Fall detecting clothes in realtime based seniors full body motion capture system using multiple inertial sensors

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Abstract. The physical ability of the elderly will decrease along with the aging process, thus increasing the potential for falls. An elderly person who has experienced a fall and is not detected for a long time will bring many possible consequences. Early detection of an elderly fall will help to minimize this possibility by reducing the time between the occurrence of an event and the arrival of medical assistance. The purpose of this research is to build a Fall Detecting Clothes in Realtime Based Art Full Body Motion Capture System Using Multiple Inertial Sensors. This system builds by Waterfall methodology where every research step is done in sequence, start from analysis, design, coding, testing. Testing methodology is black box, which is a test every feature function. The Fall Detecting Clothes in Real Time Based Systems Full Body Motion Capture System Using Multiple Inertial Sensors has been tested using black testing box with the results of all feature functions working properly. The system has been tested with several conditions with the results of all controls and output data works properly as well.

1. Introduction
Worldwide, the growth of the elderly population is very fast compared to other age groups. Elderly belongs to the fastest growing population group in the world. The population is expected to double from 606 million to 1.2 billion in the next half century [1]. According to the UN report in 2011, in 2000 the elderly population reached 7% of the world's population and is expected to increase to 28.68% in 2045 [2].

The physical ability of the elderly will decrease along with the aging process, thus increasing the potential for falls. An elderly person who has experienced a fall and is not detected for a long time will bring many possible consequences. Early detection of an elderly fall will help to minimize this possibility by reducing the time between medical events and the arrival of help [3]. Incidence of falls in the elderly can result in physical impact (most frequent head injury) and physiological effects (fear of falling). If emergency treatment arrives late, falling injuries can result in disability, paralysis, and even death [4]. Based on a survey in the United States, around 30% of elderly people over 65 years of age experience falls. Half of these numbers occur repeatedly. Falling incidence experienced by Americans in the age group of more than 65 years was recorded as many as 1800 incidents per year which caused death [5].

In the current era of globalization requires humans to be busy working to fulfill their needs. As a result, time for supervision and assistance to the elderly is very minimal. Fall detection technology is currently being developed with a variety of methods, both using a camera, and using sensors that can detect movement. The use of cameras for monitoring is a good method with high precision, but often
the use of the camera causes discomfort in the elderly because how old do they feel their movements are curbed and always monitored by the camera. Therefore, it is necessary to have a system that is able to carry out remote monitoring well without giving a sense of oversight to the activities of the elderly with early warning to accelerate the provision of medical help to reduce the risk of death in the elderly who experience a falling incident. The prototype that we will design uses full-body motion capture technology which provides a solution to remotely monitor the movement of the elderly in real time by reducing discomfort due to excessive monitoring as done by the camera. The combination of the gyroscope sensor and accelerometer is used to detect every movement of the elderly. The results of the sensor readings were sent by NodeMCU via the wifi network. If detected falls, the system will send a notification to the family along with the coordinates of the scene to be followed up to contact the nearest medical officer. This prototype is in the form of a special shirt that has 10 IMU sensors installed with a power bank power supply that can be used flexibly and easily to recharge the power with a 4G LTE connection to support data transfer speeds, so notifications can be sent quickly and accurately.

2. Methods
This system using waterfall methods. Start from analysis, design, coding, testing.

MySQL database still the better to choose when it comes to data reliability and secure assurance of performed transactions. Relational database management systems are more popular and offer both free and paid support. In case any issue arises, it can be solved easier than NoSQL databases. Relational databases are the go to solution for difficult querying and data keeping requirements. They are more competent and outclass in this domain.

2.1. Analysis
The first step taken at this stage of the analysis is to validate by ensuring that the system is made in accordance with the needs of the user and able to handle the problems that exist in the user, as well as analyzing the needs of both hardware and software to build the system. Figure 1 is system overview of Fall Detection Clothes. This system uses hardware consisting of 10 IMU sensors (MPU-6050) that are connected to each other in a specially designed shirt. The prototype that we designed uses full-body motion capture technology which provides a solution to remotely monitor the movement of the elderly in real time by reducing discomfort due to excessive surveillance as the camera does. The combination of gyroscope sensor and accelerometer is used to detect every movement of the elderly based on the acceleration of angle changes. Results from sensor readings are sent by NodeMCU via the wifi network. If detected falls, the system will send a notification to the family along with the coordinates of the scene to be followed up to contact the nearest medical officer. The design power supply of this tool uses a power bank that can be used flexibly and easily to recharge the power with a 4G LTE connection to support data transfer speeds, so notifications can be sent quickly and accurately.

![Figure 1. System overview of fall detection clothes.](image-url)
2.2. Design
Design stage produces block diagram which shows the relationship between inter blocks in the system. Figure 2 is block diagram of Fall Detection Clothes. Elderly clothes design falls there is an MPU6050 element and the power supply that enters the Lolin V3 MCU Node element which is connected to the wifi network so as to produce output data stored in the database, the data is processed to generate android push notifications when the elderly is dropped.

![Block Diagram of Fall Detection Clothes](image)

**Figure 2.** System overview of fall detection clothes.

2.3. Coding
The language used in making Android applications of Fall Detection Clothes is java with the addition of a retrofit library, Picasso, Recycle View, and Firebase Cloud Messaging. Encoding on MCU nodes uses C language where the MCU node is used as a client http.

2.4. Testing
The types testing to test functionality is blackbox that focuses on functional of system.

3. Results
The results obtained from this system are in the form of old clothes falling and the push notification application for the elderly in a state of falling. Figure 3 shows the appearance of clothes for elderly in falling conditions. Figure 4 shows the splash screen display of the Android application.

![Image of Elderly in Falling Conditions](image)

**Figure 3.** the appearance of clothes for elderly in falling conditions.

![Image of Android Application Splash Screen](image)

**Figure 4.** The splash screen display of the Android application.

Figure 5 shows the experiment when the elderly falls and Figure 6 shows the push notification given by the Android application when the elderly is in a state of falling.
3.1. Blackbox testing

This test is based on main function that already plan in previous time before create an application. Table 1 displays whether application work properly as expectation or not. And it shows the result black box testing of this system.

| Data                                | Expected results                                      | Results                                           | Conclusion                                      |
|-------------------------------------|-------------------------------------------------------|--------------------------------------------------|------------------------------------------------|
| Retrieve gyro and accelerometer data| Store gyro and accelerometer data in database         | All gyro and accelerometer data can store in database | In accordance with system specifications         |
| Retrieve Notification based fall detection condition | Display notification on android application           | Display notification on android application       | In accordance with system specifications         |
| Call telephone number that integrated in Android application where elderly in fall condition | Call telephone number that integrated in android application Where elderly in fall condition | Can make a call with The telephone number that integrated when elderly in fall condition | In accordance with system specifications         |

4. Conclusion

Based on the results of this system, it concludes that the Fall Detecting Clothes in Realtime Based Seniors Full Body Motion Capture System Using Multiple Inertial Sensors has been tested using black box testing with the results of all feature functions work properly. The system has been tested with several conditions with the results of all controls and output data work properly as well.

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