**HW6 IMU Integration**

Johns Hopkins University

Real Time Software for Embedded Systems

Fall 2014

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2014-10-28

**Tutorial**

**Parts List**

* (1) BeagleBone or BeagleBone Black
* (1) spool of hobby wire
* (1) USB 2.0 A/B cable
* (1) breadboard
* (1) Ethernet cable
* (1) 6 DOF Gyro, Accelerometer IMU - MPU6050

**Software**

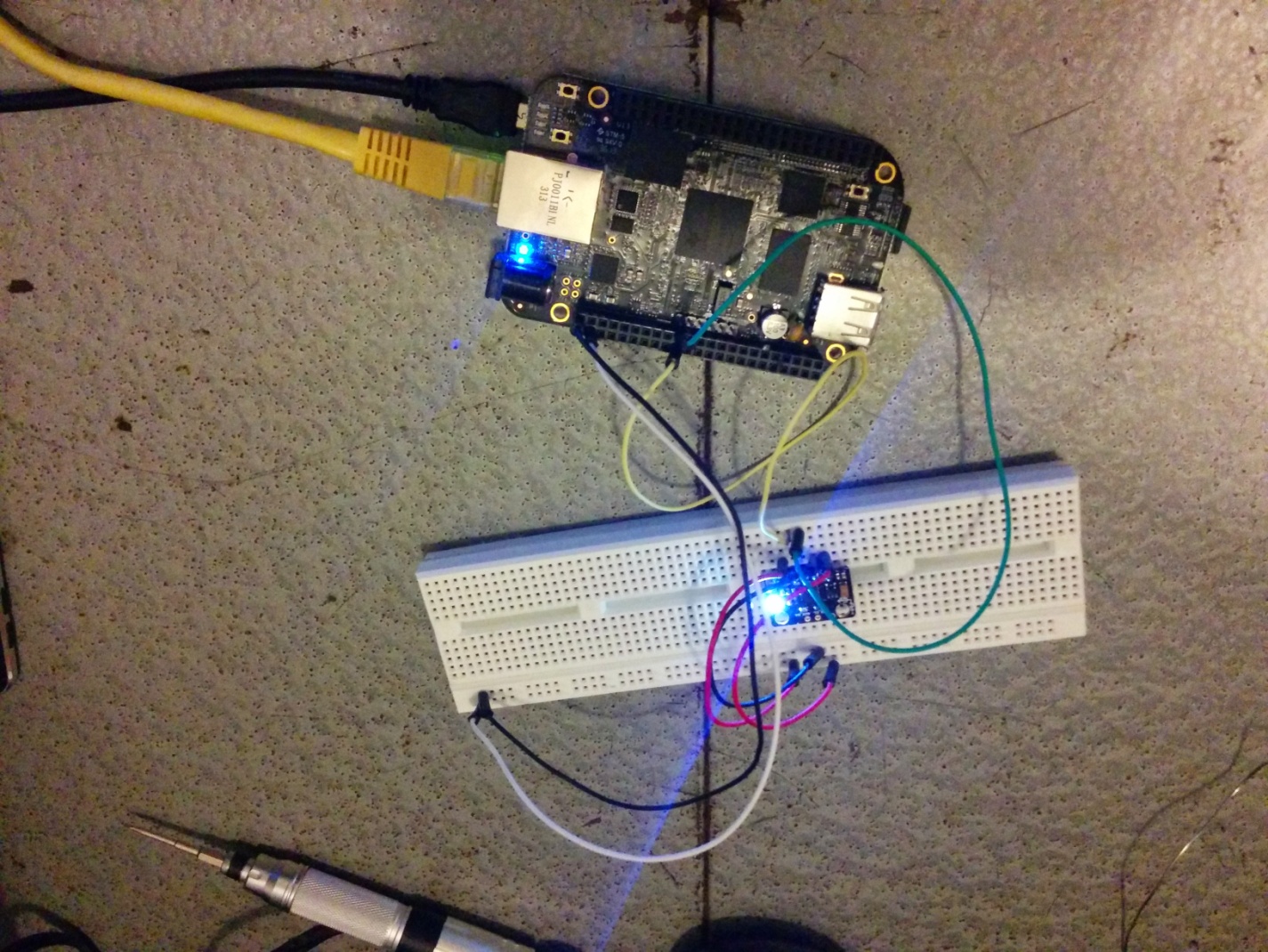
* Windows 8.1
* Latest version of Putty

**Quick Start**

This tutorial will demonstrate the steps needed to set up the development environment on a BeagleBone and execute the test application that satisfies the requirements for the IMU Integration homework.

