ECE-GY 6483- Embedded Challenge Fall 2021

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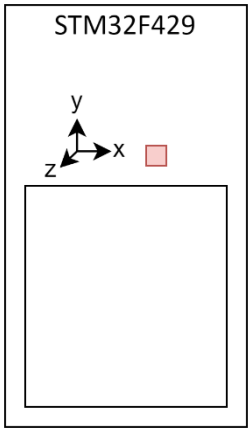
Objectives

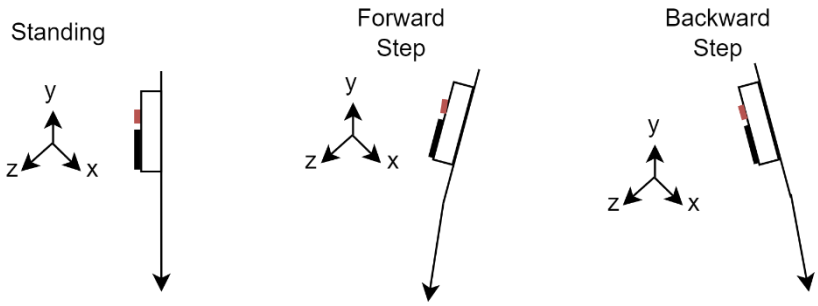
The objective of this project is to build a wearable speedometer which can calculate velocity by measuring angular velocities available from the built-in gyroscope (L3GD20) on STM32F429 without a GPS.

Design

The design described here was based acquiring the data from 3 axis gyroscope(L3GD20) and analysing a sample set of data using plots to identify the sensors outputs under static conditions and under the conditions when the device was mounted on the body and by taking steps.



For the convenience of the user, the choice was made to keep the device in user's pocket. For the purpose of the demonstration, the device was affixed on the thigh so that the live data can be easily visible.



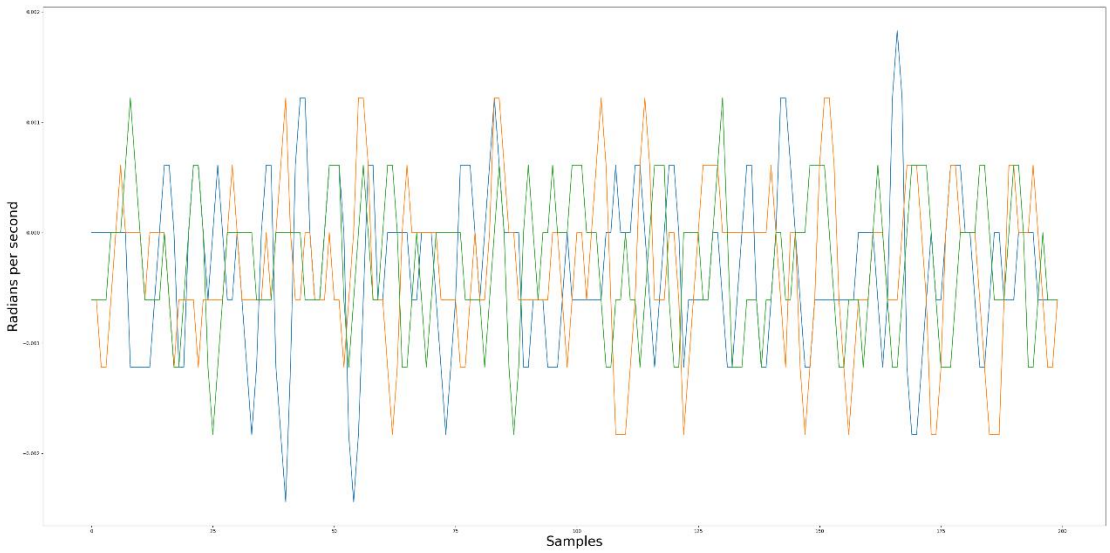
The orientation in which the device is mounted clearly shows that while walking **only meaningful rotation is about the X axis and hence the rotations about the Y axis and the Z axis are ignored.**

Data Analysis

First the data from the gyroscope was acquired and analyzed(not real time) in python.

