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AGRICULTURE • INNOVATION • LIFE

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Development of a Wearable Human Fall Detection System

GROUP MEMBERS

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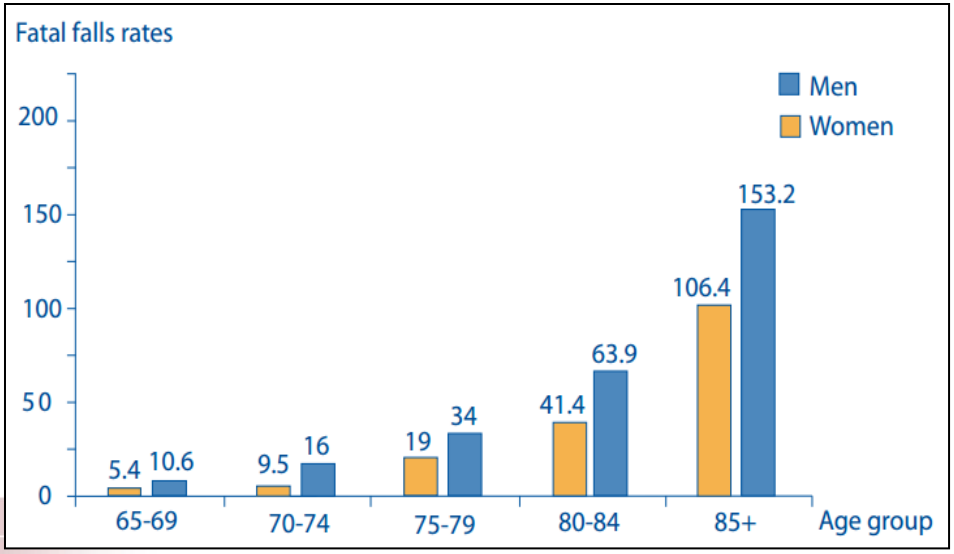
Introduction

- Falls can be defined as involuntary, unexpected and uncontrollable events resulting in a person impacting and coming to rest at a lower level
- It is estimated that 28-35% of people aged 65 and above fall each year
- Falls are the leading cause of injury and accidental death for those over 75. (70% of accidental deaths)

Source: World Health Organization
Global Report on Falls Prevention in Older Age



Problem Statement

- A typical commercial fall detection devices would have offered the basic function of detecting a fall and immediately alert caregivers or monitoring base unit to provide necessary actions depending on the person's condition.
- Most of the devices have no specific feature to monitor and classify physical activities of daily living (ADL) and also no specific feature to monitor the stability of the person who is wearing it to practice early prevention of falls.
- This idea conveys to propose a fall detection and monitoring stability device to be implemented in the future.

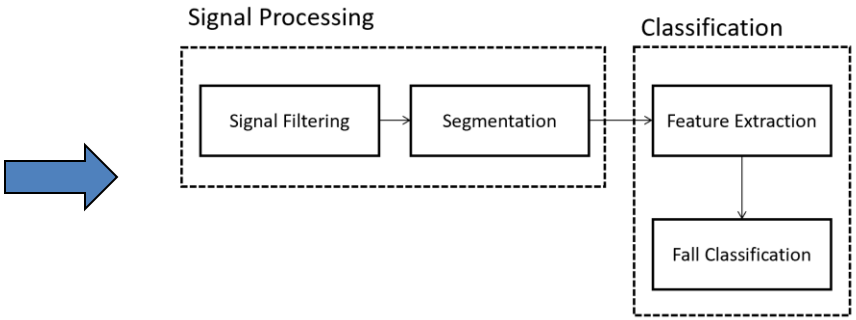
Objectives

To propose and develop a system that can detect fall of the elderly automatically using a wearable detector and able to alert the family members via mobile phone application.

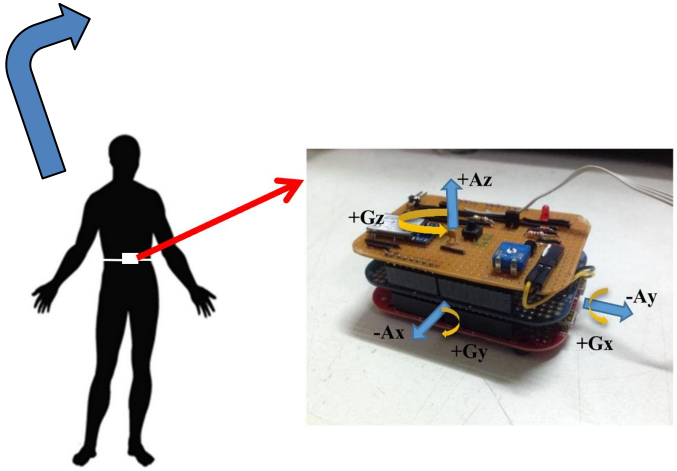
Sub-objectives:

1. Develop a wearable/fall detection device that will send data in the occurence of fall.
2. Develop a effective algorithm for fall detection by capturing patterns of falls
3. To enhance features of existing wearable/fall detection device by incorporating balance and physical activities of daily living (ADL)
4. Develop a caretaker alert system, health monitoring real-time system and health record collection

