HLAB10
Embedded Motion Tracking System
Demonstration [Marks: 10]

This lab demonstrates the embedded motion tracking system by using the IMU data and further signal processing to compute the real-time orientation of the sensor. The demonstration will be marked out of 10 which is worth 10% of the total course marks.

1. AIMS

- To perform further signal processing on the IMU data within the Atmega328 board to compute the accurate orientation of the sensor.
- To demonstrate the motion tracking system using a provided GUI program.
- To prepare for a short report which is due at 5 pm Friday 25 May to the Wattle

2. Demonstration Marking (out of 10)

- Marks [0-6] - System is fully or partly working.
- Marks [7-8] - System is fully working accurately under dynamic motion.
- Marks [9-10] - System is fully working accurately under dynamic motion with extra efforts on innovation.

3. Further Signal Processing

- Data fusion: The orientation was computed from the accelerometer and magnetometer in HLAB09. It can also be computed by integrating the Euler angle rates (which is slightly different to the gyroscope outputs. See Appendix on how to convert the angular rates to the Euler rates). By taking a weighted average, a better orientation can be obtained. The weighting factor can be found heuristically or systematically (which is related to the Kalman filtering theory). You can adjust the weighting factor by considering a) the noise strengths of sensors, b) the amount of dynamic acceleration which causes errors in computing the direction of the gravity vector (roll and pitch).
- *Sensor setting*: Investigate the datasheet to further tune the sensors. For example, the sensor ranges can be changed which affect the resolution and dynamic sensitivity – a larger sensing-range means a lower resolution but detect wider dynamics.
- *Output data rates* can also be adjusted. A 10Hz output rate will be suitable for display but can be higher for internal processing.
- *Interrupt-based TWI reading*. Interrupt will enable the background-mode sensor reading thus maximising the signal processing time. The UART transmission can

also be done using interrupt with a ring-buffer. The Baud rate can be 115.2K to increase the serial speed.

- *Calibration*: The angular rates from the gyroscopes contain some biases, which can be averaged out while the sensors are in stationary.
- A 3D GUI program written in Python will be provided in Wattle as shown in Figure 1 below. It will be helpful to visualise the orientation and testing the system. It requires a *pyserial* module in the desktop PC.

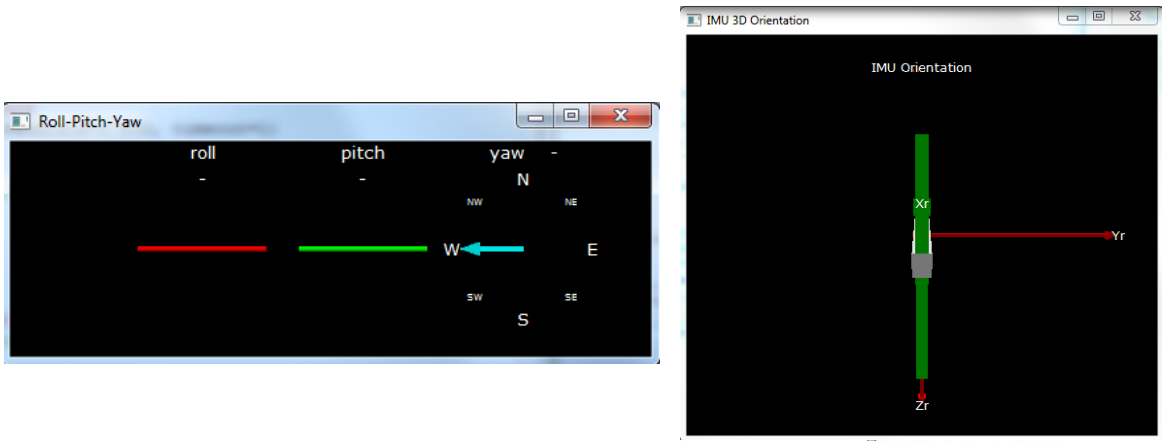

Figure 1 A Python GUI program for the demonstration.

4. **Report Submission**

- A brief report (5% weight) should be submitted on the embedded motion tracking system developed throughout the labs. The submission due is 5 pm Friday 25 May to the Wattle.
- The format is maximum 4 pages (any extra materials can be attached as an appendix). An exemplary outline is – abstract, introduction, hardware and software design, key results and discussion, conclusion and reference.

Appendix A1. Euler angle calculation using Angular rates

Appendix A2. Euler angle calculation using Gravity/Magnetic fields direction

Appendix A3.Weighted averaging