**CENG4480 Embedded System Development and Applications**

**Computer Science and Engineering Department**

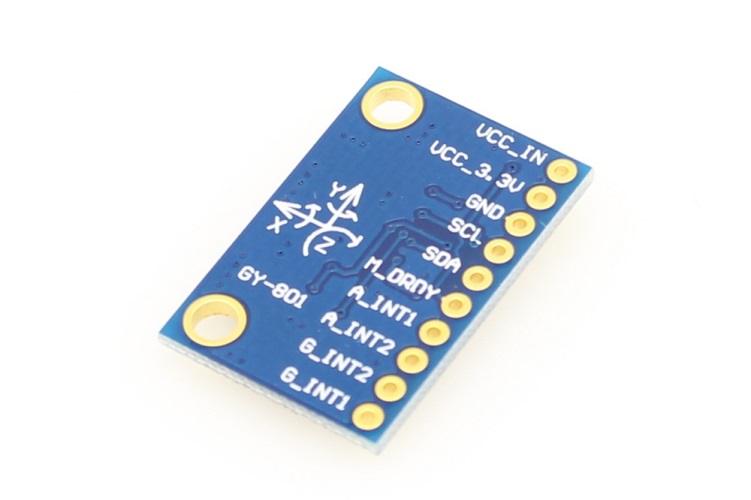
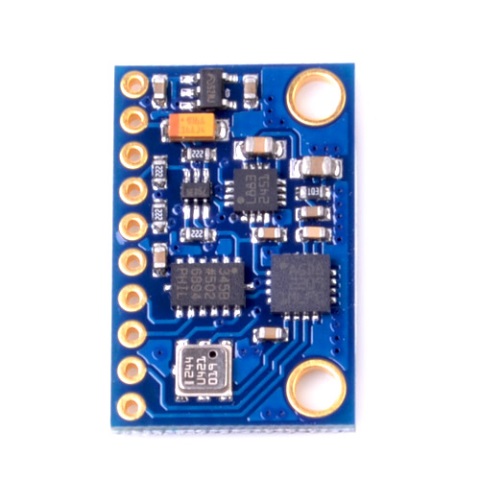
**The Chinese University of Hong Kong**