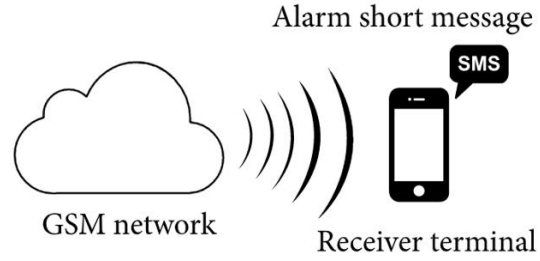
Methodology



Pattern Recognition

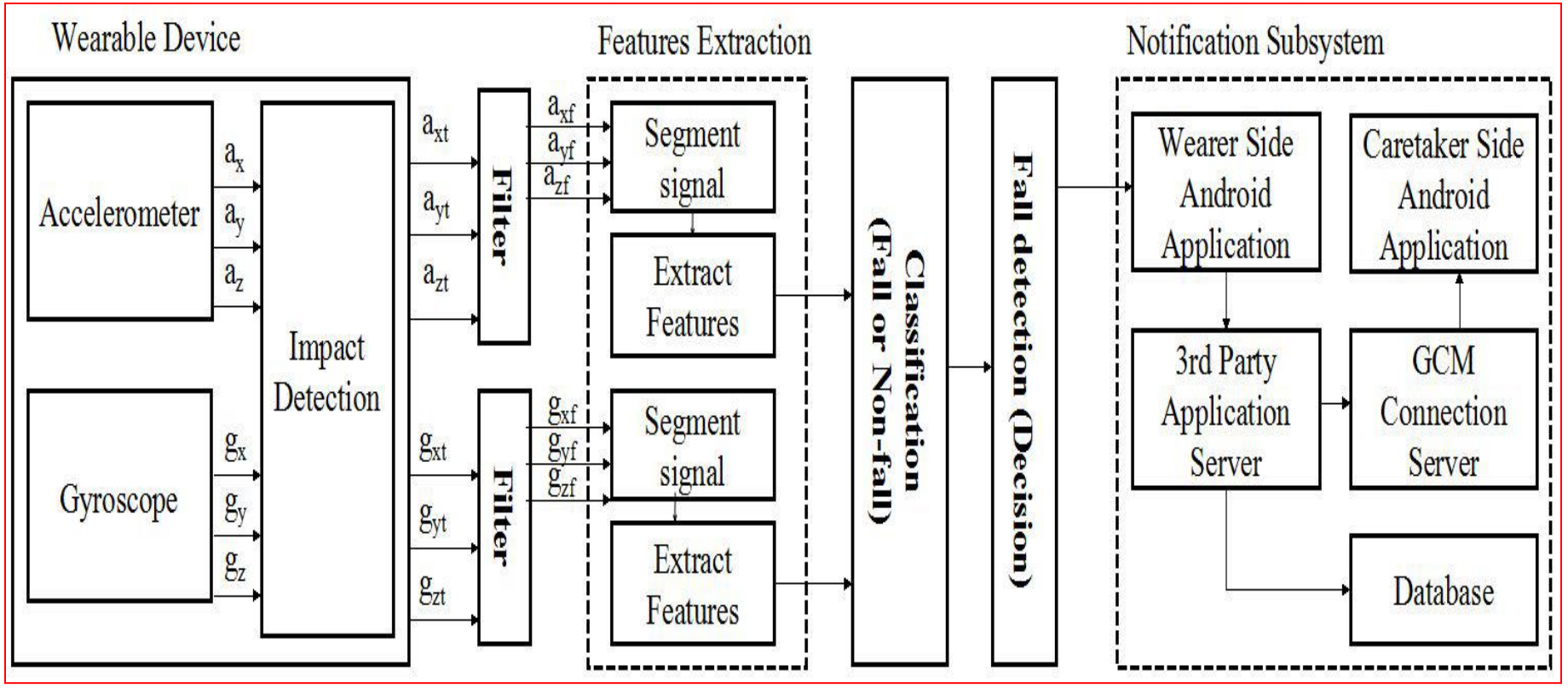


Wearable Device

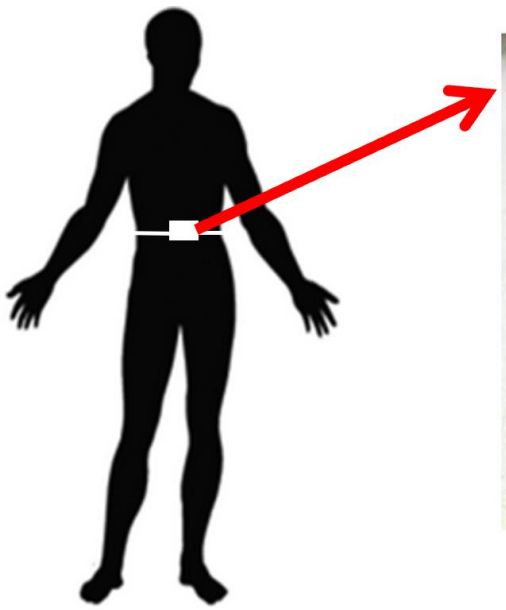


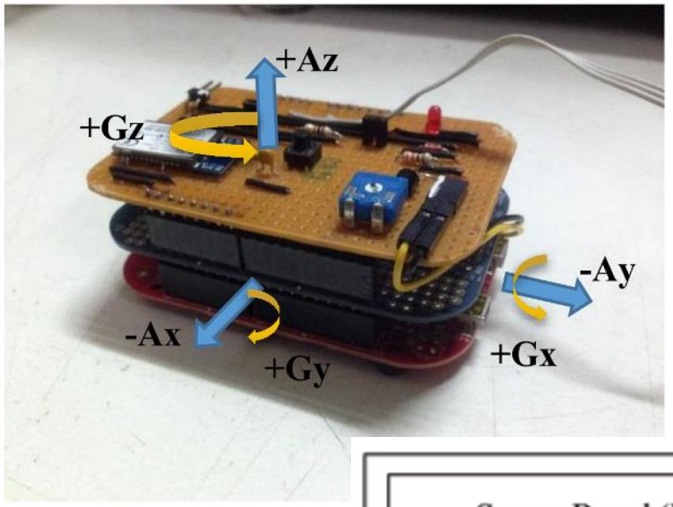
Notification System

Design Concept

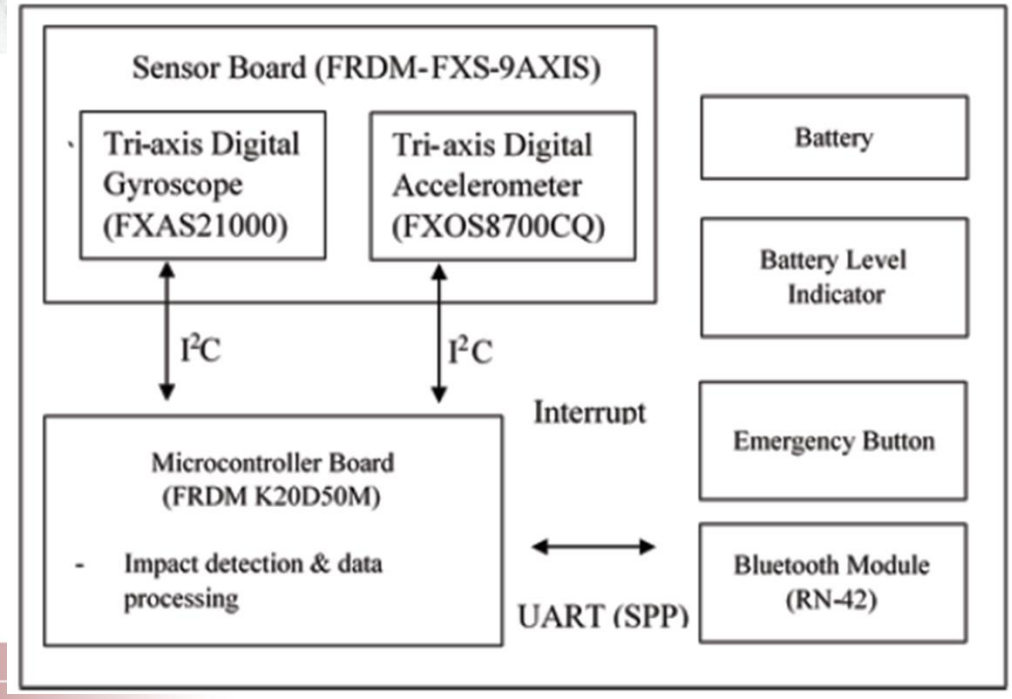


Proof of Concept



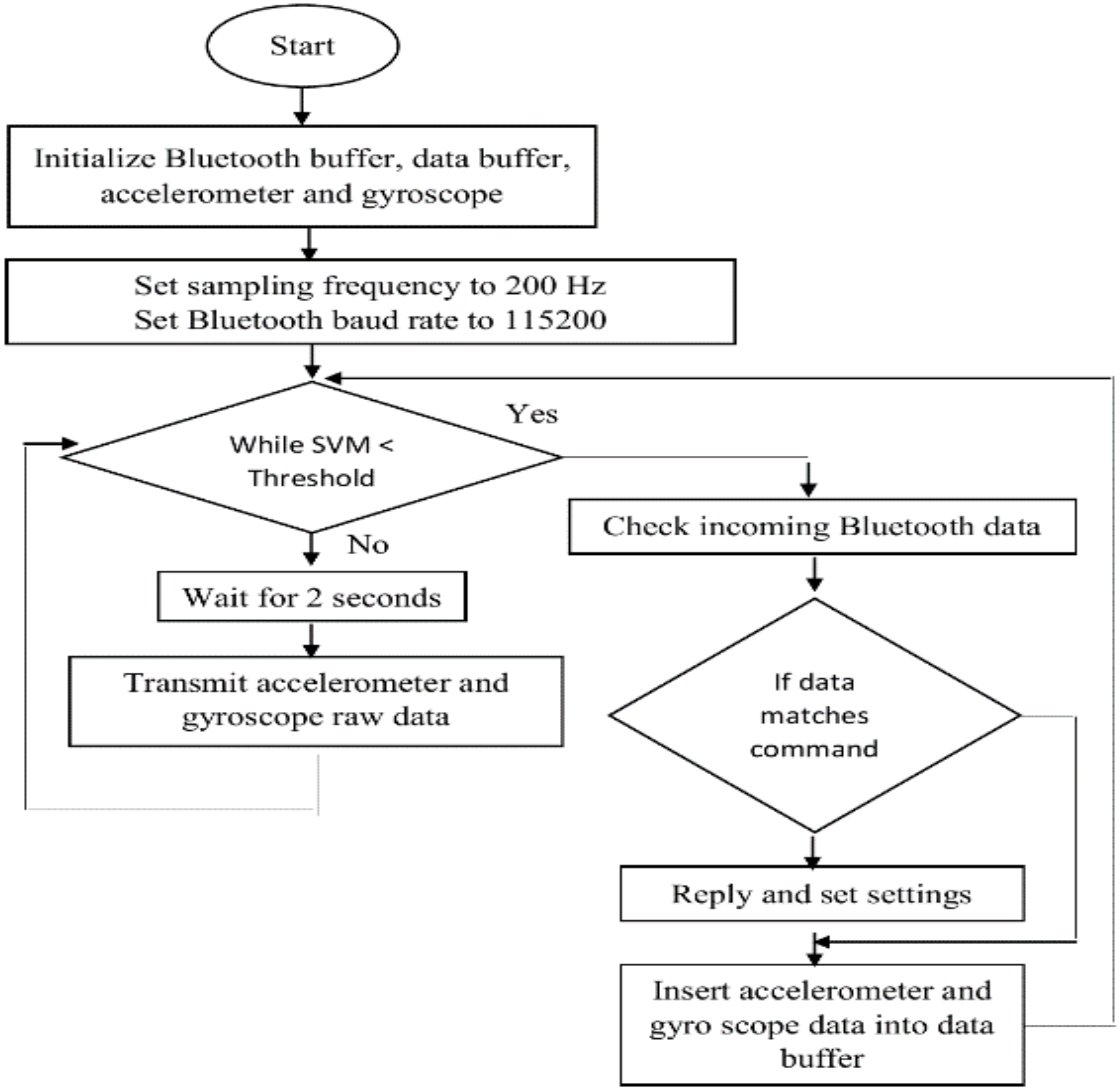


1st Prototype: Wearable Device



