HW6 IMU Integration

Johns Hopkins University

Real Time Software for Embedded Systems

Fall 2014

Tony Florida & Joe DiMarino

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

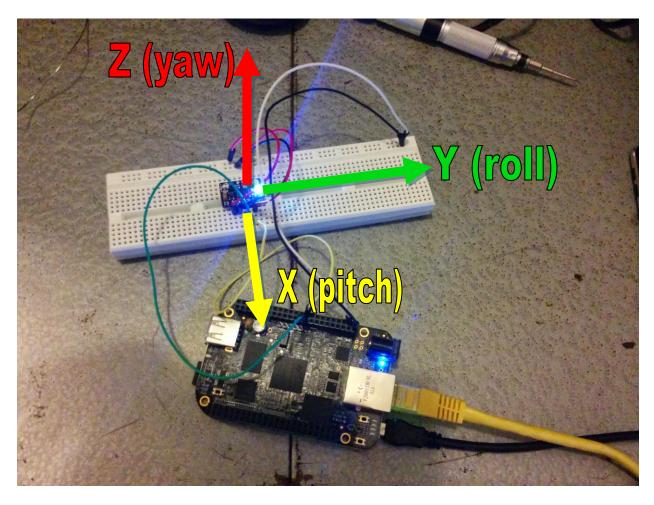
- Windows 8.1
- Latest version of Putty

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
 - O https://learn.adafruit.com/beaglebone-black-installing-operating-systems/windows
- Flash image to BeagleBone
 - https://learn.adafruit.com/beaglebone-black-installing-operating-systems/flashing-thebeaglebone-black
- SSH into BeagleBone using Putty
 - o SSH over USB or plug in an Ethernet cable
 - o Default IP address is 192.168.7.2
 - Login at root, no password
- Install mpu6050 package
 - o npm install mpu6050
- Install python-smbus
 - o sudo apt-get install python-smbus
- Download the application
 - o wget https://jshare.johnshopkins.edu/tflorid1/public html/imu.py
- Execute
 - o 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 >= FIITER SIZE:
                index = 0
        sleep(0.01)
```

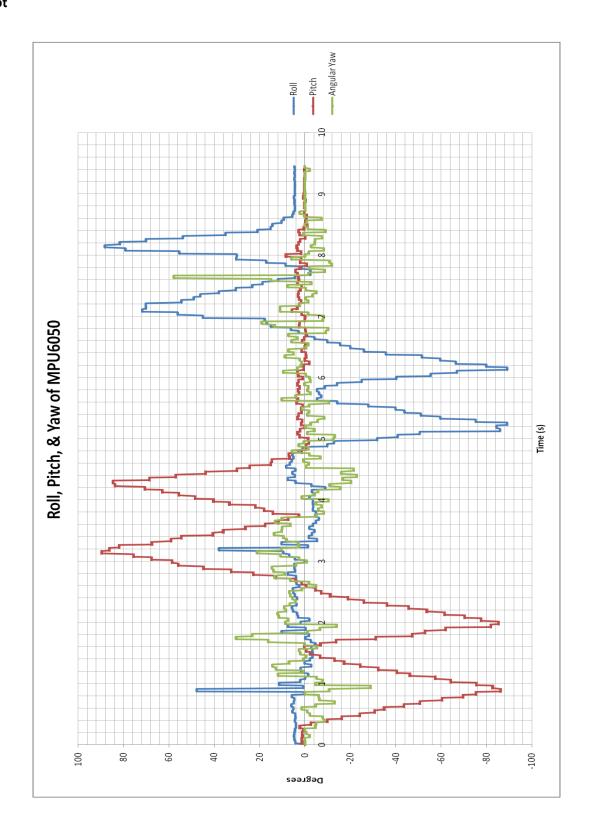
Results

Raw I2C Data

Doll Ditab Voss	15 027 60 626 5 020	2 721 10 400 E 152	12 550 10 760 15 572
ROII PILCH IAW	+3.03/ -09.030 -3.939	-2.721 +0.400 -3.133	+3.330 -10.762 +3.373
+0.000 +0.000 +0.000	+5.837 -69.636 -5.939	-2.721 +0.408 -5.153	+3.558 -18.762 +5.573
+0.000 +0.000 +0.000	+5.837 -69.636 -5.939	-2.721 +0.408 -5.153	+3.558 -18.762 +5.573
+4 323 +1 429 +0 046	+0 366 -75 252 +0 198	-4 631 -6 719 ±0 305	+4 588 -11 039 +6 511
11.323 11.123 10.010	10.300 73.232 10.130	1.001 0.719 10.305	11.500 11.039 10.511
+4.323 +1.429 +0.046	+0.366 -75.252 +0.198	-4.631 -6.719 +0.305	+4.588 -11.039 +6.511
+4.323 +1.429 +0.046	+0.366 -75.252 +0.198	-4.631 -6.719 +0.305	+4.588 -11.039 +6.511
+4 323 +1 429 +0 046	+0 366 -75 252 +0 198	-4 631 -6 719 +0 305	+4 588 -11 039 +6 511
14 323 11 420 10 046	10.300 75.252 10.190	4 631 6 710 10 305	14 500 11 030 16 511
+4.323 +1.429 +0.046	+0.366 -75.252 +0.198	-4.631 -6.719 +0.305	+4.588 -11.039 +6.511
+4.783 +1.484 +0.237	+47.827 -86.125 -10.611	-2.477 -13.597 +16.336	+5.205 -7.013 +6.962
+4.783 +1.484 +0.237	+47.827 -86.125 -10.611	-2.477 -13.597 +16.336	+5.205 -7.013 +6.962
14 703 11 404 10 227	147 007 06 105 10 611	2 477 12 507 116 226	15 205 7.013 16 062
T4./03 T1.404 TU.23/	T47.027 -00.123 -10.011	-2.4// -13.39/ +10.330	+3.203 =7.013 +0.902
+4.783 +1.484 +0.237	+47.827 -86.125 -10.611	-2.477 -13.597 +16.336	+5.205 -7.013 +6.962
+4.783 +1.484 +0.237	+47.827 -86.125 -10.611	-2.477 -13.597 +16.336	+5.205 -7.013 +6.962
+4 868 +1 188 -1 916	+0 931 -82 615 -28 863	_0 132 _31 100 +30 435	+5 /39 =/ 62/ +1 /27
14.000 11.100 1.510	10.551 02.015 20.005	0.132 31.100 130.435	15.433 4.024 11.427
+4.868 +1.188 -1.916	+0.931 -82.615 -28.863	-0.132 -31.100 +30.435	+5.439 -4.624 +1.427
+4.868 +1.188 -1.916	+0.931 -82.615 -28.863	-0.132 -31.100 +30.435	+5.439 -4.624 +1.427
+4 868 +1 188 -1 916	+0 931 -82 615 -28 863	-0 132 -31 100 +30 435	+5 439 -4 624 +1 427
14 060 11 100 1 016	10.001 02.015 20.005	0.132 31.100 130.133	15 430 4 634 11 437
+4.868 +1.188 -1.916	+0.931 -82.613 -28.863	-0.132 -31.100 +30.435	+5.439 -4.624 +1.427
