Automatic Gait Balance Detection System

Jani Macari Pallis, Ph.D., Parth Shah, Miad Faezipour, Ph.D.
Departments of Computer Science and Engineering, Biomedical Engineering and Mechanical Engineering
University of Bridgeport, Bridgeport, CT 06604, USA

Abstract:

Falls are one of the major causes of injury in elderly people over 65 years. Each year, 2.5 million people are treated for a serious fall injury. In addition to the fall there is the delay in receiving assistance. Researchers have developed three methodologies to detect falls: image/video processing by implementing cameras and trackers, acoustic recognition using floor and wall sensors and by analysis of wearable sensors. Fall detection using smartphones has also been proposed in the past. A smartphone may have many constraints due to which a wearable device is a much more viable option for such a critical issue. This poster aims to suggest an effective way to detect falls by using a wearable device of which the major components are: 3-axial accelerometer, Arduino Uno, and GPS-GSM device. Apart from that, a buzzer is also integrated to notify people nearby for assistance. The location of the wearable device also affects the acceleration and the result of fall and motion detection. Although the wrist is the most common body part for any wearable device, the acceleration signal may vary widely. It is efficient to place the device in areas of least movement like a knee or waist.

Hardware Prototype:

The Arduino Uno is an open source hardware device (microcontroller) which can be programmed to control different devices and processing tasks. Figure 1 shows prototype of the hardware:

- Arduino Uno R2
- 3-axial Accelerometer
- GPS-GSM module
- Buzzer

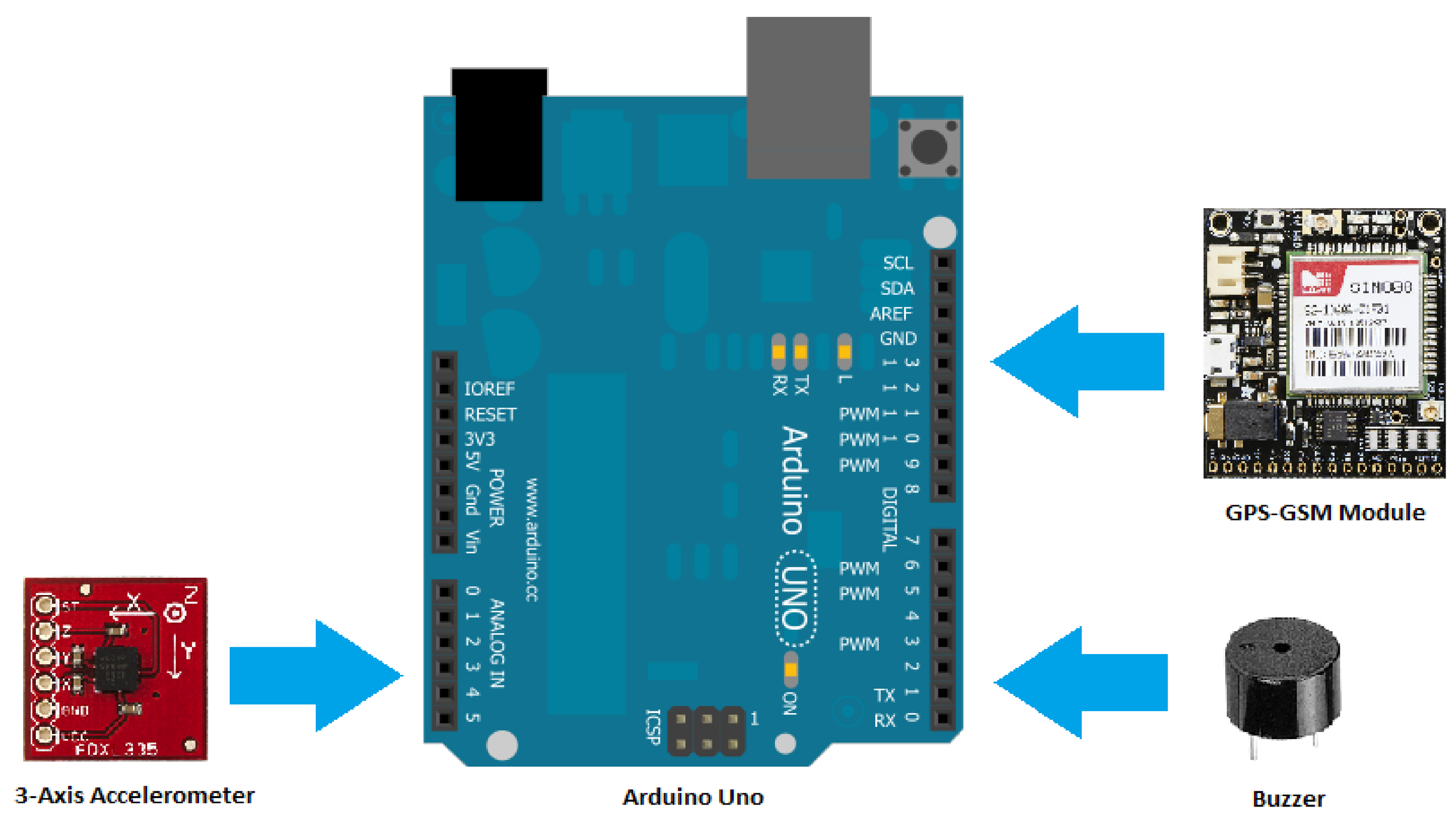

Figure 1

Methodology:

Existing algorithms evaluate fall detection based on acceleration threshold only. This work has studied evaluation not only based on an acceleration threshold but also with analysis of previous stored data. The objective of this project is to use logistic regression on accelerometer data to differentiate between positives and negatives (falls – non-falls). Figure 2 explains the proposed methodology.