* Download the latest image
  + <http://beagleboard.org/latest-images>
* Extract and copy image to SD card
  + <https://learn.adafruit.com/beaglebone-black-installing-operating-systems/windows>
* Flash image to BeagleBone
  + <https://learn.adafruit.com/beaglebone-black-installing-operating-systems/flashing-the-beaglebone-black>
* SSH into BeagleBone using Putty
  + SSH over USB or plug in an Ethernet cable
  + Default IP address is 192.168.7.2
  + Login at root, no password
* Install mpu6050 package
  + npm install mpu6050
* Install python-smbus
  + sudo apt-get install python-smbus
* Download the application
  + wget https://jshare.johnshopkins.edu/tflorid1/public\_html/imu.py
* Execute
  + python imu.c

**Photograph**



**Equations**

Convert raw accelerometer data into pitch and roll in radians:

**pitch = atan (x / sqrt(y^2 + z^2))**

**roll = atan (y / sqrt(z^2 + z^2))**

Convert radians into degrees:

**pitch = (pitch \* 180) / PI**

**roll = (roll \* 180) / PI**

**Implementation**

The following file, *imu.py*, is written in Python. It reads raw I2C values. The values read are accelerometer and gyroscope values. The values converted into roll, pitch and yaw values in degrees. A median filter is used to avoid outliers in the data. Yaw is outputted as **angular yaw** due to yaw drift and a lack of a manometer.

# Tony Florida

# 2014-10-28

# JHU RTSW HW 6 - IMU

from Adafruit\_I2C import Adafruit\_I2C

from time import sleep

import math

# Filter enum

ROLL = 0

PITCH = 1

YAW = 2

# Filter index

index = 0

# Filter array len

FIlTER\_SIZE = 5

# Filters

roll\_filter=[0,0,0,0,0]

pitch\_filter=[0,0,0,0,0]

yaw\_filter=[0,0,0,0,0]

def median\_filter( filt, val ):

if filt == ROLL:

roll\_filter[index]=val

sorted(roll\_filter)

return roll\_filter[2]

elif filt == PITCH:

pitch\_filter[index]=val

sorted(pitch\_filter)

return pitch\_filter[2]

elif filt == YAW:

yaw\_filter[index]=val

sorted(yaw\_filter)

return yaw\_filter[2]

else:

print "Filter error"

return 0;

# initialize i2c connection to MPU6050

# i2c address is 0x68

i2c = Adafruit\_I2C(0x68)

# wake up the device (out of sleep mode)

# bit 6 on register 0x6B set to 0

i2c.write8(0x6B, 0)

print "Roll Pitch Yaw"

while True:

#Accel

#read i2c accelerations in m/s^2

ax = (i2c.readS8(0x3b)\*256+i2c.readU8(0x3c))/16384.0

ay = (i2c.readS8(0x3d)\*256+i2c.readU8(0x3e))/16384.0

az = (i2c.readS8(0x3f)\*256+i2c.readU8(0x40))/16384.0

#print "{:+03.3f}".format(ax),

#print "{:+03.3f}".format(ay),

#print "{:+03.3f}".format(az)

#Gyro

#read i2c gyroscope in degree/s

gx = (i2c.readS8(0x43)\*256+i2c.readU8(0x44))/131.0

gy = (i2c.readS8(0x45)\*256+i2c.readU8(0x46))/131.0

gz = (i2c.readS8(0x47)\*256+i2c.readU8(0x48))/131.0

#print "{:+03.3f}".format(gx),

#print "{:+03.3f}".format(gy),

#print "{:+03.3f}".format(gz)