+4.758 +1.226 -0.435	+11.404 -75.534 -4.557	-1.695 -47.080 +23.313	+2.562 -0.377 -4.794
+4 758 +1 226 -0 435	+11 404 -75 534 -4 557	-1 695 -47 080 +23 313	+2 562 -0 377 -4 794
+4 750 +1 226 -0 425	+11 404 -75 524 -4 557	_1 605 _47 000 ±22 212	+2 562 -0 377 -4 794
T4.750 T1.220 T0.455	T11.404 -75.554 -4.557	-1.095 -47.000 +25.515	+2.502 -0.577 -4.794
+4.758 +1.226 -0.435	+11.404 -75.534 -4.557	-1.695 -47.080 +23.313	+2.562 -0.3// -4./94
+4.758 +1.226 -0.435	+11.404 -75.534 -4.557	-1.695 -47.080 +23.313	+2.562 -0.377 -4.794
+4 392 +0 949 +0 229	+2 135 -64 225 -7 748	+10 296 -52 876 -1 031	+3 885 +1 508 -1 695
TV 303 TU 0V0 TU 330	+2 125 -64 225 7 740	110 206 -52 976 1 021	12 005 11 500 1 605
T4.J9Z TU.949 TU.ZZ9	TZ.133 =04.ZZ3 =1.748	TIU.290 =32.070 =1.U31	+3.003 TI.3U8 =1.095
+4.392 +0.949 +0.229	+2.135 -64.225 -7.748	+10.296 -52.876 -1.031	+3.885 +1.508 -1.695
+4.392 +0.949 +0.229	+2.135 -64.225 -7.748	+10.296 -52.876 -1.031	+3.885 +1.508 -1.695
+4 302 +0 040 +0 220	+5.837 -69.636 -5.939 +5.837 -69.636 -5.939 +5.837 -69.636 -5.939 +0.366 -75.252 +0.198 +0.366 -75.252 +0.198 +0.366 -75.252 +0.198 +0.366 -75.252 +0.198 +0.366 -75.252 +0.198 +0.366 -75.252 +0.198 +47.827 -86.125 -10.611 +47.827 -86.125 -10.611 +47.827 -86.125 -10.611 +47.827 -86.125 -10.611 +47.827 -86.125 -10.611 +47.827 -86.125 -10.611 +0.931 -82.615 -28.863 +0.931 -82.615 -28.863 +0.931 -82.615 -28.863 +0.931 -82.615 -28.863 +0.931 -82.615 -28.863 +1.404 -75.534 -4.557 +11.404 -75.534 -4.557 +11.404 -75.534 -4.557 +11.404 -75.534 -4.557 +11.404 -75.534 -4.557 +11.404 -75.534 -4.557 +11.404 -75.534 -4.557 +2.135 -64.225 -7.748 +2.135 -64.225 -7.748	-1.695 -47.080 +23.313 -1.695 -47.080 +23.313 +10.296 -52.876 -1.031 +10.296 -52.876 -1.031 +10.296 -52.876 -1.031 +10.296 -52.876 -1.031 +10.296 -52.876 -1.031 -0.186 -61.980 -6.527 -0.186 -61.980 -6.527 -0.186 -61.980 -6.527 -0.186 -61.980 -6.527 -0.186 -61.980 -6.527 -0.186 -61.980 -6.527 +7.656 -81.872 -13.855 +7.656 -81.872 -13.855 +7.656 -81.872 -13.855	+3 885 +1 500 -1 605
T4.392 TU.949 TU.229	TZ.133 -04.223 -7.740	T10.290 -32.070 -1.031	+3.003 +1.300 -1.093
+4.052 +2.332 -4.496	+0.018 -57.277 -4.992	-0.186 -61.980 -6.527	+3.942 +4.170 +6.565
+4.052 +2.332 -4.496	+0.018 -57.277 -4.992	-0.186 -61.980 -6.527	+3.942 +4.170 +6.565
+4 052 +2 332 -4 496	+0 018 -57 277 -4 992	-0 186 -61 980 -6 527	+3 9/12 +/ 170 +6 565
14.052 12.552 4.450	10.010 57.277 4.552	0.100 01.500 0.527	13.342 14.170 10.303
+4.052 +2.332 -4.496	+0.018 -57.277 -4.992	-0.186 -61.980 -6.527	+3.942 +4.170 +6.565
+4.052 +2.332 -4.496	+0.018 -57.277 -4.992	-0.186 -61.980 -6.527	+3.942 +4.170 +6.565
+4.052 -2.496 -4.771	-1.410 -46.146 +12.023	+7.656 -81.872 -13.855	+4.014 +12.777 +13.550
+4 052 -2 406 -4 771	_1 /10 _/6 1/6 ±12 022	±7 656 _01 072 _13 055	+4 014 +12 777 +13 550
+4.032 -2.430 -4.771	-1.410 -46.146 +12.023 -1.410 -46.146 +12.023 -1.410 -46.146 +12.023 -1.410 -46.146 +12.023 +1.714 -40.303 +0.916 +1.714 -40.303 +0.916 +1.714 -40.303 +0.916 +1.714 -40.303 +0.916 +1.714 -40.303 +0.916 +2.055 -32.181 +12.908 +2.055 -32.181 +12.908	+7.000 -01.072 -13.000	T4.014 T12.777 T13.330
+4.052 -2.496 -4.771	-1.410 -46.146 +12.023	+7.656 -81.872 -13.855	+4.014 +12.777 +13.550
