AI Sensors & Virtual/ Augmented Reality Technologies

Lab 1 and Homework 1

NOTE:

Homework 1 (HW1) is evaluated in terms of 10% of Final Mark!

Students who are absent in Lab 1 could not submit the HW1.

Submission of HW1 from individual student is not expected!

Lab 1 – 25/08/2023 @ Linear Electronics Lab

Sensing Signal Processing; Interfacing to IoT; Python Basics

Lecturer: Prof. Chengkuo Lee (elelc@nus.edu.sg)

Lab1 Lab Staff: Xinge Guo

About Lab1 and Homework1

Preparation:

1. Two students form a group and email to GA about the names and students ID.

   GA: Mr. Junsheng Xie (junshengxie@u.nus.edu) before 1PM, **Aug 24th**.
2. Every student is suggested to bring one laptop to the Lab.
3. Every student should **install Arduino IDE and Python before the lab.**
4. Relative code used in Lab1 will be provided and can be downloaded through Canvas before the class
5. Both students in one group need to attend the Lab 1 together in order to be eligible for Homework 1 submission.
6. If you do not find a pal to form the two-student group, please come to the lab venue at 5:45PM, Aug 25th (Fri). Then the CEG Lab Technical Staff will help to make group for those students.

Homework 1 (Deadline: Sep 22, 13:00): CA 10%

Submit a zip file to Canvas named "Name1-Student ID1_Name2- Student ID2_Lab1.zip", which includes:

a. One report that includes: your codes (screenshot with comments), explanations for the solutions and approaches, a screenshot/video to show the results and a statement about the contribution of the group member to each problem.

b. The original code.

c. Submission of homework 1 from students who do not attend the Lab 1 will not be taken into the CA of CEG5205.

d. Late submission will not be counted in the CA of CEG5205.

CEG5205 Weekly Plan (Update on Aug 23) -

NUS National University of Singapore

Semester starts on Aug 14

Week 1 (Aug 18)	Week 1: Introduction
Week 2 (Aug 25)	Week 2: Lab 1 – Sensing Signal Processing; Interfacing to IoT; Python Basics (E4A 06-03) @ Linear Electronics Lab
Week 3 (Sept 1)	National Holiday (Election)
Week 4 (Sept 8)	Week 3: MEMS Inertial Sensors, Tactile Sensors and Applications
Week 5 (Sept 15)	Week 4: VR/AR Technologies and Enabling Devices
Week 6 (Sept 22)	Week 5: Lab 2 – 3D Unity Basics; Real Time Control Demonstration in VR Space (E4A 06-03) @ Linear Electronics Lab
Recess Week:	Week 6: Make-up Session for the Sept 1st Time Slot – Consultation for Lab 2
Week 7 (Oct 6)	Week 7: Human-like Tactile Sensors, Glove-based Wearable Sensors and Finger Motion Sensors
Week 8 (Oct 13)	Week 8: Sensors for Intelligent Robotic Manipulators; Haptic Technology; Smart Home; Digital Twins; Metaverse
Week 9 (Oct 20)	Week 9: Futuristic Views of Metaverse Technology (AR in Cars)
Week 10 (Oct 27)	Week 10: Lab 3 – Deep Learning Basics; AIoT Sensor Demonstration @ Linear Electronics Lab
Week 11 (Nov 3)	Week 11: *Live Demonstration Project Consultation*
Week 12 (Nov 10)	Week 12: *Live Demonstration Project Consultation*
Week 13 (Nov 17)	Week 13: Individual Literature Review Report in PPT and Presentation

Reading Week (Nov 20-24): Final Live Demonstration, Report and Presentation (@ Linear Electronics Lab; Time Slots to Be Arranged)

CA Ratio: Homework Assignment / Individual Project - Literature Review Report / Quiz/ Class Participation (40%);
Group Project - Live Demonstration (10%)
Final Exam (50%)

Homework 1 – Lab1

1. Explore the influence of data transmission rates:

There are totally four Baud rates that need to be set in this lab: (Arduino board, two CC2530 modules, python)

You can try to set the Baud rate as listed in the table, write down what happens for the received signal, and overall explain the reason.