Block Diagram

Flow Chart


Start
Initialize Bluetooth buffer, data buffer, accelerometer and gyroscope
Set sampling frequency to 200 Hz
Set Bluetooth baud rate to 115200
While SVM < Threshold
Yes
No
Wait for 2 seconds
Transmit accelerometer and gyroscope raw data
Check incoming Bluetooth data
If data matches command
Reply and set settings
Insert accelerometer and gyro scope data into data buffer

Data Collection

- Study participants

i) 15 total: 10 male, 5 female

ii) Age range: 20 – 25

iii) Height: 160 – 190 cm

iv) Weight: 50-95 kg

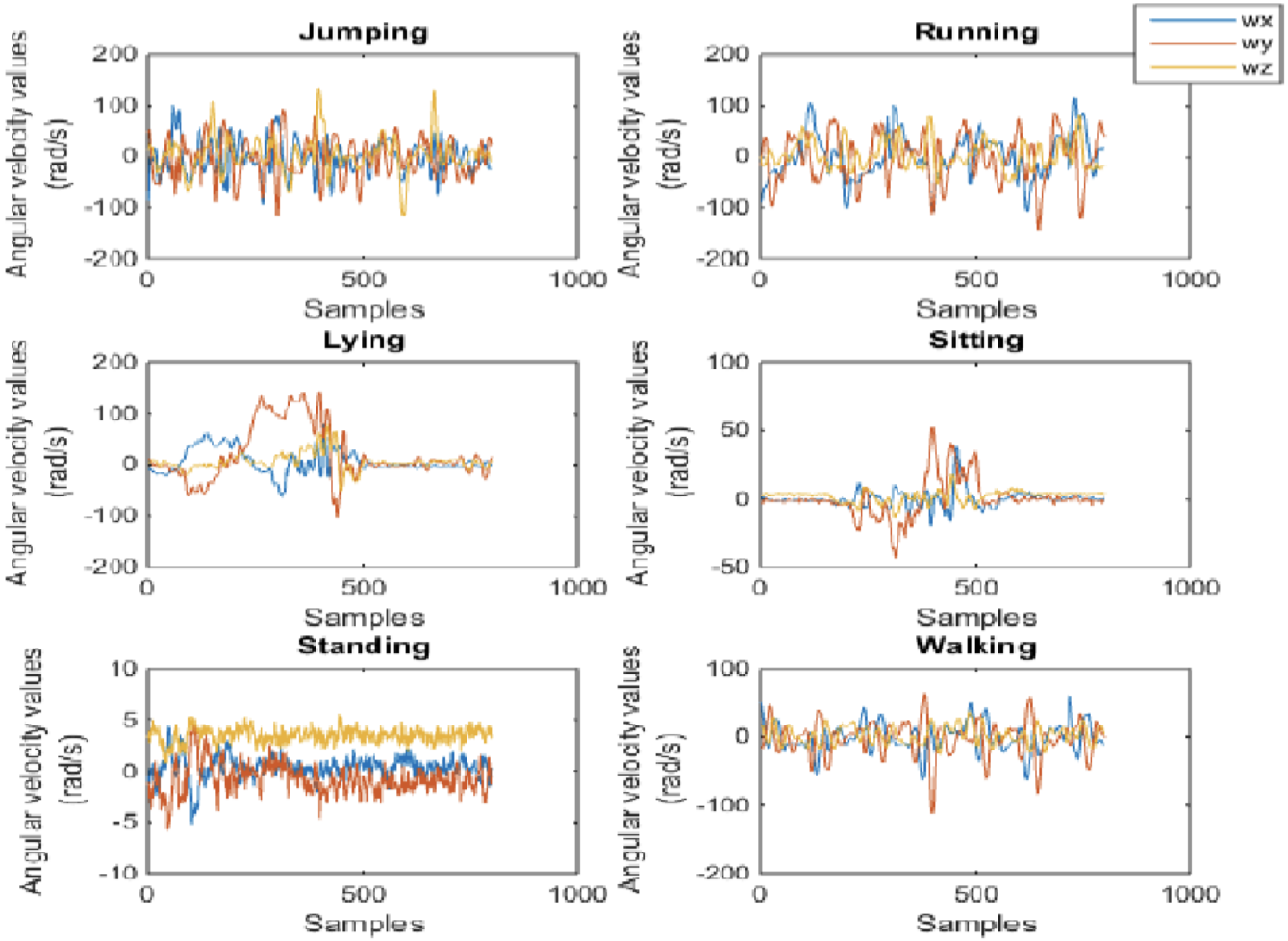
- Each participant performed 3 sets of activities during testing. There are 7 types of activities to be performed as shown.
- Total data: 315 ADLs (15 subjects x 3 sets x7 activities)