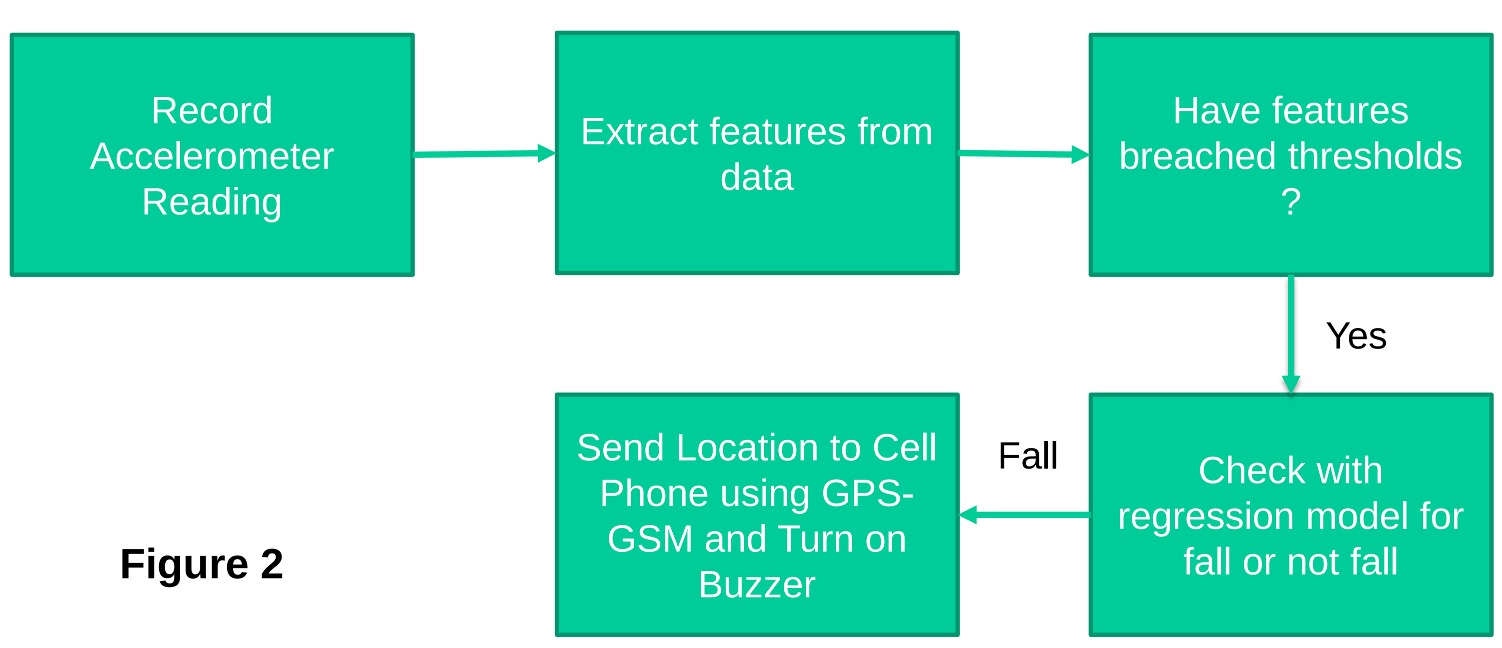

Figure 2

Features and Classification:

Classification:

As stated earlier, the objective of this project is to introduce a machine learning algorithm to obtain reliable fall detection results. Logistic classification and regression serves this purpose. Logistic regression learns from an existing labeled data set (fall/ non-fall) and this self-learning algorithm is used to predict the output from data with similar features. Other ML algorithms like- SVM, Logistic Regression with Regularization may be considered in future for the same purpose.

Features:

The accelerometer generates acceleration for axis- x known as Roll, y known as Pitch and z known as Yaw. Total acceleration can be calculated as the square root of the total sum of the acceleration squares + . Single point acceleration will not be enough to determine fall or non-fall occurences. Below are the proposed features to produce reliable results-