**Laboratory 7: IMU (Inertial Measurement Unit)**

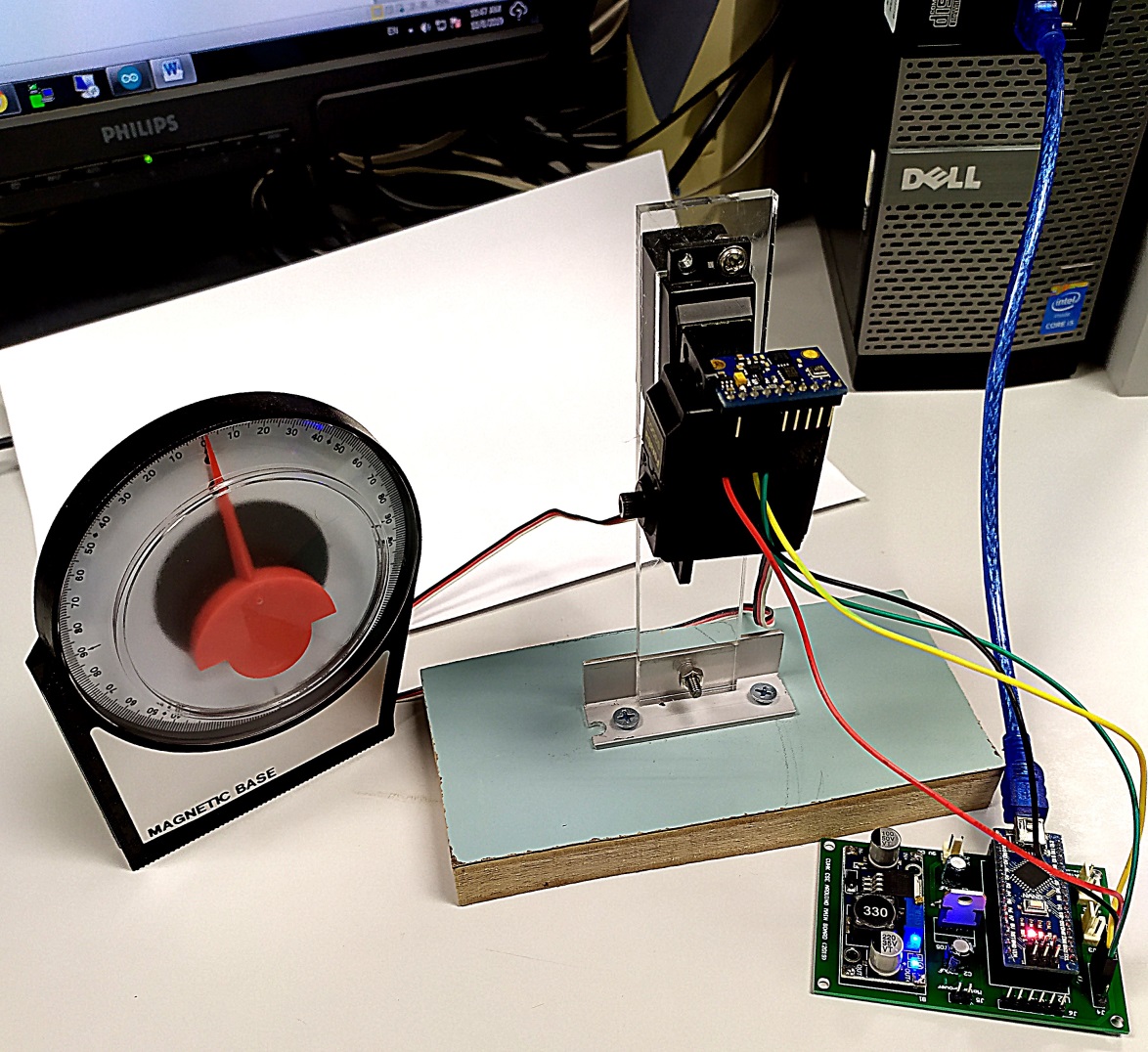
October, 2019

**Introduction**

In this exercise you will learn how to use IMU to measure the angle of an object and how to interface and read the IMU data via I2C channel by using Arduino controller board. In this exercise, we use a low cost IMU GY-801 module (see Figure 1) which based on MEMS (Micro Electro-Mechanical System) technology. GY-801 IMU module consists of 3-axis accelerometer ADXL345, 3-axis gyro L3G4200D, 3-axis compass HMC5883L and barometer BMP180. The platform is used to collect measurements from the accelerometers and gyros (see Figure 2).