+4.052 -2.496 -4.771	-1.410 -46.146 +12.023	+7.656 -81.872 -13.855	+4.014 +12.777 +13.550
+4.052 -2.496 -4.771	-1 410 -46 146 +12 023	+7 656 -81 872 -13 855	+4.014 +12.777 +13.550
14.032 2.430 4.771	1.710 40.140 112.025	17.030 01.072 13.033	17.014 112.777 113.550
+4.546 -9.697 -8.511	+1./14 -40.303 +0.916	+2.038 -85.166 +8.771	+7.687 +22.910 +9.061
+4.546 -9.697 -8.511	+1.714 -40.303 +0.916	+2.038 -85.166 +8.771	+7.687 +22.910 +9.061
+4.546 -9.697 -8.511	+1.714 -40.303 +0.916	+2.038 -85.166 +8.771	+7.687 +22.910 +9.061
+4.546 -9.697 -8.511	11 714 40 303 10 016	12 030 05 166 10 771	17 607 122 010 10 061
T4.340 -9.097 -0.311	T1./14 -40.303 T0.916	TZ.030 -03.100 TO.7/1	+7.007 +22.910 +9.001
+4.546 -9.697 -8.511	+1.714 -40.303 +0.916	+2.038 -85.166 +8.771	+7.687 +22.910 +9.061
+4.221 -16.069 -7.779	+2.055 -32.181 +12.908	-1.888 -77.589 +7.443	+4.395 +32.633 +13.931
+4.221 -16.069 -7.779	+2 055 -32 181 +12 908	-1 888 -77 589 +7 443	+4 395 +32 633 +13 931
14 221 16 060 7 770	12.055 32.101 112.500	1 000 77.509 17.113	14 205 122 622 112 021
+4.221 -16.069 -7.779	+2.055 =32.181 +12.908	-1.888 -//.389 +/.443	+4.395 +32.633 +13.931
+4.221 -16.069 -7.779	+2.055 -32.181 +12.908	-1.888 -77.589 +7.443	+4.395 +32.633 +13.931
+4.221 -16.069 -7.779	+2.055 -32.181 +12.908	-1.888 -77.589 +7.443	+4.395 +32.633 +13.931
+4.347 -24.097 -2.031	-2 650 -24 372 +14 458	+3 139 =70 334 +11 626	+4 785 +44 881 +14 672
11.017 21.007 2.001	2.000 21.072 111.100	13.133 70.331 111.020	11.705 111.001 111.072
+4.347 -24.097 -2.031	-2.650 -24.372 +14.458	+3.139 = 70.334 +11.626	+4.785 +44.881 +14.672
+4.347 -24.097 -2.031	-2.650 -24.372 +14.458	+3.139 -70.334 +11.626	+4.785 +44.881 +14.672
+4.347 -24.097 -2.031	-2.650 -24.372 +14.458	+3.139 -70.334 +11.626	+4.785 +44.881 +14.672
+4.347 -24.097 -2.031	-2 650 -24 372 +14 458	+3 139 =70 334 +11 626	+4 785 +44 881 +14 672
IE E10 20 627 0 047	10 200 17 171 17 000	13 EO6 61 304 112 000	14 671 155 055 14 000
+5.519 -30.627 -0.947	TU.29U =1/.1/1 +/.U99	TJ.JUD =01.394 +12.U92	T4.0/1 T00.900 +4.092
+5.519 -30.627 -0.947	+0.290 -17.171 +7.099	+3.506 -61.394 +12.092	+4.671 +55.955 +4.092
+5.519 -30.627 -0.947	+0.290 -17.171 +7.099	+3.506 -61.394 +12.092	+4.671 +55.955 +4.092
+5.519 -30.627 -0.947	+0.290 -17.171 +7 099	+3.506 -61.394 +12 092	+4.671 +55.955 +4 092
+5.519 -30.627 -0.947	+0 200 -17 171 17 000	+3 506 -61 304 113 003	±4 671 JEE 0EE 14 000
TJ.J19 -30.021 -0.941	TU.29U =1/.1/1 +/.U99	TJ.JUD =01.J94 +12.U92	T4.0/1 T00.900 +4.092
+5.173 -34.809 +1.603	+2.055 -32.181 +12.908 +2.055 -32.181 +12.908 +2.055 -32.181 +12.908 +2.055 -32.181 +12.908 +2.055 -32.181 +12.908 +2.055 -32.181 +12.908 -2.650 -24.372 +14.458 -2.650 -24.372 +14.458 -2.650 -24.372 +14.458 -2.650 -24.372 +14.458 -2.650 -24.372 +14.458 +0.290 -17.171 +7.099 +0.290 -17.171 +7.099 -2.130 -12.980 +0.802 -2.130 -12.980 +0.802	+5.358 -53.646 +8.504	+0.230 +58.568 -0.603
+5.173 -34.809 +1.603	-2.130 -12.980 +0.802	+5.358 -53.646 +8.504	+0.230 +58.568 -0.603
+5.173 -34.809 +1.603	-2.130 -12.980 +0.802	+5.358 -53.646 +8.504	+0.230 +58.568 -0.603
15 173 34 000 11 603	2 120 12 000 10 002	15 250 53.010 10.307	10 220 150.500 0.003
T3.1/3 =34.009 T1.003	-2.130 -12.900 +0.002	TJ.330 =33.040 T0.304	+0.230 +30.360 -0.603
