# Is it possible to detect epileptic spasms and falls using only fundamental sensors?

**(Fall Detection and Protection Unit ;** previously known as Epileptic Seizure Protection Unit**)**


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## Introduction of background

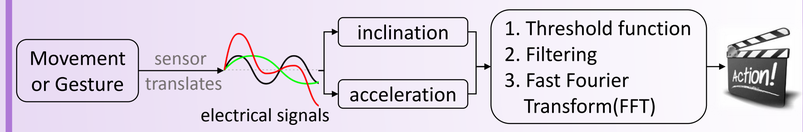
In the brain, excitation and inhibition of electrical activity are adequately balanced for transmission of "senses" and "reactions". It is generated by, normally a single or a few neurons simultaneously. However, if too many neurons transmit signals all at once (hypersynchrony[1]), as if there were a traffic congestion, the brain will not be able to appropriately react but to establish unconsciousness and introduce a seizure instead.

Different parts affected in the brain trigger different types of seizures. The most commonly known are Tonic type, in which the muscles become stiff, and Clonic type which involves jerking movements, or combination of both[2].

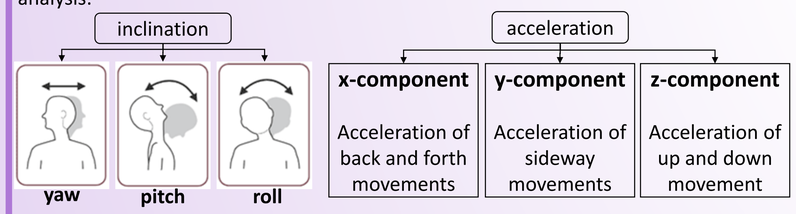
## Aim and Objectives

This research aims to investigate whether the ordinary gyroscope and accelerometer sensors are sufficient to differentiate between daily routines and Epileptic Tonic-Clonic Seizure, so that it lays a solid groundwork for future possible research in epileptic biomedical devices.

## Methodology




The sensor should correspond to our balance system, so it was placed close to the ear in fixed orientation. It translates the detected movements into electrical signals for further analysis:



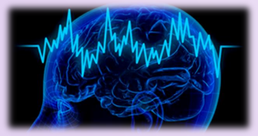

**Fall**

It involves only an inclination to a certain **degree** or a combination of:
**(i) Pitch** **(ii) Roll**

**Accelerations** involved are:
(i) An average of horizontal **x** and **y components** at **moderate level**
(ii) Vertical **z component** is **drastic** due to gravity

The microcontroller compares these signals to a threshold, and decide whether to take any action.

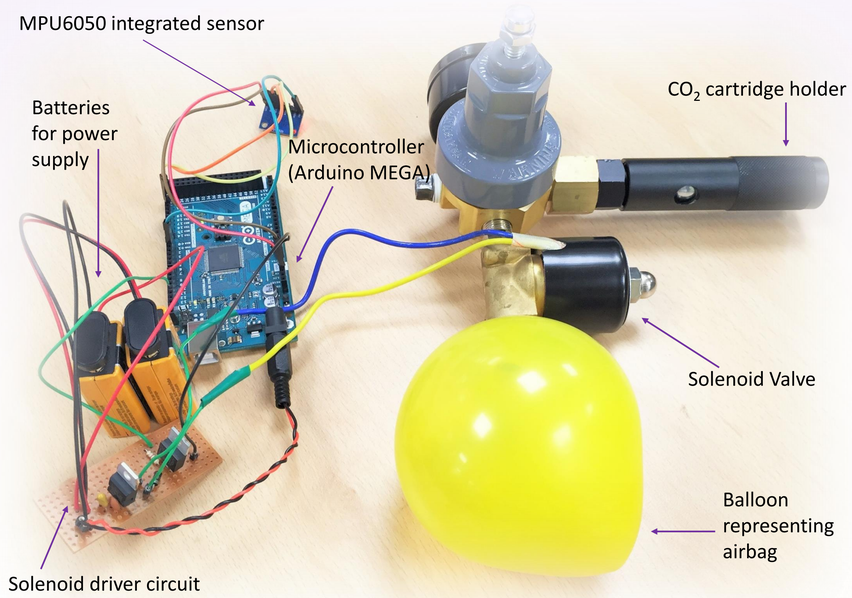
**Spasms**



It is believed to have a common specific frequencies range, involving **all 3 inclinations** in random directions:
**(i) Yaw** **(ii) Pitch** **(iii) Roll**

Frequency analysis (**FFT function**) enables these signals to be interpreted in a **spectrum of frequencies**, and to be **compared to** the **spasm threshold** by the microcontroller.