#Calculate Roll, Pitch, Yaw as degrees

# \*\* is exponent in Python

#To get Radians, remove the... \* 180) / math.pi

pitch = (math.atan(ax / math.sqrt(ay \*\* 2 + az \*\* 2)) \* 180) / math.pi

roll = (math.atan(ay / math.sqrt(az \*\* 2 + az \*\* 2)) \* 180) / math.pi

yaw = gz

#Median filter

roll = median\_filter(ROLL, roll)

pitch = median\_filter(PITCH, pitch)

yaw = median\_filter(YAW, yaw)

print "{:+03.3f}".format(roll),

print "{:+03.3f}".format(pitch),

print "{:+03.3f}".format(yaw)

index = index + 1

if index >= FIlTER\_SIZE:

index = 0

sleep(0.01)

**Results**

**Raw I2C Data**

Roll Pitch Yaw

+0.000 +0.000 +0.000

+0.000 +0.000 +0.000

+4.323 +1.429 +0.046

+4.323 +1.429 +0.046

+4.323 +1.429 +0.046

+4.323 +1.429 +0.046

+4.323 +1.429 +0.046

+4.783 +1.484 +0.237

+4.783 +1.484 +0.237

+4.783 +1.484 +0.237

+4.783 +1.484 +0.237

+4.783 +1.484 +0.237

+4.868 +1.188 -1.916

+4.868 +1.188 -1.916

+4.868 +1.188 -1.916

+4.868 +1.188 -1.916

+4.868 +1.188 -1.916

+4.758 +1.226 -0.435

+4.758 +1.226 -0.435

+4.758 +1.226 -0.435

+4.758 +1.226 -0.435

+4.758 +1.226 -0.435

+4.392 +0.949 +0.229

+4.392 +0.949 +0.229

+4.392 +0.949 +0.229

+4.392 +0.949 +0.229

+4.392 +0.949 +0.229

+4.052 +2.332 -4.496

+4.052 +2.332 -4.496

+4.052 +2.332 -4.496

+4.052 +2.332 -4.496

+4.052 +2.332 -4.496

+4.052 -2.496 -4.771

+4.052 -2.496 -4.771

+4.052 -2.496 -4.771

+4.052 -2.496 -4.771

+4.052 -2.496 -4.771

+4.546 -9.697 -8.511

+4.546 -9.697 -8.511

+4.546 -9.697 -8.511

+4.546 -9.697 -8.511

+4.546 -9.697 -8.511

+4.221 -16.069 -7.779

+4.221 -16.069 -7.779

+4.221 -16.069 -7.779

+4.221 -16.069 -7.779

+4.221 -16.069 -7.779

+4.347 -24.097 -2.031

+4.347 -24.097 -2.031

+4.347 -24.097 -2.031

+4.347 -24.097 -2.031

+4.347 -24.097 -2.031

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+5.519 -30.627 -0.947

+5.519 -30.627 -0.947

+5.519 -30.627 -0.947

+5.519 -30.627 -0.947