Test Activities and Their Respective Descriptions

Activities	Descriptions
Falling	Stand for 2 seconds then fall forward
Running	Run at normal speed of 2.53 steps per second for 8 seconds
Jumping	Jump for 8 seconds
Walking	Walk at normal speed of 1.67 steps per second for 8 seconds
Standing	Stand for 8 seconds
Lying	Stand first, then sit, follow by lying on the bed
Sitting	Stand for 2 second and then sit on the chair

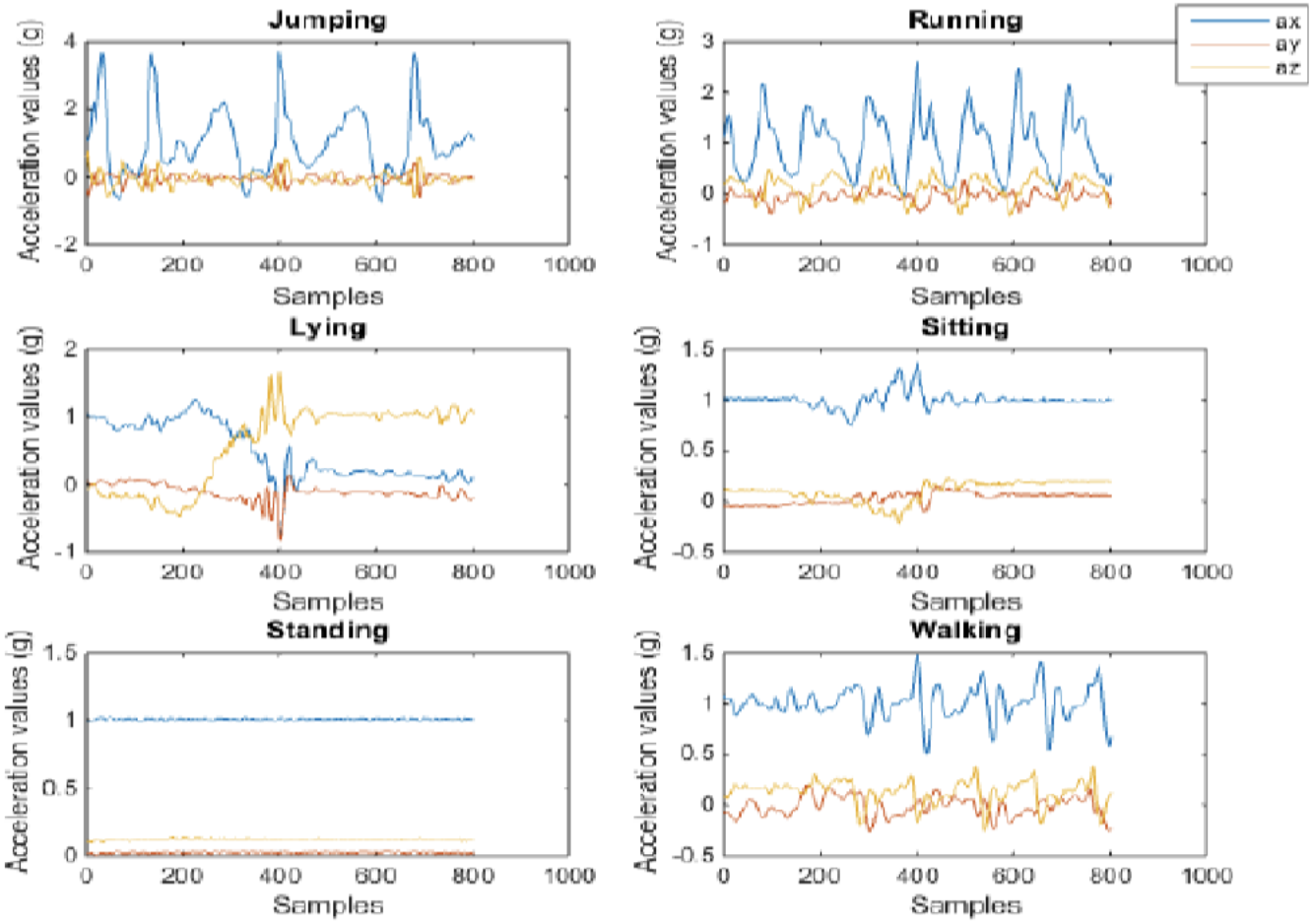
Results: Data Collection

- Gyroscope Data

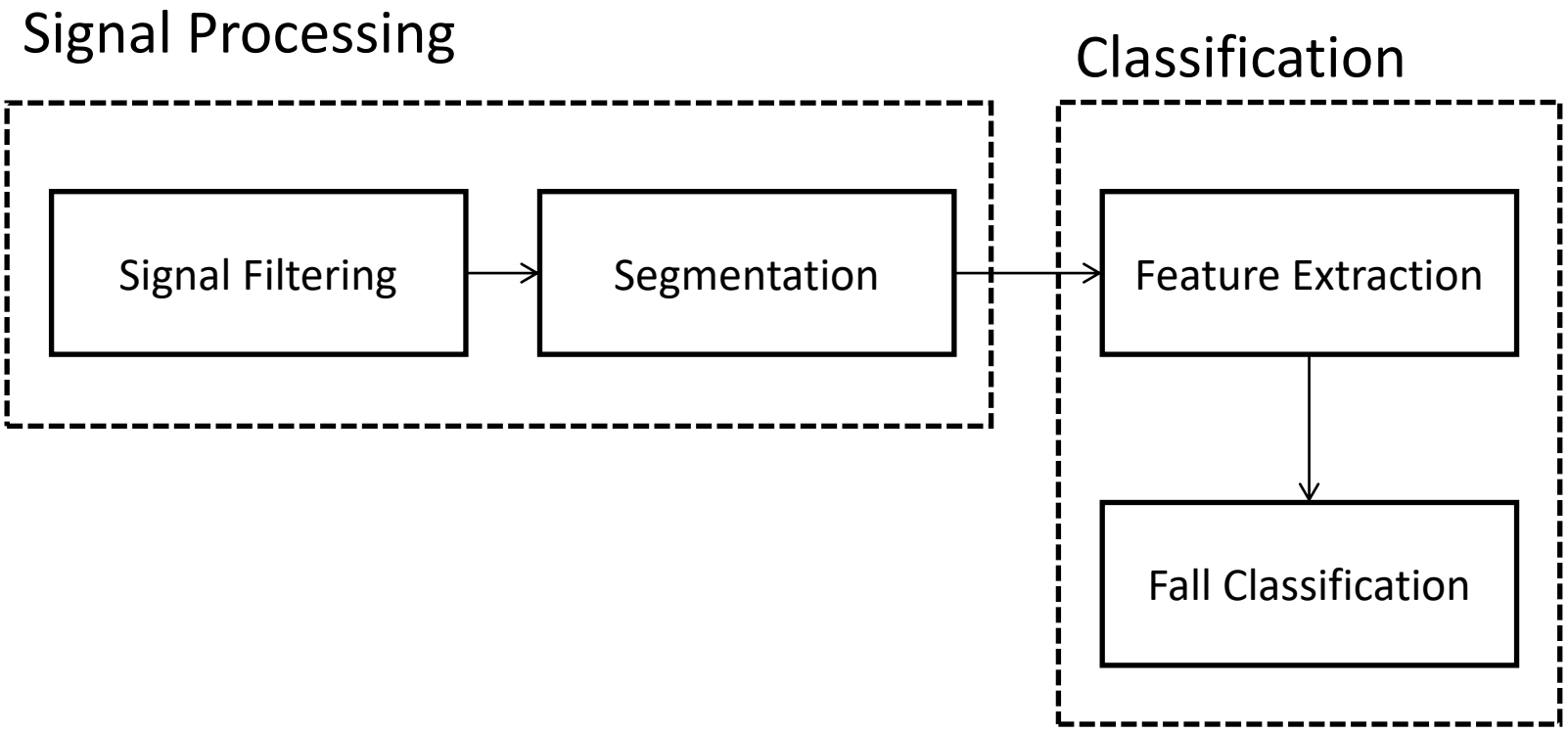


Results: Data Collection

- Accelerometer Data



Pattern Recognition



More detail:

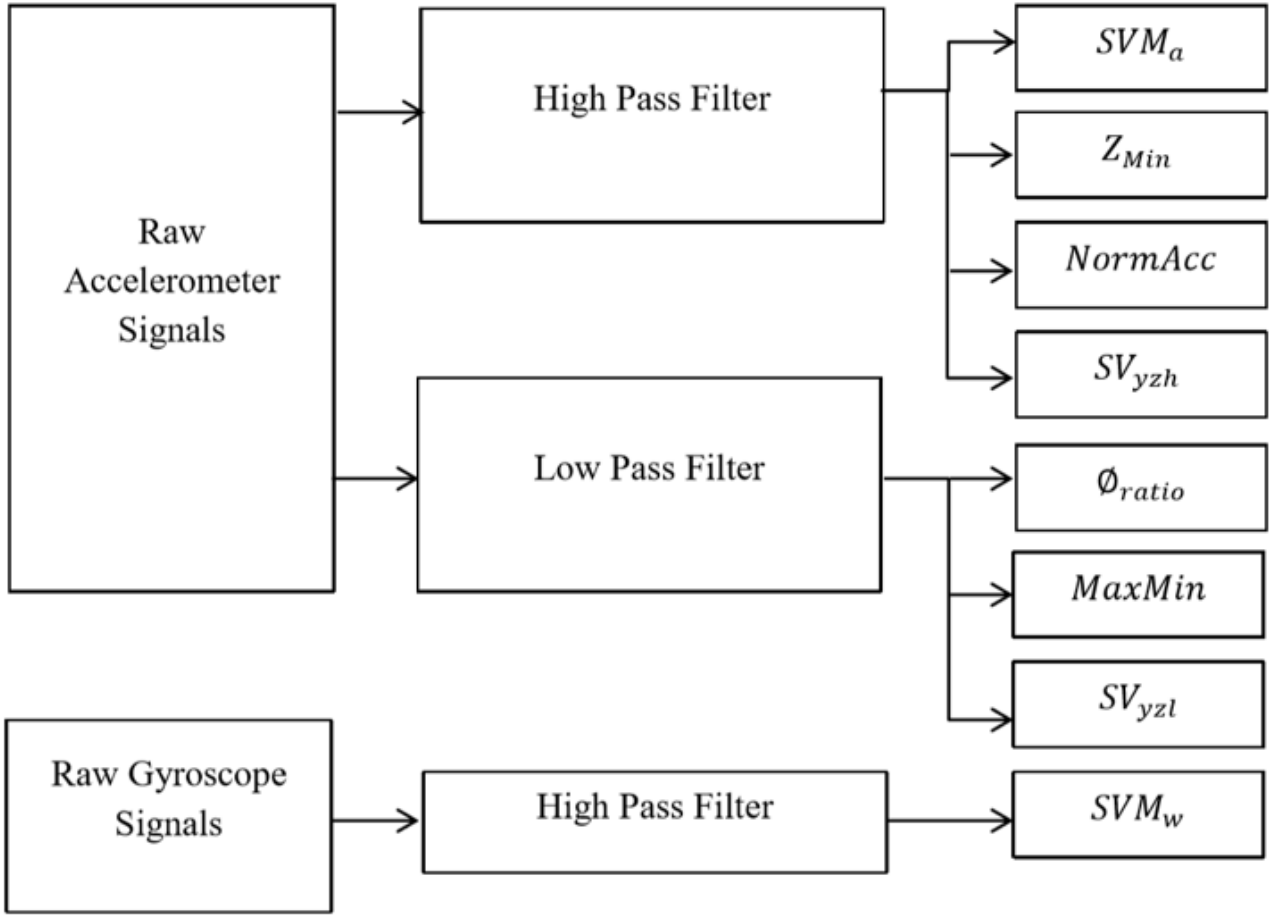
S. S. Jun, H. R. Ramli, A. C. Soh, N. A. Kamsani, R. K. R. Ahmad, S. A. Ahmad and A. J. Ishak, "Development of Fall Detection and Activity Recognition Using Threshold Based Method and Neural Network", Indonesian Journal of Electrical Engineering and Computer Science, Vol. 17, No. 3, March 2020, pp. 1338~1347

Feature Extraction

Table 2: Lists of features

No	Features	Descriptions
1	SVM_a	Sum vector magnitude of acceleration
2	SVM_w	Sum vector magnitude of angular velocity
3	*NormAcc*	L1 norm of acceleration, which is the total acceleration exerted on the device.
4	Z_{min}	Minimum value of vertical acceleration Z_2 for impact detection
5	SV_{yzh}	High pass filtered acceleration on horizontal plane y-z
6	SV_{yzl}	Low pass filtered acceleration on horizontal plane y-z
7	*MaxMin*	Differences between maximum and minimum acceleration values in last 0.5 seconds
8	θ_{ratio}	Ratio of polar angle

Feature Extraction



Sensitivity and Specificity

SENSITIVITY OF THE ALGORITHM

Falls (Number of Falls)	Fall detected (TP)	Fall not Detected (FN)	Sensitivity (TP)/(TP+FN)
Forward Fall (45)	44	1	97.78%