## The Concept




Sensor: MPU6050
(Gyroscope & Accelerometer)

MOVEMENT & GESTURES

Processing Unit: Arduino MEGA
(Microcontroller)

Condition to confirm a fall:
- Overall body inclination
  $((\text{Pitch} + \text{Roll}) \div 2) \geq \alpha^{\circ}$ **AND**
- Average horizontal acceleration
  $((x + y) \div 2) \geq \beta$ **AND**
- Vertical acceleration
  $z \geq Y$

Else, if not fulfilled, no signal is sent to solenoid to trigger a further action.

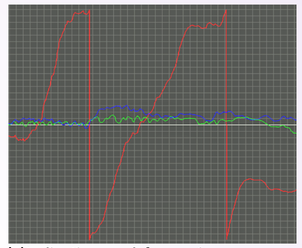

$CO_2$ gas supply cartridge — Pressure regulator — Electronic Solenoid Valve — Airbag


**References**
**[1]** E.J.Donner. About Kids Health. (2010) *What Causes Seizures?* [Online] Available from: http://www.aboutkidshealth.ca/en/resourcecentre/epilepsy/aboutepilepsy/pages/what-causes-seizures.aspx [Accesed: 16/10/2015]
**[2]** O.Devinsky, J.I. Sirven. Epilepsy Foundation. (2013) *What is a tonic-clonic seizure?* [Online] Available from: http://www.epilepsy.com/learn/types-seizures/what-tonic-clonic-seizure [Accessed: 17/10/2013]
**[3]** M.Poulsen, P.Krøgholt. Aplha Trainer. (2013) *2.1.1 Classic BCI applications and techniques.* Figure 2.3(b): Raw EEG and Fast Fourier transformed EEG. [Online] Available from: http://alphatrainer.github.io/alpha-trainer/technical-background.html [Accessed: 17/10/2013]

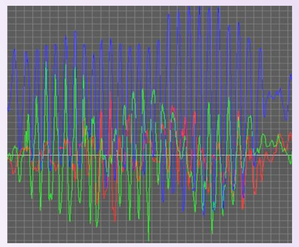

## Results and Discussion

**Fall Detection**

A set of different activities were carried out to compare and analyse, but only one of them are selected for illustration, as shown on the left below:



***(a)Inclination graph for running***
*Red – yaw; Green – pitch; Blue – roll*



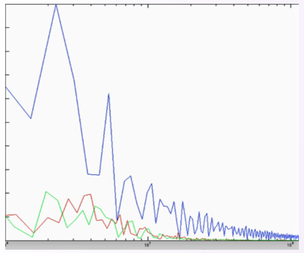
***(b) Acceleration graph for running***
*Red – y component; Green – x component; Blue – z component*

(a) The fixed orientation lets the sensor to detect the significant changes in yaw when the user is not running in a straight line.

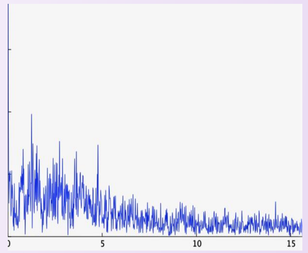
(b) **z component** shows the great vertical movement the body is engaged to.
**x & y components** illustrate the forward and sideway directions and the speed change of changing steps.

**Seizure Detection**

FFT computes the major frequencies of the particular activities studied, by showing significant sharp spikes on the graph. Diagram(c) below shows the FFT of 3 different sets of activities:



***(c) FFT for three different activities***
*Blue – Running; Red – Brushing Teeth; Green – Eating Cereal*




***(d) An expectation on FFT graph shape***
*FFT of EEG test that sense electrical activity from scalp[3]*

(c) The exponential decrease in this FFT graph gives no information to spasm. An anticipated graph pattern is as depicted in (d). Further investigating this issue, an alternative FFT analysis using two identical sensors were implemented, but a graph similar to (c) were still obtained.

## Conclusion & Possible Social Impact

Conclusion was brought up that the fundamental sensor, or possibly the integrated MPU6050 is insufficient to detect epileptic spasms, but not limited to detect an ordinary fall.

This project however has successfully demonstrated a fall detection unit which could possibly be made compact into a wearable device. It is also believed to give impact to the society especially to toddlers, elders and motor cyclists.

## Acknowledgment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