid notification of critical events such as heart attacks, falls, or respiratory distress. This paper contains validation results of a wireless Bluetooth Low Energy (BLE) patch sensor consisting of two electrocardiography (ECG) electrodes, a microcontroller, a tri-axial accelerometer, and a BLE transceiver. The sensor measures heart rate, heart rate variability (HRV), respiratory rate, posture, steps, and falls and was evaluated on a total of 25 adult participants who performed breathing exercises, activities of daily living (ADLs), various stretches, stationary cycling, walking/running, and simulated falls. Compared to reference devices, the heart rate measurement had a mean absolute error (MAE) of less than 2 bpm, time-domain HRV measurements had an RMS error of less than 15 ms, respiratory rate had an MAE of 1.1 breaths per minute during metronome breathing, posture detection had an accuracy of over 95% in two of the three patch locations, steps were counted with an absolute error of less than 5%, and falls we. Conclusion of this journal, we have demonstrated that a small wireless patch sensor allows for robust

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acquisition, recording, and transmission of a number of important vital sign and activity measurements. These measurements are of comparable accuracy to those made by traditional, larger medical devices. All three tested locations demonstrated accurate measurement of many physiological and activity parameters. The unobtrusive form-factor enables continuous monitoring of heart rate and HRV, while the accelerometer facilitates detection of posture, steps, and falls. Fusion of both ECG-derived features and accelerometry provides an accurate measurement of respiratory rate. It may be possible to apply this type of sensor fusion to the measurement of other types of health and activity information such as energy expenditure, psychological stress, and sleep-related information. The advancing age of the world population makes remote monitoring an important technology for preventive care and rapid response to critical events. The minimalist form-factor of the patch design enables long-term, unobtrusive wear of such a sensor, and the rapid expansion of wireless connectivity over the last several years makes possible the continuous, real-time streaming of important health information to caregivers or healthcare professionals. Finally, while a wireless patch device like the one described here facilitates longterm remote monitoring of important vital signs and activity metrics, it is important to note that such a device must be easy to use if it is to be widely adopted and useful. (Alexander M. Chan, Ferdosi, & Narasimhan, 2013)

2.2. System Design and Model

System design and model is a tool design stage of the system that monitors the health of the elderly, starting from design planning tools, and materials used as well as the concept of the program.
a. System Block Diagram

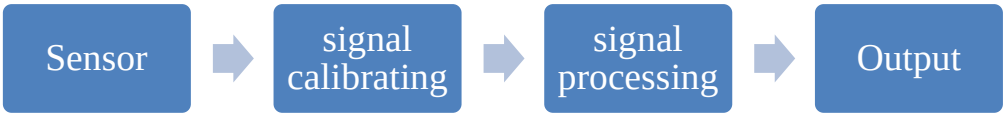

Figure 1. System block diagram

b. Details of system components

- Sensor body information here as detection of temperature, humidity, heart rate and elevation position where the elderly are.
- Calibration or signal conditioning have a function to provide commands to the microcontroller in the form of Arduino Pro Mini to process data from the sensor.
- The signal processing have a function to process data from sensors such as temperature, humidity, heart rate and elevation position where the elderly are.
- The output of the command given HC05 microcontroller to the Bluetooth module sends data to the sensor readings to an Android smartphone.

1.1 Collection of Tools and Materials

Tools and materials required in the manufacture of Elmos technology "Elderly Health Monitor System" As an Integrated Health Service Monitor Android Smartphone To Prevent Health Problems In Elderly are as follows:

Materials used are:
1. Module DPS 310
2. Arduino Pro Mini
3. Pulse Sensor
4. Bluetooth Module HC05

Tools used:
1. Screwdriver
2. Solder
3. toolset
4. Handbook Microcontroller
5. Android Smartphone

1.2 Toolmaking

All tools and materials are prepared and made a picture. Here are the details:

1) **Creating design technology**

The design of technology Elmos "Elderly Health Monitor System" As an Integrated Health Service Monitor For Android Smartphones Prevent Health Problems In Elderly using SketchUp software and

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Fritzing to determine the design of the tool as well as the layout of the electronic components used, shown in Figure 2.