Design the Baud rate that you think is most appropriate (not required to be one of the combinations shown in the table), and explain the reason.

	#1	#2	#3	#4	#5	#6	#7
Arduino Board	19200	38400	19200	38400	38400	2400	115200
Transmitter CC2530 linked with Arduino	19200	19200	57600	38400	38400	2400	115200
Receiver CC2530 linked with laptop	19200	19200	57600	57600	19200	2400	115200
Python for reading the port	19200	19200	19200	57600	19200	2400	115200

Homework 1 – Lab1

2. Transfer the obtained data to acutual acceleration and change the sensing range to ± 16g

a. Currently, the sense data, e.g., 12340, is not the actual acceleration value, transfer it to corresponding acceleration.

Tips: the ADC value is 16-bit value.

b. Currently, the sensing range was set to ± 2g, while we can know from the data sheet that this inertial sensor have four different ranges: ± 2g, ± 4g, ± 8g, ± 16g. Change the sensing range to ± 16g.

Tips: you can try to find the function in MPU6050.h file

3. Data visualization

In the lab, we provide the method to draw the three-axis accelerations at the same time in one figure. Try to draw them separately in three figures.

Homework 1 – Lab1

Please set the sensing range of the accelerometer and gyroscope based on the numbers to finish the following question 4 and question 5.

The specific number for each group will be notified through email.

For example, if your group receive number “5”, then you should set the sensing range to ±2g, ±500°/s to finish Q4 & Q5

Group Number	Acc Range	Gyro Range	Group Number	Acc Range	Gyro Range	Group Number	Acc Range	Gyro Range
1	±2g	±250°/s	6	±4g	±500°/s	11	±8g	±1000°/s
2	±4g	±250°/s	7	±8g	±500°/s	12	±16g	±1000°/s
3	±8g	±250°/s	8	±16g	±500°/s	13	±2g	±2000°/s
4	±16g	±250°/s	9	±2g	±1000°/s	14	±4g	±2000°/s
5	±2g	±500°/s	10	±4g	±1000°/s	15	±8g	±2000°/s
						16	±16g	±2000°/s

Homework 1 – Lab1

4. Use the Sensed Data to Remove the Effect of Gravity:

The aim is to measure acceleration while accurately eliminating gravity's influence. This is essential for determining the true movement of the object without the constant pull of gravity skewing the results.

a. Attempt to Eliminate Gravity's Influence Using IMU's 3-axis Acceleration Data:

- When stationary at any angle, the acceleration on the x, y, and z axes should all be zero.
- After freely moving the IMU module for a while and then letting it rest at any angle, the acceleration on the x, y, and z axes should still be zero.

b. Try Adding IMU's Three-Axis Gyroscope for Measurement:

- Attempt to counteract gravity's effect using IMU's 6-axis data, including both acceleration and angular velocity.
- When stationary at any angle, the acceleration on the x, y, and z axes should all be zero.
- After freely moving the IMU module for a period and then letting it rest at any angle, the acceleration on the x, y, and z axes should still be zero.
- Compare the Effects With and Without Using Gyroscope Data. What kind of motion scenarios allow the inclusion of gyroscope data to make the measurements more effective?

Homework 1 – Lab1

5. Use the Sensed Data to Estimate the Velocity and Displacement

Noise and Errors in Acceleration Signals:

The detected acceleration signals often contain substantial noise and might include occasional error data points. These inaccuracies can cause a drift in the calculated values of velocity and displacement.

Filtering to Correct the Drift:

Method Options: You can correct the drift using methods like low-pass filters or Kalman filters. Feel free to try other approaches as well. You can either use python, Arduino, or Matlab to achieve this.

Objective: The goal is to ensure that the integrated **velocities return to zero on the x, y, and z axes once the motion comes to a halt.** To test this, manually move the IMU module at a specific frequency in back-and-forth motions, either left to right or up and down.

Frequency Evaluation: Evaluate the effectiveness of your chosen method within a particular frequency range.

Further Integration for Displacement:

Zero Point Return: Can your method allow the IMU to return to zero displacements on the x, y, and z axes after any random movement?

Displacement Precision: Use a ruler to assess the degree of precision your method can achieve in displacement measurements.