+5.173 -34.809 +1.603	-2.130 -12.980 +0.802	+5.358 -53.646 +8.504	+0.230 +58.568 -0.603
+6.082 -43.470 -4.618	-3.173 -6.708 -0.450	+5.745 -45.517 +9.260	+4.461 +67.704 +2.679
+6.082 -43.470 -4.618	-3.173 -6.708 -0.450	+5.745 -45.517 +9.260	+4.461 +67.704 +2.679
+6.082 -43.470 -4.618	-3.173 -6.708 -0.450	+5.745 -45.517 +9.260	+4.461 +67.704 +2.679
+6.082 -43.470 -4.618	-3.173 -6.708 -0.450	+5.745 -45.517 +9.260	+4.461 +67.704 +2.679
+6.082 -43.470 -4.618	-3.173 -6.708 -0.450	+5.745 -45.517 +9.260	+4.461 +67.704 +2.679
+5.031 -50.630 -12.901	-3.314 -2.032 +2.160	+3.796 -36.119 +6.763	+6.997 +75.589 +10.878
+5.031 -50.630 -12.901	-3.314 -2.032 +2.160	+3.796 -36.119 +6.763	+6.997 +75.589 +10.878
+5.031 -50.630 -12.901	-3.314 -2.032 +2.160	+3.796 -36.119 +6.763	+6.997 +75.589 +10.878
+5.031 -50.630 -12.901	-3.314 -2.032 +2.160	+3.796 -36.119 +6.763	+6.997 +75.589 +10.878
+5.031 -50.630 -12.901	-3.314 -2.032 +2.160	+3.796 -36.119 +6.763	+6.997 +75.589 +10.878
+4.825 -60.291 -6.206	-3.133 -0.422 +2.733	+4.364 -25.953 +4.290	+9.632 +89.653 +21.328
+4.825 -60.291 -6.206	-3.133 -0.422 +2.733	+4.364 -25.953 +4.290	+9.632 +89.653 +21.328
+4.825 -60.291 -6.206	-3.133 -0.422 +2.733	+4.364 -25.953 +4.290	+9.632 +89.653 +21.328
+4.825 -60.291 -6.206	-3.133 -0.422 +2.733	+4.364 -25.953 +4.290	+9.632 +89.653 +21.328
+4.825 -60.291 -6.206	-3.133 -0.422 +2.733	+4.364 -25.953 +4.290	+9.632 +89.653 +21.328
+5.837 -69.636 -5.939	-2.721 +0.408 -5.153	+3.558 -18.762 +5.573	+37.919 +86.346 +10.450
+5.837 -69.636 -5.939	-2.721 +0.408 -5.153	+3.558 -18.762 +5.573	+37.919 +86.346 +10.450

+37.919 +86.346 +10.450	-3.851 +55.647 -4.206	-12.707 -1.572 +0.527	-8.701 +2.393
+37.919 +86.346 +10.450	-3.851 +55.647 -4.206	-12.707 -1.572 +0.527	-8.701 +2.393
+37.919 +86.346 +10.450 -1.261 +82.048 +2.809	-3.851 +55.647 -4.206 -3.851 +55.647 -4.206	-31.757 -1.285 -12.435 -31.757 -1.285 -12.435	-8.701 +2.393 -8.701 +2.393
-1.261 +82.048 +2.809	-3.851 +55.647 -4.206	-31.757 -1.285 -12.435	-14.031 +3.333
-1.261 +82.048 +2.809	-2.980 +62.944 -5.672	-31.757 -1.285 -12.435	-14.031 +3.333
-1.261 +82.048 +2.809 -1.261 +82.048 +2.809	-2.980 +62.944 -5.672 -2.980 +62.944 -5.672	-31.757 -1.285 -12.435 -40.770 +2.411 -13.023	-14.031 +3.333 -14.031 +3.333
+10.413 +67.584 +2.985	-2.980 +62.944 -5.672	-40.770 +2.411 -13.023	-14.031 +3.333
+10.413 +67.584 +2.985	-2.980 +62.944 -5.672	-40.770 +2.411 -13.023	-24.881 +2.923
+10.413 +67.584 +2.985 +10.413 +67.584 +2.985	-8.927 +70.676 -15.519 -8.927 +70.676 -15.519	-40.770 +2.411 -13.023 -40.770 +2.411 -13.023	-24.881 +2.923 -24.881 +2.923
+10.413 +67.584 +2.985	-8.927 +70.676 -15.519	-50.450 +3.223 -0.901	-24.881 +2.923
-5.213 +59.023 +8.229 -5.213 +59.023 +8.229	-8.927 +70.676 -15.519 -8.927 +70.676 -15.519	-50.450 +3.223 -0.901 -50.450 +3.223 -0.901	-24.881 +2.923 -40.184 +1.121
-5.213 +59.023 +8.229	-2.734 +83.737 -10.817	-50.450 +3.223 -0.901	-40.184 +1.121
-5.213 +59.023 +8.229	-2.734 +83.737 -10.817	-50.450 +3.223 -0.901	-40.184 +1.121
-5.213 +59.023 +8.229 -1.660 +54.628 +9.618	-2.734 +83.737 -10.817 -2.734 +83.737 -10.817	-85.888 +2.310 -4.046 -85.888 +2.310 -4.046	-40.184 +1.121 -40.184 +1.121