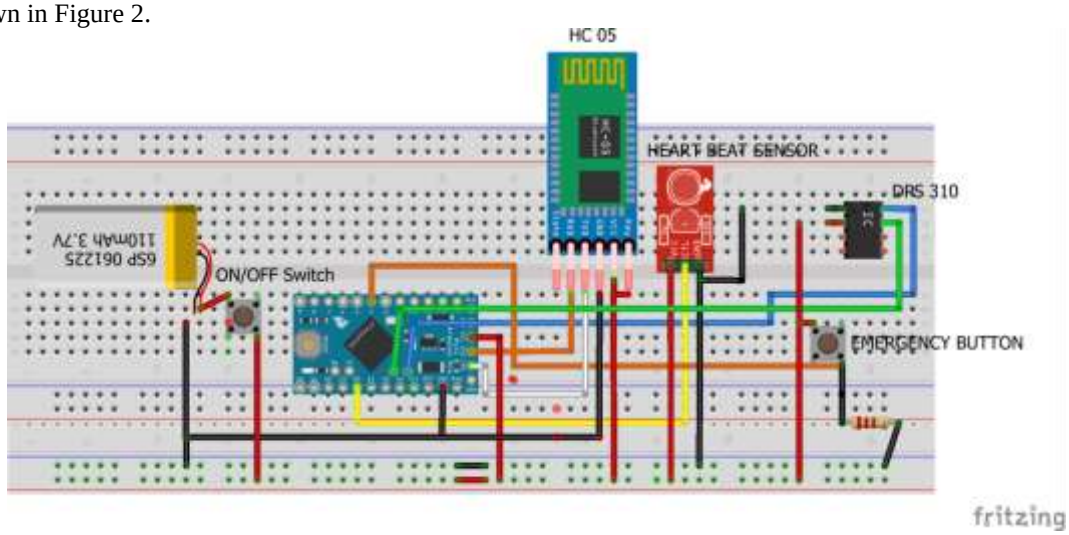

Figure 2. Electronic circuit Elmos

2) **implementation of the Program**

From the description of the problems and objectives, then executed the manufacture Elmos for Elderly prevent health problems in a simple, safe, practical and effective..

3. Results and Discussion

Elderly (seniors) is the final stage in human life. Man who entered this stage characterized by decreasing the body's ability to work as a result of the function of body's organs is decreased or changed. It will cause a lot of problems especially regarding to the health monitoring and prevention of elderly in this era of globalization. This problem encourages the people to create an innovation as the elderly service and monitor. That is health monitoring services Elmos "Elderly Health Monitor System" as an integrated elderly health monitoring services android smartphone to prevent elderly health problem.

Figure 3 .Elderly Health Monitor System (ELMOS)

Initial testing in the form of initial tests of the sensors and modules. Then determined flaws or imperfections of the model. It also carried out tests on the accuracy of the sensor readings. Data evaluation during the initial trials used as a reference for the refinement tools. The minor executions in the form of assembly and installation of the prototype external fittings will be done at this stage after check the stability, shape and it can be sure that the tool is safe, effective, and functional.

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3.1 Device Positioning

The positioning of the health monitor system plays an important role in this project.Correct placement of the device will increase the reliability of the fall detection system.Currently commercialized health monitor systems available are in the form of pendant and wristband. Table 1 shows the advantages and disadvantages for using pendant and wristband

Table 1. Comparison between pendant and wristband

	Pendant	Wristband
Advantages	• Easy to wear and remove	• Easy to reach • Easy to wear and remove
Disadvantages	• Affect daily life activities • High false alarm rate due to device swinging	• High false alarm rate due to frequent hand movement

Both pendant and wristband has a high false alarm rate due to movement during performing daily life activities although they are easy to wear and remove. Therefore, in this project, the proposed method to be used is a wrist strap. The advantage of this wrist strap is that it can reduce false alarm rate due to less movement from upper arm. Besides that, it's also easy to wear and remove especially for the elderly people and patients.