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+5.173 -34.809 +1.603

+5.173 -34.809 +1.603

+5.173 -34.809 +1.603

+5.173 -34.809 +1.603

+6.082 -43.470 -4.618

+6.082 -43.470 -4.618

+6.082 -43.470 -4.618

+6.082 -43.470 -4.618

+6.082 -43.470 -4.618

+5.031 -50.630 -12.901

+5.031 -50.630 -12.901

+5.031 -50.630 -12.901

+5.031 -50.630 -12.901

+5.031 -50.630 -12.901

+4.825 -60.291 -6.206

+4.825 -60.291 -6.206

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+4.825 -60.291 -6.206

+4.825 -60.291 -6.206

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+5.837 -69.636 -5.939

+5.837 -69.636 -5.939

+5.837 -69.636 -5.939

+5.837 -69.636 -5.939

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-1.410 -46.146 +12.023

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-2.650 -24.372 +14.458

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+0.290 -17.171 +7.099

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-3.173 -6.708 -0.450

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-3.314 -2.032 +2.160

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-3.314 -2.032 +2.160

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+4.785 +44.881 +14.672

+4.785 +44.881 +14.672

+4.671 +55.955 +4.092

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+37.919 +86.346 +10.450

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+4.600 +56.956 -22.664

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+4.579 +0.276 -1.916

+4.579 +0.276 -1.916

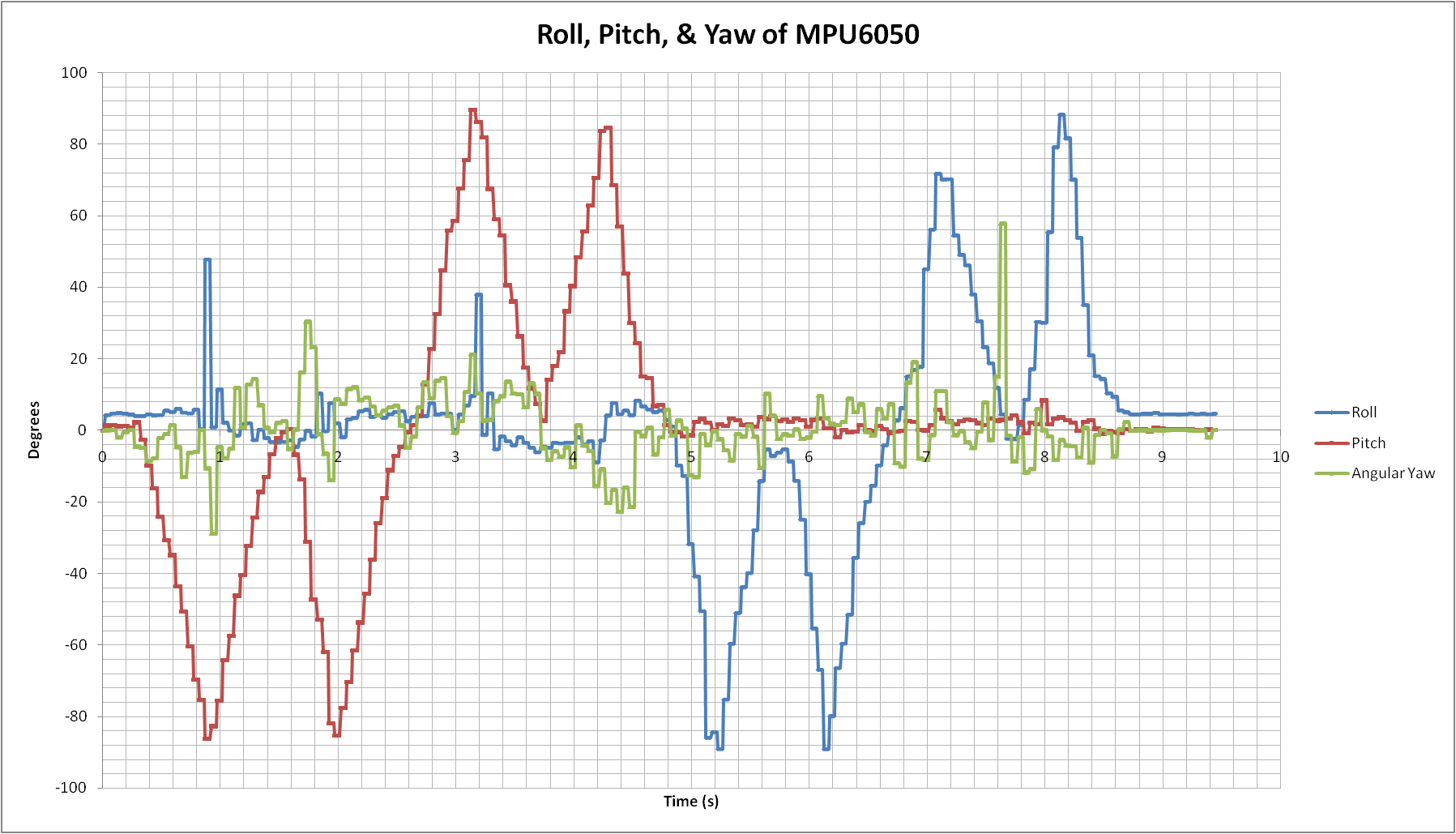
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+4.637 +0.179 +0.176

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+4.637 +0.179 +0.176

**Plot**

**Video Presentation**

<https://www.youtube.com/watch?v=aHcPScUt5aw>

**References**

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[3] <https://github.com/BunsenMcDubbs/BeagleCar/blob/master/src/test/xaccel.py>

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