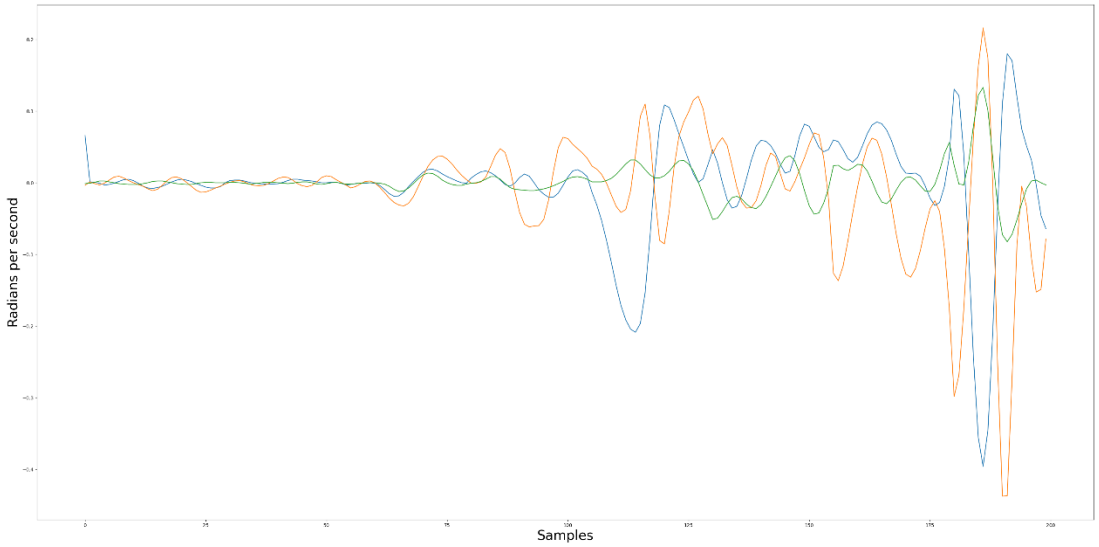
- Following is the plot of rotation about x,y,z axis under static conditions. It was seen that the variation even if the device was kept static was found to be between **+-0.003 radians per second**(not visible in the plot. The raw data file is added as a .txt file along with this report **Reference 1**)

Static Example

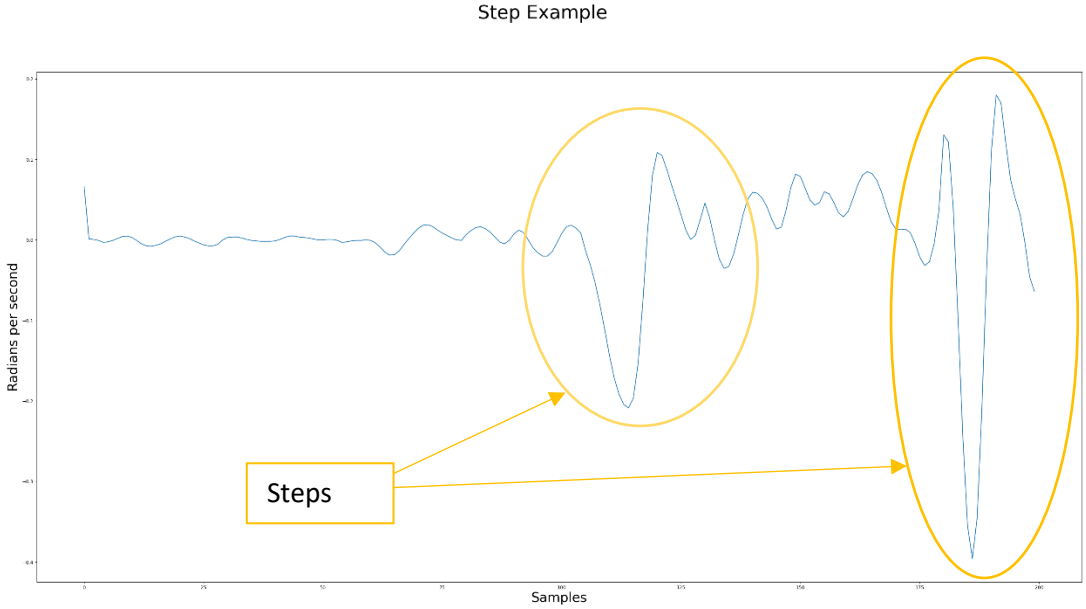


- Following is the plot of rotation about x,y,z axis when the user takes a step.