Figure 4. Wrist Strap

3.2 Heart rate

Pulse Heart Rate Sensor is a heart rate sensor. This sensors is able to detect the pulse on the index finger of the hand by combining data pulse sensor to the microcontroller program, it obtained the value of bpm Heart rate itself as heart rate per unit of time, typically expressed in beats per minute (bpm).

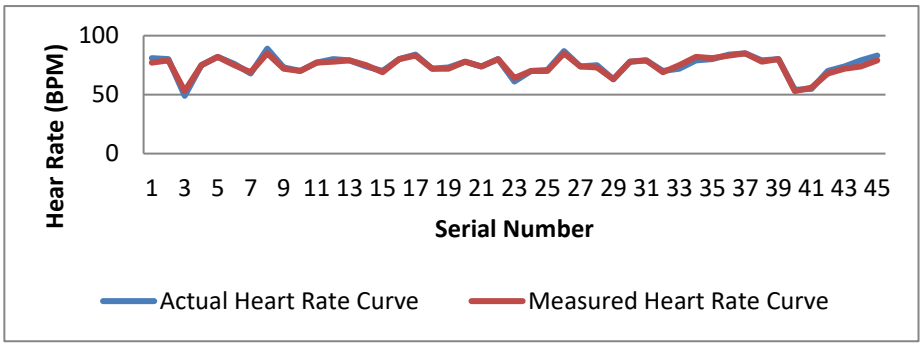

Figure 5.Curves for heart rate actual vs. measured

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Figure 5 shows the double curve where the red curve shows the measurement of heart rate and the blue curve shows the actual heartbeat for some practical data. We see that there is a bit difference between the two curves in a double curve which reflects that the error is low.

3.3 Body temperature

Sensor DS18B20 is a digital sensor which has an internal 12-bit ADC. It is very precise, because if there is 5volt voltage reference, then due to changes in temperature, it is able to feel the smallest change by 5 / (212-1) = 0.0012 Volt, In the temperature range of -10 to +85 degrees Celsius, this sensor has an accuracy of +/- 0.5 degrees. The sensor works by using a communication protocol 1-wire (one-wire).

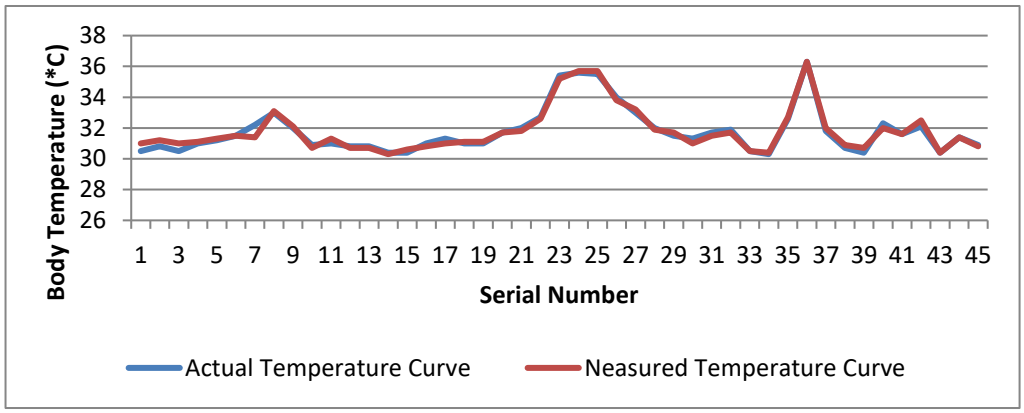

Figure 6. Curve to actual vs. body temperature measured

Figure 6 shows the double curve, the red curve shows the measument of temperature and the blue curve shows the actual body temperature for several practical data. We see that there is a bit difference between the two curves in a double curve which reflects that the error is low.