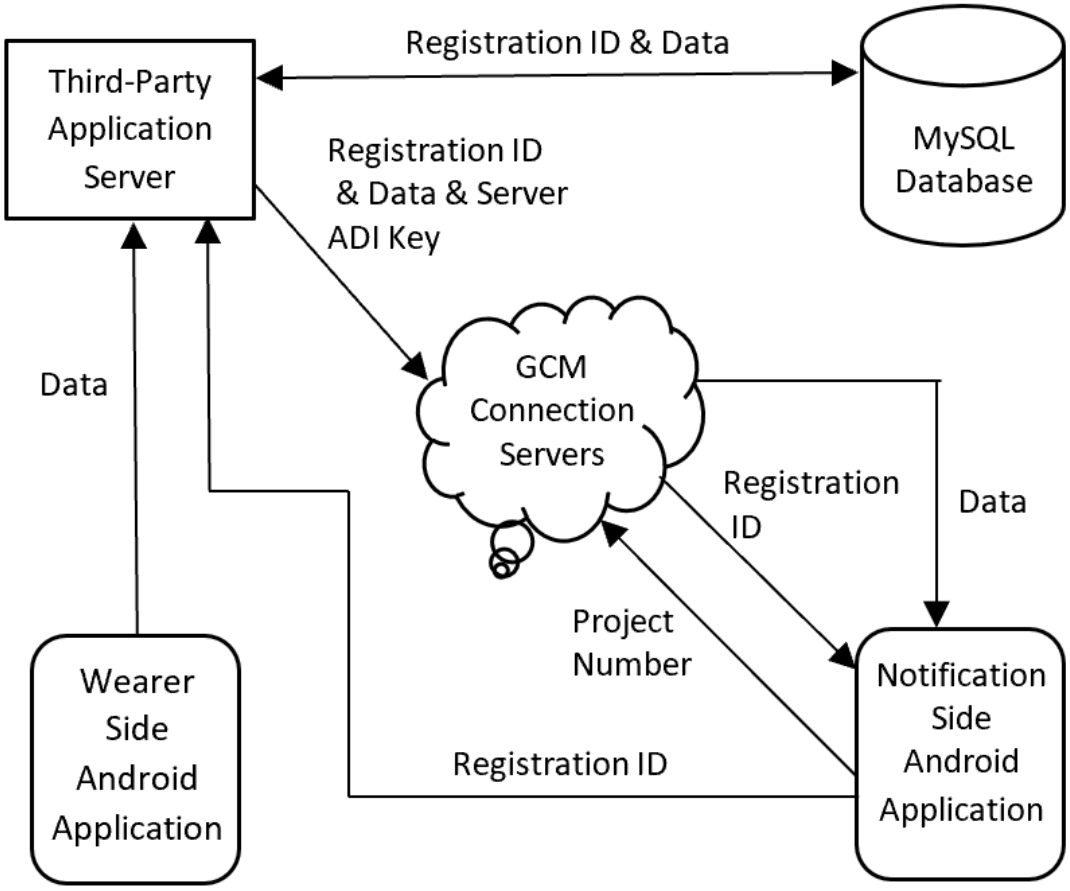
SPECIFICITY OF THE ALGORITHM

ADL (Number of tests)	Fall not detected (TN)	Fall Detected (FP)	Sensitivity (TN)/(TN+FP)
Running (45)	43	2	95.56%
Jumping (45)	43	2	95.56%
Walking (45)	45	0	100.00%
Standing (45)	45	0	100.00%
Sitting (45)	45	0	100.00%
Lying (45)	45	0	100.00%
Total (270)	266	4	98.52%

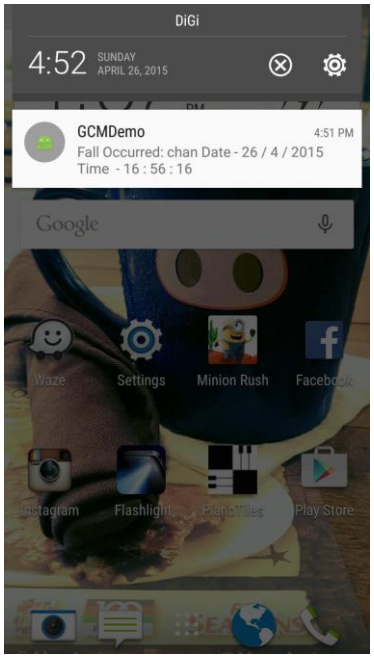
Implementation of Notification system

- The system was then implemented using two Android smart phones. Each of them has the fall detection system's Android applications installed. One smart phone was for the wearer and the other was for the caregiver.
- The wearer's application was expected to transmit the fall event message to the notification application of the caregiver and at the same time, updates the event of the fall of the wearer in the database.
- The third-party application server was responsible for receiving the fall-related messages and registration ID to update the database and to send these messages to the GCM server, including the server ADI key (which was previously obtained from the Google account). The GCM server will then submit the messages to the caregiver's Android phone.
- Hence, the fall event will be recorded in the database and messages related to the fall will be notified to the caregiver. This sequence produces the event-triggered fall notification system.

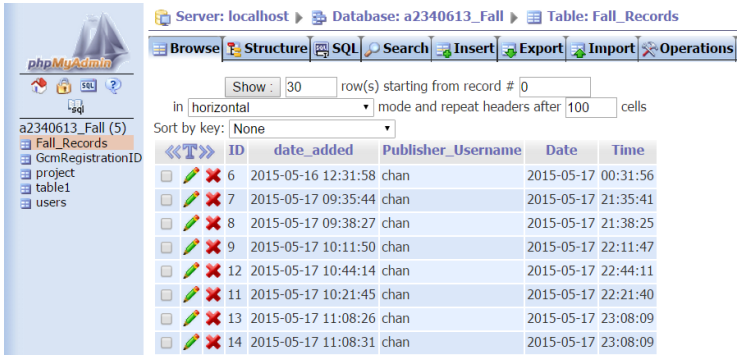
Notification Subsystem



The notification subsystem architecture



The Notification Delivery



Database

Next Phase Research/Project

Implementation of the work will be carried out as follows:

- To design a new wearable device with a slim and small size.
- To design the algorithm for improve the accuracy of fall/ balance detection device by capturing patterns of falls/ movements.
- The use of technology in a existing system that has been improved to be a smart wearable human fall detection system, incorporated with few others features.
- To develop a real-time system for fall detection & activity recognition, balance and health monitoring among older persons

Expected Outcome

- At the end of the project, it is expected that the innovation of this wearable human fall detection system could benefit the community especially to the elderly and caretakers.
- The caretakers could make use of this system to monitor the elderly and keep them alert of the elderly condition.
- The system can help to minimize any serious injuries and accidents that possibly could happen to the elders when they are under no supervision.
- An advanced fall detection system for older persons can be solved and help in improving their quality of life and develop for commercialization.

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