Step Example



As only the rotation about x axis is meaningful, ignoring y and z axis rotation,



It was seen that the variation when the user takes a step was over **1.5 rps** for a slow step and over **2.0 rps** for a faster step(not visible in the plot. The raw data file is added as a .txt file along with this report **Refernece 2**)

Assumption: Higher rps means faster leg movement translating to more distance travelled!

Design Parameters

Control Register 1 = 0x0F

Power Down = 1(normal mode)
Enable X,Y,Z = 1

Control Register 3 = 0x20

Full scale(FS1,FS0) = 10(2000dps)

Control Register 4 = 0x12

HPF enabled = 1
Output_sel[1:0] = 10

TFT Display rate = 1sec
Gyro Read sample rate = 80ms
Step Calculation = 400ms
These timing parameters were implemented using 3 separate ticker functions.

There were two techniques employed to compute the linear distance from angular rotation about the x axis which are described in the following section.

Method 1

This method calculates the linear distance based on the rate of change of radians multiplied with a constant. These steps were chosen after taking multiple samples of varying steps.

	rps	dist
1	<1.5	dist = dist + rps*0
2	1.5-2.0	dist = dist + rps*90
3	2.0-2.5	dist = dist + rps*100
4	>2.5	dist = dist + rps*120

Method 2

This method calculates the linear distance based on the rate of change of radians assuming a constant step size. These steps were chosen after taking multiple samples of varying steps.

	rps	dist
1	<1.5	dist = dist + rps*0
2	1.5-2.0	dist = dist + 20
3	2.0-2.5	dist = dist + 30
4	>2.5	dist = dist + 40

These values were chosen after trial and error multiple runs till the device started giving satisfactory results.

The distance is calculated from angular velocity and displayed on the TFT on the STM32F429. (Ref code used for TFT https://os.mbed.com/users/dreschpe/code/SPI_TFT_ILI9341/. This code was ported to platform IO and STM32F429)

Additional Work

- The device also calculates the number of steps taken by the user!
- The device also translates and displays the calories burnt by the user based on the activity of the user!(Not sure how accurate though)

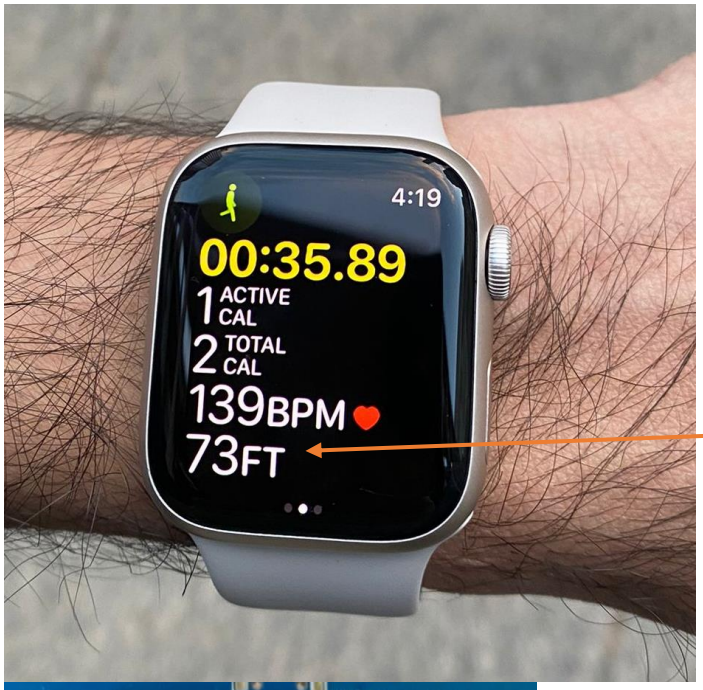
Testing

The working was tested and verified by using an **Apple Watch 7 fitness tracker!**
Please watch the video for the demo!!!

	Type	Actual Distance	Method1	Method2	Error
Test 1	Long Distance	127.6	115.3	117.9	>10%
Test 2	Walking	22.25	22.39	22	<1%
Test 3	Running	41.45	57.92	40.7	1-2%

It was observed that Method2 performed better than Method1 the error was high for higher distances and faster walking speeds

Eg.



73 Feet = 22.25m

Using Method 1 Above

Using Method 2 Above