

Freefall detector

DGMD-13 Final Project



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# **Goals**

## ****Project Goals****

To use acceleration data from the sensor tile to predict a device free falling.

## Learning Goals

To learn the process from start to finish integrating hardware and software to develop a real potential product.

# Elevator Pitch

Develop a device to detect if a cellphone is falling (or use the cellphone’s internal sensors) and prevent damage by deploying protective measures.

# Data Collection

Data is collected in real time in text files using a SensorTile board via Bluetooth and the gatttool utility on a Raspberry PI W. It is then transferred to my mac to be processed and analyzed.

The process for capturing repeatable data is as follows:

The SensorTile was soldered to the Cradle+ cradle so no wires need to be connected to it.

It was flashed with AllMems1 firmware so acceleration data could be captured.

The “Freefall” data collection process.

1. From a height of 31” the tile will be held steady and flat by hand and then released/dropped.
2. The device lands softly on a blanket.
3. Tester picks up device and brings back to starting position and holds steady in preparation for the next drop.
4. Steps above are repeated until at least 10 freefalls are captured. Each freefall and reset takes about 5 seconds.

# Data Analysis

The captured data is in a raw hex format. Using python scripting it is converted to decimal and reviewed to separate each instance of a freefall. Based on the sampling timing (50 milliseconds), known time to drop and reset (about 5 seconds), as well as the accelerometer values, it is fairly easy to identify each freefall.

Each accelerometer axis (x, y, and z) measurement is used as a feature.

The SensorTile Z axis theoretically has 1g of force exerted on it when flat and at rest and the x/y axes have 0g.

When the tile is dropped, the g-force drops to 0 on the Z axis. Regardless of what the x and y axes forces are, when normalized, the value is near 0 g’s.

This is how we can determine if a freefall is occurring. When the combined axis values change from 1g to 0g.

Normalization formula:

# Models

Using Supervised Learning and a Linear Regression model, the data was classified via a Support Vector Machine.

# Technologies

I used a Jupyter notebook Jose provided during one of our classes to perform all the analysis. The notebook includes several python technologies. Pandas, MatPlotLib, Scikit-learn, as well as NumPy and Seaborn.

# Proof of Concept

There already is a similar proof of concept1 that Jose identified for me. See the references section for info.

For this project the specific poc is to detect a fall without hitting the ground.

# Tasks

## April 14th – April 21st

* Complete proposal

## April 21st – April 28th

* Determine model and training details and start framing out a Jupyter notebook
* Flash hardware and start testing/training

## April 28th - May 4th

* Complete notebook coding
* Testing as well as document project as required by professor

## May 4th – May 12th

* Finalize documentation and prepare to demo

# Conclusion and Future Work

Freefalls can easily be detected and in my testing, I was able to detect them 100% of the time.

The harder thing to discern is whether it’s just a motion, such as a person quickly lowering their arm while holding their phone versus them actually dropping and damaging it.

Since a freefall is a physical state of zero gravity, it is not the only thing needed for that determination.

Future work on this would be to determine how to discern the difference. Some ideas are using barometric pressure and/or gyroscopic data as well as time in freefall to decide if it is an actionable event.

I learned an immense amount in this class and will continue on in this field of work as it is really exciting and fulfilling.

Thank You Professor Ramirez Herran!

# Bibliography

[1] P. Jatesiktat and W. T. Ang, "An elderly fall detection using a wrist-worn accelerometer and barometer," 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Seogwipo, 2017, pp. 125-130.