**Figure 1. GY-801 IMU module**



**Figure 2. Experiment setup**

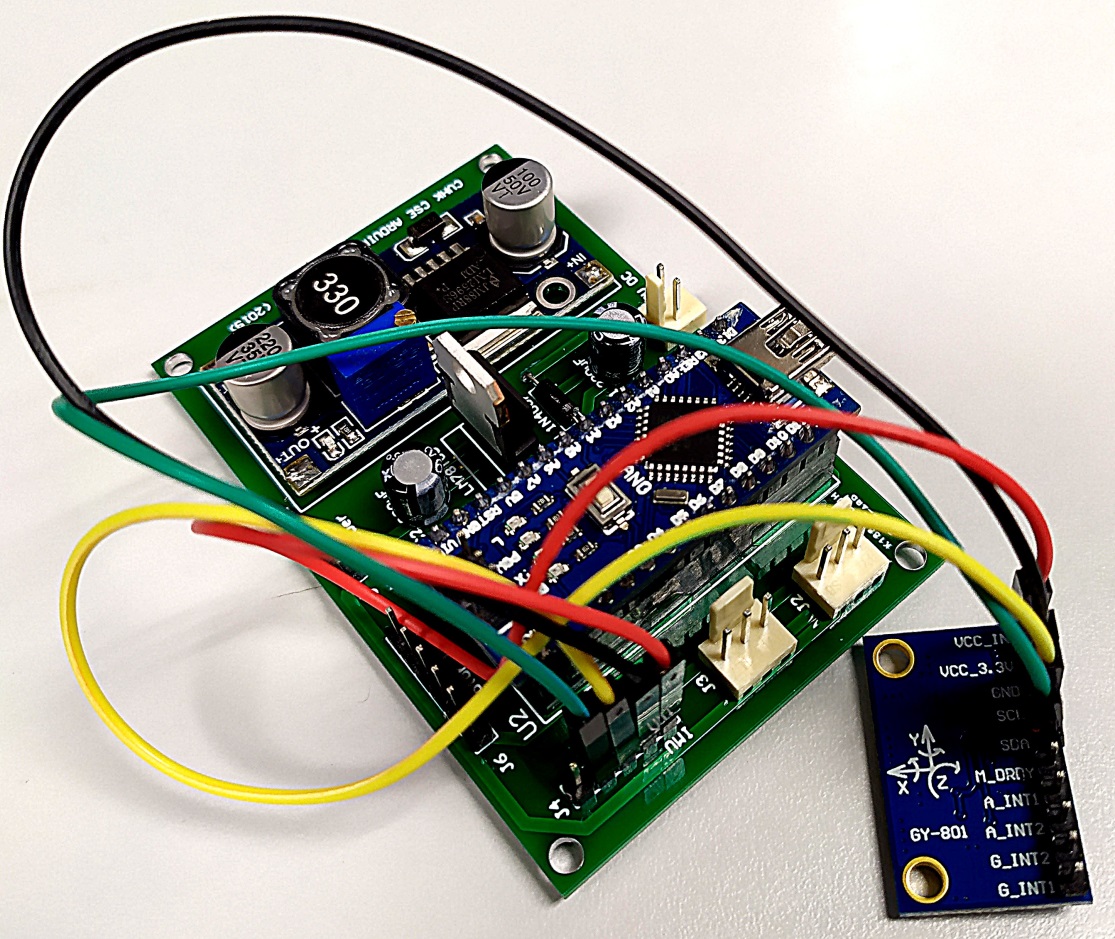
**Objectives**

* To learn how to interface IMU module to Arduino microcontroller via I2C
* To learn how to use IMU to measure the angle of an object
* To study the improvement of data stability by using Complement and Kalman filters

Procedures

1. **Connect the IMU module to Arduino board**

* Use dupont wires connect the VCC\_IN, GND, SCL and SDA of the IMU module to Arduino main board IMU connector J4 VCC, GND, SCL and SDA as shown on Figure 3. (refer to sample)

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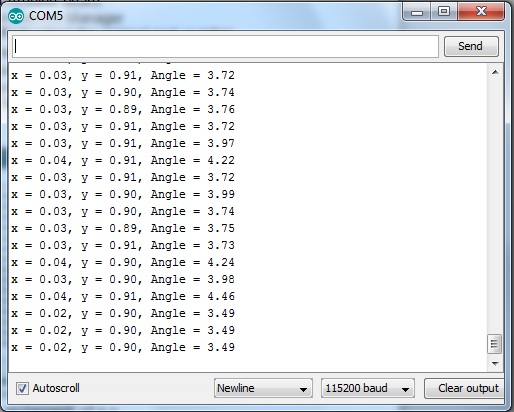
**Figure 3. Connection of IMU module**

1. **Attach the IMU module on the platform**

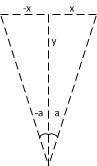
* Attach the IMU module on the platform by using plastic tape.
* Make sure it can rotate freely along the x axis.

1. **Upload the program Lab7.ino to Arduino board**

* Double click *Lab7.ino*
* Connect the USB cable from PC to Arduino board
* Observe the COM port number from Device Manager
* On the Arduino IDE **Tools**, **Serial Port** select the correct port number
* On the Arduino IDE **Tools**, **Board select** the **Arduino Nano**
* On the Arduino IDE press the Upload button
* Wait for the uploading program finish
* On the Arduino IDE **Tools**, select **Serial Monitor**, you should see the following window (use 115200 baud rate)



* X is the accelerometer value on x-axis, y is the accelerometer value on y-axis the angle a can be calculated from arctangent of x,y



* In Arduino there is an atan2(y,x) function, the angle value shown in the window is the result of atan2(y,x) function

1. **Record and fill the table for the platform in the different angle**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Platform Angle**  **(Degree)** | **-50** | **-40** | **-30** | **-20** | **-10** | **0** | **10** | **20** | **30** | **40** | **50** |
| **X** |  |  |  |  |  |  |  |  |  |  |  |
| **Y** |  |  |  |  |  |  |  |  |  |  |  |
| **Angle=atan2(y,x)**  **(Degree)** |  |  |  |  |  |  |  |  |  |  |  |

***Question 1. Find the approximate offset angle of IMU from your results. (The offset of IMU is different from module to module)***

1. **Study the improvement of data stability by using Complement and Kalman filters**

Complement and Kalman filters are commonly used in sensor fusion application. Sensor fusion is a set of adaptive algorithms for prediction and filtering. It takes advantage of different and complementary information coming from various sensors, combining it together in a smart way to optimize the performance of the system and enable new amazing applications [1].

For further details in theory of Complement and Kalman filter application in sensor fusion, you can refer to document in reference [1].