3.4 Fall detection

The kinematic based method is best to detect fall signal. The system is inexpensive because there is no requirement for installation. The user can freely perform activities of daily living (ADL) while being monitored without concerning about privacy either indoor or outdoor environment. However, this method utilized accelerometer and gyroscope which are sensitive to movement. This may cause a few false alarms while the user is performing ADL (sitting down quickly).As for this project, the fall detection device is attached to a person body using wrist strap. This method is based on kinematic technique which utilized accelerometer.

Fall detection and Arduino-based warning systems will continuously monitor the amount of user acceleration. The component used to measure acceleration is the MPU 6050 Accelerometer. Because the algorithm can measure acceleration in three axes, the algorithm used only focuses on the total acceleration even in the direction using the following formula:

$$\text{Sum of Vector Acceleration } = \sqrt{x^2 + y^2 + z^2}$$

Where x, y and z are the magnitude of the acceleration in their respective directions. When the magnitude of the acceleration is higher than the threshold, the microcontroller will translate these signals as falling conditions.

Few experiments were conducted by using MPU 6050 Accelerometer as the data collector for acceleration while performing daily life activities and falling scenarios. In order to obtain the data, the author is required to demonstrate some of the common fall motions while wearing the accelerometer sensor.

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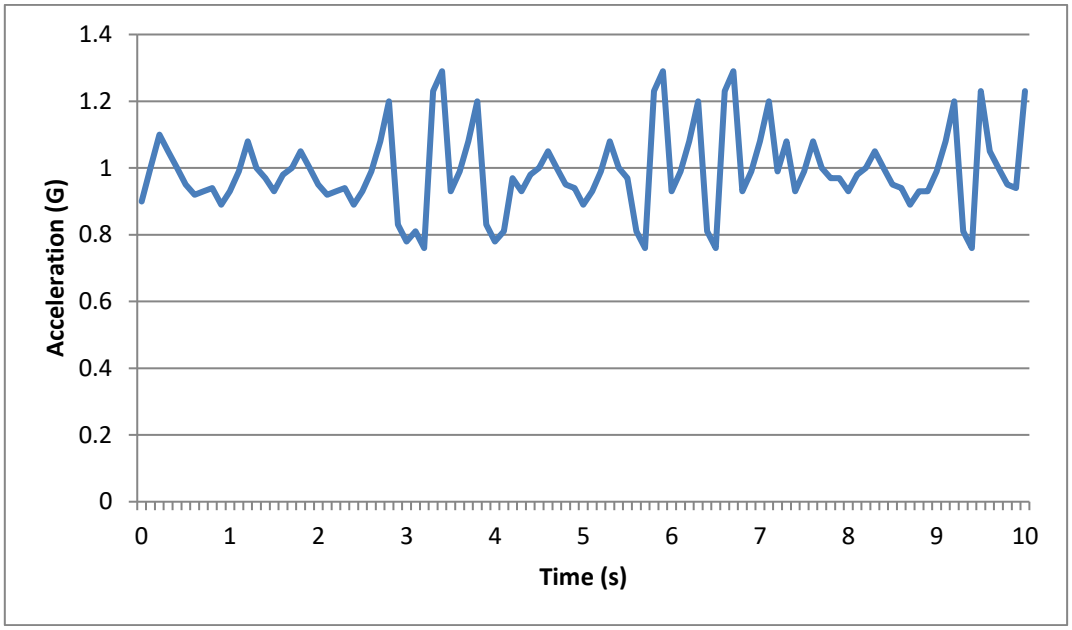