-1.660 +54.628 +9.618	-2.734 +83.737 -10.817	-85.888 +2.310 -4.046	-55.310 +3.019
-1.660 +54.628 +9.618	+4.151 +84.704 -20.229	-85.888 +2.310 -4.046	-55.310 +3.019
-1.660 +54.628 +9.618 -1.660 +54.628 +9.618	+4.151 +84.704 -20.229 +4.151 +84.704 -20.229	-85.888 +2.310 -4.046 -84.337 +0.209 -0.168	-55.310 +3.019 -55.310 +3.019
-2.958 +40.605 +13.695	+4.151 +84.704 -20.229	-84.337 +0.209 -0.168	-55.310 +3.019
-2.958 +40.605 +13.695 -2.958 +40.605 +13.695	+4.151 +84.704 -20.229 +7.740 +68.563 -16.573	-84.337 +0.209 -0.168 -84.337 +0.209 -0.168	-66.863 +3.256 -66.863 +3.256
-2.958 +40.605 +13.695	+7.740 +68.563 -16.573	-84.337 +0.209 -0.168	-66.863 +3.256
-2.958 +40.605 +13.695	+7.740 +68.563 -16.573	-89.032 +1.741 -2.443	-66.863 +3.256
-4.148 +36.072 +10.382 -4.148 +36.072 +10.382	+7.740 +68.563 -16.573 +7.740 +68.563 -16.573	-89.032 +1.741 -2.443 -89.032 +1.741 -2.443	-66.863 +3.256 -89.071 +0.713
-4.148 +36.072 +10.382	+4.600 +56.956 -22.664	-89.032 +1.741 -2.443	-89.071 +0.713
-4.148 +36.072 +10.382	+4.600 +56.956 -22.664	-89.032 +1.741 -2.443	-89.071 +0.713
-4.148 +36.072 +10.382 -1.890 +26.358 +10.214	+4.600 +56.956 -22.664 +4.600 +56.956 -22.664	-75.156 +1.291 -5.489 -75.156 +1.291 -5.489	-89.071 +0.713 -89.071 +0.713
-1.890 +26.358 +10.214	+4.600 +56.956 -22.664	-75.156 +1.291 -5.489	-79.879 +0.703
-1.890 +26.358 +10.214 -1.890 +26.358 +10.214	+5.599 +43.909 -15.847 +5.599 +43.909 -15.847	-75.156 +1.291 -5.489 -75.156 +1.291 -5.489	-79.879 +0.703 -79.879 +0.703
-1.890 +26.358 +10.214	+5.599 +43.909 -15.847	-59.592 +3.272 -8.336	-79.879 +0.703 -79.879 +0.703
-3.399 +17.667 +6.511	+5.599 +43.909 -15.847	-59.592 +3.272 -8.336	-79.879 +0.703
-3.399 +17.667 +6.511 -3.399 +17.667 +6.511	+5.599 +43.909 -15.847 +4.259 +30.018 -21.344	-59.592 +3.272 -8.336 -59.592 +3.272 -8.336	-66.398 -1.889 -66.398 -1.889
-3.399 +17.667 +6.511	+4.259 +30.018 -21.344	-59.592 +3.272 -8.336	-66.398 -1.889
-3.399 +17.667 +6.511 -4.772 +11.855 +13.214	+4.259 +30.018 -21.344 +4.259 +30.018 -21.344	-51.008 +2.817 -0.901 -51.008 +2.817 -0.901	-66.398 -1.889 -66.398 -1.889
-4.772 +11.855 +13.214 -4.772 +11.855 +13.214	+4.259 +30.016 -21.344	-51.008 +2.817 -0.901	-59.548 +0.250
-4.772 +11.855 +13.214	+8.371 +24.416 -0.313	-51.008 +2.817 -0.901	-59.548 +0.250
-4.772 +11.855 +13.214 -4.772 +11.855 +13.214	+8.371 +24.416 -0.313 +8.371 +24.416 -0.313	-51.008 +2.817 -0.901 -43.853 +1.471 -1.702	-59.548 +0.250 -59.548 +0.250
-6.059 +7.477 +10.244	+8.371 +24.416 -0.313	-43.853 +1.471 -1.702	-59.548 +0.250
-6.059 +7.477 +10.244	+8.371 +24.416 -0.313	-43.853 +1.471 -1.702	-51.504 -0.573 -51.504 -0.573
-6.059 +7.477 +10.244 -6.059 +7.477 +10.244	+6.718 +15.096 -1.557 +6.718 +15.096 -1.557	-43.853 +1.471 -1.702 -43.853 +1.471 -1.702	-51.504 -0.573
-6.059 +7.477 +10.244	+6.718 +15.096 -1.557	-39.805 +1.838 +1.382	-51.504 -0.573
-4.604 +2.774 -4.916 -4.604 +2.774 -4.916	+6.718 +15.096 -1.557 +6.718 +15.096 -1.557	-39.805 +1.838 +1.382 -39.805 +1.838 +1.382	-51.504 -0.573 -35.576 -0.212
-4.604 +2.774 -4.916	+5.886 +14.708 +0.840	-39.805 +1.838 +1.382	-35.576 -0.212
-4.604 +2.774 -4.916	+5.886 +14.708 +0.840	-39.805 +1.838 +1.382	-35.576 -0.212 -35.576 -0.212