- Maximum Acceleration
- Minimum Acceleration
- Time difference between both

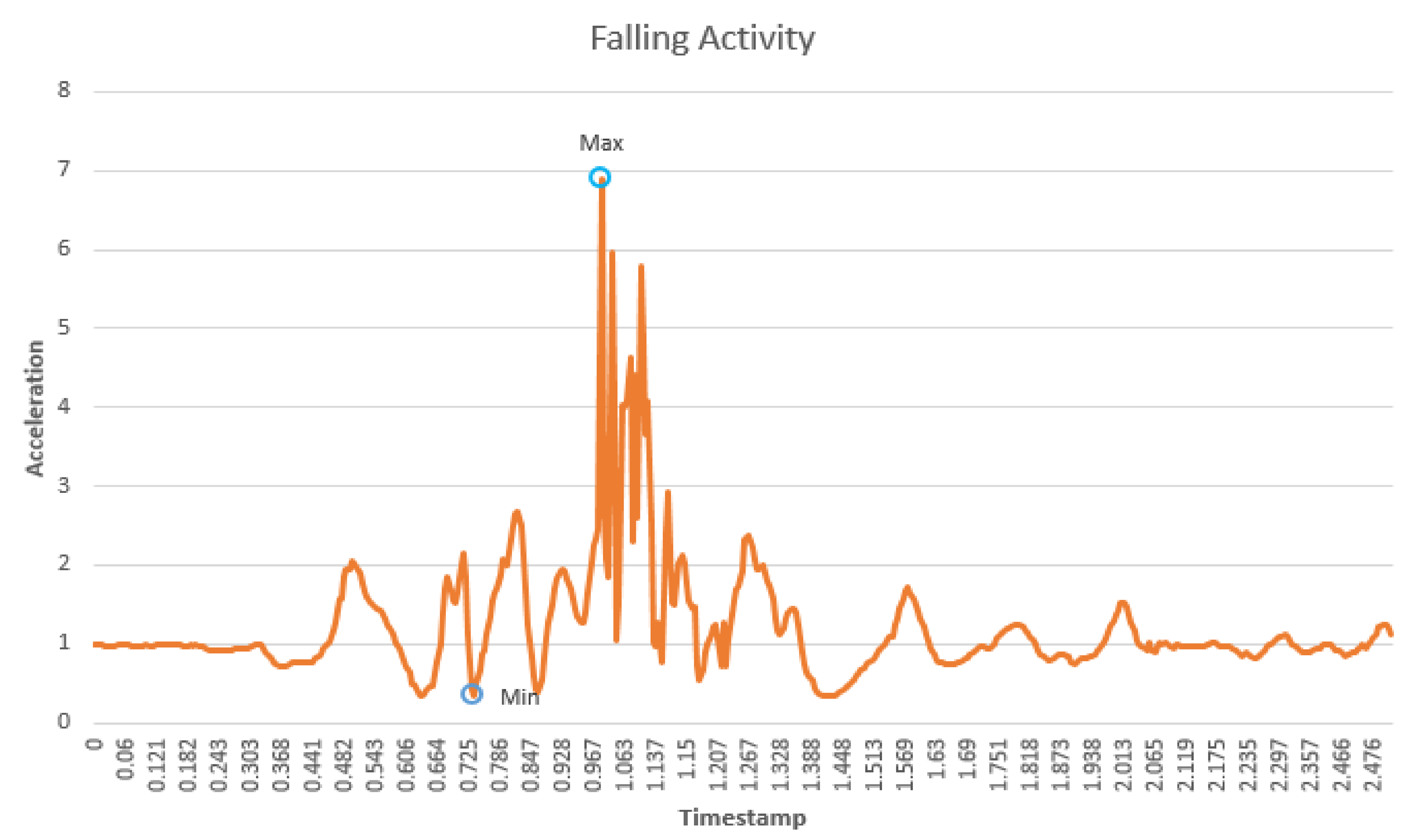

Figure 3

Accelerometer location- lower pocket.
Time duration- 2.5 to 3 seconds.
Type- front face falling.

Fall Thresholds:

Considering earth's gravitational force, the unit of acceleration is taken as 'g'.

- **Minimum Acceleration:** Theoretically, when there is a free fall, acceleration falls to 0g. But practically, it varies based on geographical location and the type of fall. 0.5 g is a reliable threshold for minimum acceleration.
- **Maximum Acceleration:** Maximum acceleration ranges between 3g-8g based on the type of fall.
- **Time difference:** At the time of fall, the difference between timestamp of minimum and maximum acceleration is usually less than 0.8 sec depending on the distance from ground[2].

Results and Outcomes:

Comparing features of daily human activities provides clear insight of acceleration differences. Below are the statistics of different activities for the proposed features-

Activity	Minimum Acceleration(g)	Maximum Acceleration(g)	Time difference (Sec)
Sitting	0.914	1.094	0.851
Walking	0.777	1.328	0.067
Jogging	0.489	2.916	2.219
Falling	0.332	6.899	0.243

Table 1

Future work:

- Integrate accelerometer data extraction and MATLAB logistic regression model to produce a more reliable algorithm for fall detection.
- Detect gait pattern to classify patient and non-patient groups. We have been accepted to receive sample data from the Michael J. Fox Foundation for Parkinson's Research. We will be using our algorithms on their data (which was collected in a similar way) to determine the robustness of our algorithms.
- Determine type of fall and sub classify the fall activity.
- We will also pursue a grant with the Muscular Dystrophy Association.
- Currently integrating the usage of Raspberry Pi computer in lieu of Arduino.

References:

[1] Kangas, M., Konttila, A., Lindgren, P., Winblad, I., & Jämsä, T. "Comparison of lowcomplexity fall detection algorithms for body attached accelerometers", Gait & posture, Vol. 28, No. 2, pp. 285-291, 2008.

[2] Yujia Ge & Bin Xu, "Detecting Falls Using Accelerometers by Adaptive Thresholds in Mobile Devices" , JOURNAL OF COMPUTERS, VOL. 9, NO. 7, JULY 2014