Figure 7. Walk

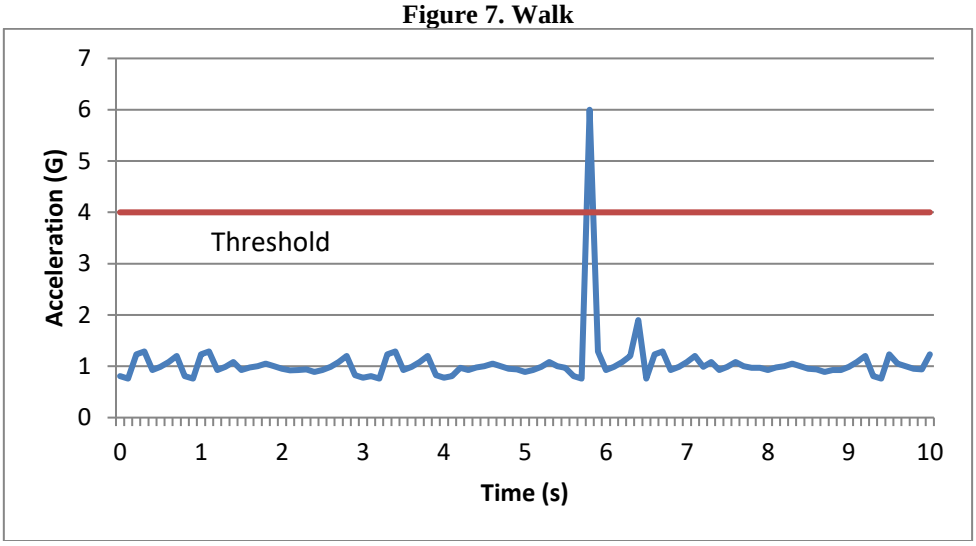

Figure 8. Genesis fall

SVM peak value (denoted by P), mostly falling SVM has a value higher than the daily activities as shown in Figure 8 , thus the peak value of SVM is a good choice in designing algorithms detection. Figure 7 shows that the waveforms run out to find that the peak value of the SVM daily activity is lower than a certain threshold. Consequently, it can detect a fall in total but there are still some faults in readings the fall.

3.5 Performance

It is important for the fall detection system to be reliable in order to detect a fall experienced by the user. Therefore, a performance evaluation was conducted in order to test the reliability of the system. There are four possible outcomes from the reliability test:

- True Positive (TP) : System able to detect it when a fall occurred.
- False Positive (FP) : System detect a fall, but it didn't happen.
- True Negative (TN) :System doesn't detect fall when it didn't happen.
- False Negative (FN) : System doesn't detect fall when it happens.

There are total number of 25 falling down motion which consists of falling backward,falling forward and falling sideway are demonstrated during this reliability test. Besides that, the user also performed 25

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activities of daily life (ADL) which includes walking, running, sitting and laying. The result were shown in Table 2

Table 2 . Activity vs System's detection

		Activity	
		FALL	ADL
System's detection	FALL	22(TP)	3(FP)
	ADL	3(FN)	22(TN)

In order to evaluate these four scenarios, there are two criteria proposed which are:

- Sensitivity: It is capability to detect fall.

$$Sensitivity = \frac{TP}{TP+FN}$$

- Specificity: It is the capability to detect only a fall.

$$Specivity = \frac{TN}{TN+FP}$$

By using the above formulas, the sensitivity and specificity of the fall detection system can be calculated

- $Sensitivity = \frac{22}{22+3} \times 100\%$

$$Sensitivity = 88\ \%$$

- $Sensitivity = \frac{22}{22+3} \times 100\%$

$$Sensitivity = 88\ \%$$

Based on above calculations, it is concluded that the sensitivity and specificity of the fall detection system are *88* % and *88* % respectively. This means that *88* % of the falls was detected and ADL was properly classified. This test shown that the fall detection system is reliable in detecting a fall down.

4. Conclusions

As for this project, the elderly health monitor system device is attached to a person body using a wrist strap. This method is based on a kinematic technique that utilized an accelerometer. Besides that, this project included a heartbeat and body temperature monitoring. The device has the sensitivity and specificity of 88% and 88% respectively. This shows that the health monitor system is reliable in monitoring heartbeat, body temperature, and fall detection.

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