-4.604 +2.774 -4.916 -4.795 +14.224 -8.168	+5.886 +14.708 +0.840 +5.886 +14.708 +0.840	-27.843 +1.097 -1.687 -27.843 +1.097 -1.687	-35.576 -0.212
-4.795 +14.224 -8.168	+5.886 +14.708 +0.840	-27.843 +1.097 -1.687	-25.918 +1.619
-4.795 +14.224 -8.168 -4.795 +14.224 -8.168	+5.122 +6.866 -6.702 +5.122 +6.866 -6.702	-27.843 +1.097 -1.687 -27.843 +1.097 -1.687	-25.918 +1.619 -25.918 +1.619
-4.795 +14.224 -8.168	+5.122 +6.866 -6.702	-14.186 +3.887 -10.450	-25.918 +1.619
-3.382 +18.153 -5.756 -3.382 +18.153 -5.756	+5.122 +6.866 -6.702	-14.186 +3.887 -10.450	-25.918 +1.619
-3.382 +18.153 -5.756 -3.382 +18.153 -5.756	+5.122 +6.866 -6.702 +5.581 +7.193 -1.855	-14.186 +3.887 -10.450 -14.186 +3.887 -10.450	-19.880 +0.196 -19.880 +0.196
-3.382 +18.153 -5.756	+5.581 +7.193 -1.855	-14.186 +3.887 -10.450	-19.880 +0.196
-3.382 +18.153 -5.756 -3.561 +21.925 -7.237	+5.581 +7.193 -1.855 +5.581 +7.193 -1.855	-5.287 +3.245 +10.328 -5.287 +3.245 +10.328	-19.880 +0.196 -19.880 +0.196
-3.561 +21.925 -7.237 -3.561 +21.925 -7.237	+5.581 +7.193 -1.855	-5.287 +3.245 +10.328 -5.287 +3.245 +10.328	-19.880 +0.196 -15.428 +0.014
-3.561 +21.925 -7.237	+2.939 +1.593 +5.863	-5.287 +3.245 +10.328	-15.428 +0.014
-3.561 +21.925 -7.237	+2.939 +1.593 +5.863	-5.287 +3.245 +10.328 -7.145 +4.082 +4.145	-15.428 +0.014 -15.428 +0.014
-3.561 +21.925 -7.237 -3.333 +33.383 -4.695	+2.939 +1.593 +5.863 +2.939 +1.593 +5.863	-7.145 +4.082 +4.145 -7.145 +4.082 +4.145	-15.428 +0.014 -15.428 +0.014
-3.333 +33.383 -4.695	+2.939 +1.593 +5.863	-7.145 +4.082 +4.145 -7.145 +4.082 +4.145	-9.737 +1.230
-3.333 +33.383 -4.695 -3.333 +33.383 -4.695	+1.141 -0.363 -1.420		-9.737 +1.230 -9.737 +1.230
-3.333 +33.383 -4.695 -3.333 +33.383 -4.695	+1.141 -0.363 -1.420 +1.141 -0.363 -1.420	-7.145 +4.082 +4.145 -6.155 +2.698 -2.336	-9.737 +1.230
-3.363 +40.398 -10.260	+1.141 -0.363 -1.420	-6.155 +2.698 -2.336	-9.737 +1.230
-3.363 +40.398 -10.260 -3.363 +40.398 -10.260	+1.141 -0.363 -1.420 -9.742 -0.500 +2.748	-6.155 +2.698 -2.336 -6.155 +2.698 -2.336	-4.123 +0.418 -4.123 +0.418
-3.363 +40.398 -10.260 -3.363 +40.398 -10.260	-9.742 -0.500 +2.748 -9.742 -0.500 +2.748	-6.155 +2.698 -2.336 -6.155 +2.698 -2.336	-4.123 +0.418 -4.123 +0.418
-3.363 +40.398 -10.260	-9.742 -0.500 +2.748	E 200 (2 212 1 002	-4.123 +0.418
-1.960 +48.399 +1.481 -1.960 +48.399 +1.481	-9.742 -0.500 +2.748 -9.742 -0.500 +2.748	-5.208 +3.213 -1.092 -5.208 +3.213 -1.092 -5.208 +3.213 -1.092	-4.123 +0.418 -0.499 -0.664
-1.960 +48.399 +1.481	-12.707 -1.572 +0.527	-5 /08 +3 /13 -1 09/	-0.499 -0.664
-1.960 +48.399 +1.481	-12.707 -1.572 +0.527	-5.208 +3.213 -1.092 -8.701 +2.393 -1.366	-0.499 -0.664 -0.499 -0.664

-0 499 -0 664 +7 366	+38 050 +2 987 -4 847	+79 140 +3 340 -8 206	+4.501 +0.404 +0.076
+2 901 -0 296 -0 060	+38.050 +2.987 -4.847 +38.050 +2.987 -4.847	+70 140 +3 340 -0 206	+4.501 +0.404 +0.076
+2.801 -0.286 -9.069	+30.562 +2.117 -0.229	+79.140 +3.340 -8.206	+4.501 +0.404 +0.076
12 001 0 206 0 060			
+2.801 -0.286 -9.069	+30.562 +2.117 =0.229		+4.501 +0.404 +0.076
+2.801 -0.286 -9.069	+30.562 +2.117 -0.229		+4.665 +0.352 +0.092
+2.801 -0.286 -9.069	+30.562 +2.117 -0.229		+4.665 +0.352 +0.092
+6.215 +0.000 -10.099	+30.562 +2.117 -0.229	+88.305 +3.687 -2.634	+4.665 +0.352 +0.092