Procedures of experiment:

* In Lab7.ino change the code as following:

void loop()

{

float LRspeed;

static unsigned long newMilli; //new timestamp

newMilli = millis(); //save the time when sample is taken

Read\_acc();

Read\_gyro();

//compute interval since last sampling time in millisecond

interval = newMilli - lastMilli;

lastMilli = newMilli; //save for next loop, please note interval will be invalid in first sample but we don't use it

Ayz=atan2(RwAcc[1],RwAcc[2])\*180/PI; //angle measured by accelerometer

Ayz-=offset; //adjust to correct balance point

//delay(500);

//Serial.print("x = ");

//Serial.print(RwAcc[1]); // x-axis accelerometer value

//Serial.print(", y = ");

//Serial.print(RwAcc[2]); // y-axis accelerometer value

//Serial.print(", Angle = ");

Serial.print(Ayz);

Serial.print(", ");

Angy = 0.98\*(Angy+GyroIN[0]\*interval/1000)+0.02\*Ayz;//complement filter

kang = kalmanCalculate(Angy, GyroIN[0],interval); //kalman filter

kang+=0.65; //adjust the offset

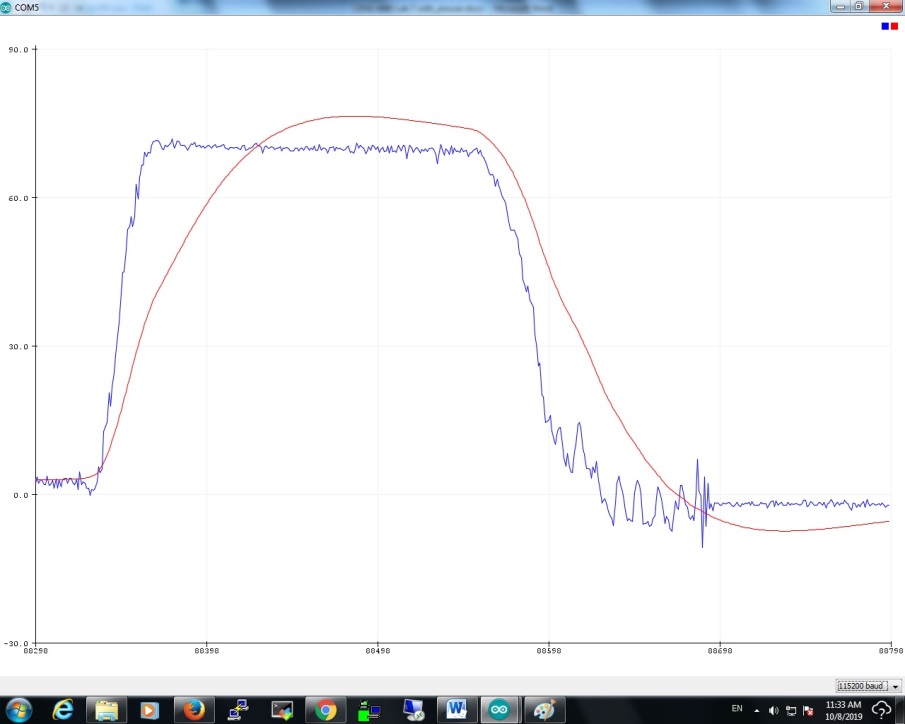
Serial.print(kang);

Serial.println(" ");

////////////////////////////

}

* Upload the program to the Arduino board by pressing the Upload button
* Place the platform in horizontal position
* On the Arduino IDE Tools, select Serial Plotter, you should see the following graphical diagram



*Blue line – data without filtering*

*Red line – data with Complement and Kalman filtering*

* Wait around one minute to let the data stable
* Rotate the platform to around 30 degree and rotate back to horizontal
* Capture the graphical diagram by pressing CTRL+Print Screen keys
* Use MS Paint to save the picture
* Open MS Paint
* Press CTRL+V keys
* Save as JPEG picture
* **Include this picture in your report**
* **In your report, explain the effect of applying Complement and Kalman filters on the IMU angle data**

**END**

Refrences:

[1] <http://www.mouser.hk/newproducts/applications.aspx?virtualdir=sensor_solutions_mems%2f>

[2] <http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1114&context=aerosp>

[3[] http://www.instructables.com/id/Guide-to-gyro-and-accelerometer-with-Arduino-inclu/](%5d%20http:/www.instructables.com/id/Guide-to-gyro-and-accelerometer-with-Arduino-inclu/)

[4] <http://ozzmaker.com/2015/01/27/guide-interfacing-gyro-accelerometer-raspberry-pi-kalman-filter/>