+6.215 +0.000 -10.099	+23.281 +1.530 +7.809	+88.305 +3.687 -2.634	+4.665 +0.352 +0.092
+6.215 +0.000 -10.099	+23.281 +1.530 +7.809	+81.630 +2.882 -4.160	+4.665 +0.352 +0.092
+6.215 +0.000 -10.099	+23.281 +1.530 +7.809	+81.630 +2.882 -4.160	+4.634 -0.180 +0.031
+6.215 +0.000 -10.099	+23.281 +1.530 +7.809 +23.281 +1.530 +7.809 +23.281 +1.530 +7.809 +23.281 +1.530 +7.809 +23.281 +1.530 +7.809	+88.305 +3.687 -2.634 +81.630 +2.882 -4.160 +81.630 +2.882 -4.160 +81.630 +2.882 -4.160	+4.634 -0.180 +0.031
+15.070 +2.683 +13.435			+4.634 -0.180 +0.031
+15.070 +2.683 +13.435	+18.803 +3.418 -2.672		+4.634 -0.180 +0.031
+15.070 +2.683 +13.435	+18 803 +3 418 -2 672	+70 094 +2 201 -4 298	+4.634 -0.180 +0.031
+15.070 +2.683 +13.435	+18.803 +3.418 -2.672 +18.803 +3.418 -2.672	+70 094 +2 201 -4 298	+4.948 +0.798 +0.153
+15.070 +2.683 +13.435	+18.803 +3.418 -2.672	+70.094 +2.201 -4.298	+4.948 +0.798 +0.153
. 4 5 04 0 . 0 . 404 . 40 . 445	.40 000 .0 440 0 680	170 004 12 201 4 200	
116.919 12.421 119.145	+18.803 +3.418 -2.672 +11.884 +2.785 +15.107 +11.884 +2.785 +15.107 +11.884 +2.785 +15.107		+4.948 +0.798 +0.153
+16.919 +2.421 +19.145	+11.884 +2.785 +15.107	+/0.094 +2.201 -4.298	+4.948 +0.798 +0.153
+16.919 +2.421 +19.145	+11.884 +2.785 +15.107	+53.862 +0.028 -7.458	+4.948 +0.798 +0.153
+16.919 +2.421 +19.145	+11.884 +2.785 +15.107	+53.862 +0.028 -7.458	+4.493 +0.625 +0.031
+16.919 +2.421 +19.145	+11.884 +2.785 +15.107	+53.862 +0.028 -7.458	+4.493 +0.625 +0.031
+17.740 +0.235 -7.824	+11.884 +2.785 +15.107	+53.862 +0.028 -7.458	+4.493 +0.625 +0.031
+17.740 +0.235 -7.824	+4.490 +2.993 +57.924	+53.862 +0.028 -7.458	+4.493 +0.625 +0.031
+17.740 +0.235 -7.824	+4.490 +2.993 +57.924	+35.104 +2.534 +0.893	+4.493 +0.625 +0.031
+17.740 +0.235 -7.824	+4.490 +2.993 +57.924	+53.862 +0.028 -7.458 +53.862 +0.028 -7.458 +53.862 +0.028 -7.458 +53.862 +0.028 -7.458 +35.104 +2.534 +0.893 +35.104 +2.534 +0.893	+4.575 +0.430 +0.115
+17.740 +0.235 -7.824	+4.490 +2.993 +57.924	+35.104 +2.534 +0.893	+4.575 +0.430 +0.115
+45.100 +0.083 -8.214	+4.490 +2.993 +57.924	+35.104 +2.534 +0.893	+4.575 +0.430 +0.115
+45 100 +0 083 -8 214	-2 282 +3 393 -1 412	+35 104 +2 534 +0 893	+4 575 +0 430 +0 115
+45 100 +0 083 -8 214	-2 282 +3 393 -1 412	+21 011 +2 948 -8 924	+4 575 +0 430 +0 115
+45 100 +0.003 0.211	-2 282 +3 393 -1 412	+21 011 +2 948 -8 924	+4 583 +0 465 +0 183
±45.100 ±0.003 =0.214	-2.202 +3.393 -1.412	+21.011 +2.940 -0.924	+4.503 +0.405 +0.103
156 160 11 614 1 200	2 202 12 202 1 412	121 011 12 040 0 024	14 503 10 465 10 103
+56.168 +1.614 -1.298	-2.282 +3.393 -1.412	+21.011 +2.948 -8.924	+4.583 +0.465 +0.183
+56.168 +1.614 -1.298	+11.884 +2.785 +15.107 +11.884 +2.785 +15.107 +11.884 +2.785 +15.107 +4.490 +2.993 +57.924 +4.490 +2.993 +57.924 +4.490 +2.993 +57.924 +4.490 +2.993 +57.924 +4.490 +2.993 +57.924 -2.282 +3.393 -1.412 -2.282 +3.393 -1.412 -2.281 +4.238 -8.687 -2.414 +4.238 -8.687 -2.414 +4.238 -8.687	+21.011 +2.948 -8.924	+4.583 +0.465 +0.183
+56.168 +1.614 -1.298	-2.414 +4.238 -8.687 -2.414 +4.238 -8.687 -2.414 +4.238 -8.687 -2.414 +4.238 -8.687	+15.235 +0.529 -1.176 +15.235 +0.529 -1.176 +15.235 +0.529 -1.176 +15.235 +0.529 -1.176 +15.235 +0.529 -1.176	+4.583 +0.465 +0.183
+56.168 +1.614 -1.298	-2.414 +4.238 -8.687	+15.235 +0.529 -1.176	+4.456 +0.333 +0.176
+56.168 +1.614 -1.298	-2.414 +4.238 -8.687	+15.235 +0.529 -1.176	+4.456 +0.333 +0.176
+71.804 +5.864 +11.130	-2.414 +4.238 -8.687	+15.235 +0.529 -1.176	+4.456 +0.333 +0.176
+71.804 +5.864 +11.130	+1.571 +2.314 -1.885	+15.235 +0.529 -1.176	+4.456 +0.333 +0.176
+71.804 +5.864 +11.130	+1.571 +2.314 -1.885	+14.351 -0.833 +0.244	+4.456 +0.333 +0.176
+71.804 +5.864 +11.130	+1.571 +2.314 -1.885	+14.351 -0.833 +0.244	+4.553 +0.291 +0.206
+71.804 +5.864 +11.130	-2.414 +4.238 -8.087 +1.571 +2.314 -1.885 +1.571 +2.314 -1.885 +1.571 +2.314 -1.885 +1.571 +2.314 -1.885 +1.571 +2.314 -1.885 +1.671 +2.314 -1.885	+14.351 -0.833 +0.244	+4.553 +0.291 +0.206
+70.151 +3.473 +11.084	+1.571 +2.314 -1.885	+14.351 -0.833 +0.244	+4.553 +0.291 +0.206
+70.151 +3.473 +11.084	+8.665 -0.777 -11.725	+14.351 -0.833 +0.244 +10.420 -0.084 -0.725 +10.420 -0.084 -0.725 +10.420 -0.084 -0.725	+4.553 +0.291 +0.206
	+8.665 -0.777 -11.725	+10.420 -0.084 -0.725	+4.553 +0.291 +0.206
	+8.665 -0.777 -11.725	+10 420 -0 084 -0 725	+4.790 +0.315 +0.053
	+8.665 -0.777 -11.725	+10 420 -0 084 -0 725	+4.790 +0.315 +0.053
	+8.665 -0.777 -11.725	+10.420 -0.084 -0.725	+4.790 +0.315 +0.053
	.45 405 .0 050 40 500		+4.790 +0.315 +0.053
170.277 12.503 12.574			+4.790 +0.315 +0.053
+70.277 +2.563 +2.374	+17.105 +2.259 =10.755		
+70.277 +2.563 +2.374	T11.1U0 +2.209 -1U.133		+4.597 +0.055 +0.023
			+4.597 +0.055 +0.023
+54.486 +1.802 -1.275	+17.105 +2.259 -10.733	+9.362 -0.563 -7.168	+4.597 +0.055 +0.023
+54.486 +1.802 -1.275	+30.393 +1.697 +6.053	+9.362 -0.563 -7.168	+4.597 +0.055 +0.023
+54.486 +1.802 -1.275	+30.393 +1.697 +6.053	+5.626 -0.807 +0.321	+4.597 +0.055 +0.023
+54.486 +1.802 -1.275	+30.393 +1.697 +6.053	+5.626 -0.807 +0.321	+4.677 +0.236 +0.076
+54.486 +1.802 -1.275	+30.393 +1.697 +6.053	+5.626 -0.807 +0.321	+4.677 +0.236 +0.076
+49.077 +2.683 -0.153	+30.393 +1.697 +6.053	+5.626 -0.807 +0.321	+4.677 +0.236 +0.076
+49.077 +2.683 -0.153	+30.128 +8.441 +0.061	+5.626 -0.807 +0.321	+4.677 +0.236 +0.076
+49.077 +2.683 -0.153	+17.103 +2.259 -10.733 +30.393 +1.697 +6.053 +30.393 +1.697 +6.053 +30.393 +1.697 +6.053 +30.393 +1.697 +6.053 +30.393 +1.697 +6.053 +30.128 +8.441 +0.061 +30.128 +8.441 +0.061	+5.062 +0.412 +2.458	+4.677 +0.236 +0.076
+49.077 +2.683 -0.153	+30.128 +8.441 +0.061	+5.062 +0.412 +2.458	+4.579 +0.276 -1.916
+49.077 +2.683 -0.153	+30.128 +8.441 +0.061	+5.062 +0.412 +2.458	+4.579 +0.276 -1.916
+46.212 +3.064 -3.244		+5.062 +0.412 +2.458	+4.579 +0.276 -1.916
+46.212 +3.064 -3.244	+55.422 +1.795 -1.588	+5.062 +0.412 +2.458	+4.579 +0.276 -1.916
+46.212 +3.064 -3.244			+4.579 +0.276 -1.916
+46.212 +3.064 -3.244		+4.503 -0.042 -0.031	
			+4.637 +0.179 +0.176
+46.212 +3.064 -3.244	+55.422 +1.795 -1.588	+4.503 -0.042 -0.031	+4.637 +0.179 +0.176
+38.050 +2.987 -4.847	+55.422 +1.795 -1.588	+4.503 -0.042 -0.031	+4.637 +0.179 +0.176
+38.050 +2.987 -4.847		+4.503 -0.042 -0.031	+4.637 +0.179 +0.176
+38.050 +2.987 -4.847	+79.140 +3.340 -8.206	+4.501 +0.404 +0.076	



Video Presentation

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

References

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