COMPSYS 704 Part 2

Final Report

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Introduction

The global tracking system (GPS) has become essential for workplace safety and socializing. GPS typically sends and receives signals between satellites and digital devices such as mobile phones. However, GPS cannot be used indoors due to the low signal strength, which results in low accuracy. Hence, new approaches are required to achieve an accurate indoor position-tracking system.

This report will discuss the implementation of the indoor tracking system using the LSM303AGR sensor and its performance.

Algorithm

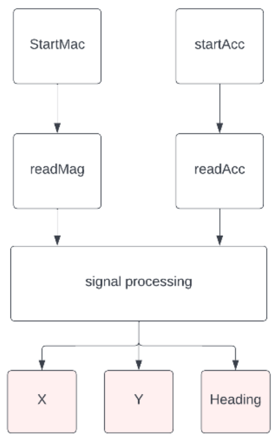


Figure 1: Overview of the proposed algorithm

The position tracking algorithm is built using five functions, as shown in figure 1: startMag, startAcc, readMag, readAcc, and the signal processing in the main function. The startMag and startAcc functions will write specific bits to the registers to initialize the accelerometer as normal mode and high mode for the magnetometer. These initializations will be the guidelines when collecting the magnetometer and accelerometer values. The readMag function reads the magnetic field values of x, y, and z. However, the values are collected separately in high and low values. As the output value requires 16 bits, we need to perform a left shift by 8 (<< 8) on the high value and combine it with the low value. This process is repeated 20 times, and the captured values are averaged to minimize the noise. The same process applies to the readAcc function; the only difference is that it captures acceleration values.

The averaged values are called in the main function where the signal processing occurs. The method that has been used to achieve tracking is step detection. Although there are multiple-step detection methods, the proposed method detects the oscillation of the arm as the target takes a step. As the sensor boots up, it will calculate the initial angle of the sensor to get the current heading.

$$\angle_0 = tan^{-1}\left(\frac{average\ magnenometer\ x}{average\ magnenometer\ y}\right) \times \frac{180}{\pi} \tag{1}$$

The pitch is calculated to detect the movement of the arm, which represents the step. The averaged values as follows:

$$Pitch = tan^{-1}\left(\frac{-average\ accelerator\ x}{average\ accelerator\ y^2}\right) + (average\ accelerator\ z^2 \times \frac{180}{\pi}) \tag{2}$$

The pitch is a rotation on the x-axis. This value is used to determine the movement of the arm. The sensitivity of the pitch can be determined through the if statement. The sensitivity of the movement is set to be sensitive as it is considered a step if the value of the pitch is greater than 2. However, the step does not get counted instantly. The if statement checks and delays the step update by 200ms by using the HAL_GetTick method and checks if the step_taken variable is true. This avoids any duplicated steps being updated multiple times. The first process in the if statement is to set the step_taken variable to false so it does not accidentally update the step twice. Next, the current angle is calculated using the equation as follows.

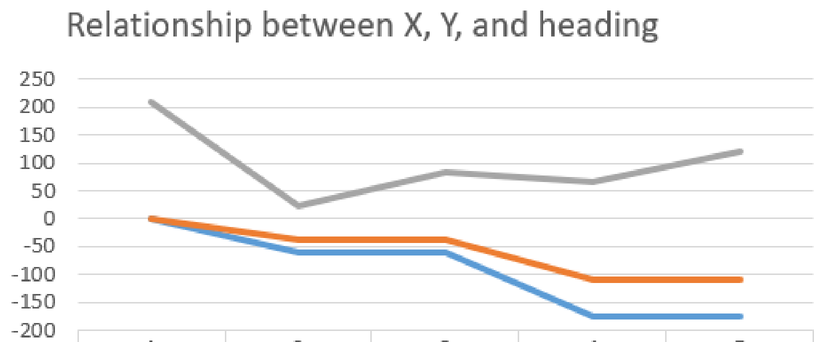
$$angle = initial\_angle - yaw\_m \tag{3}$$

The current angle is calculated by finding the difference between the previous and new angles. If the calculated angle is negative, an angle is added by 360 to avoid angle values being negative.

Angle	**Output**
0 < angle <= 90	x_position – step y_position + step
90 < angle <= 180	x_position – step y_position – step
180 < angle <= 270	x_position + step y_position – step
270 < angle < 360	x_position + step y_position + step

The angle increases anti-clockwise. The table above shows the angle conditions of the position update. The x and the y will store the data into x_position and y_position variables. Finally, the tick is updated and calculates the yaw value for angle calculation in the next event.

Performance analysis



	1	2	3	4	5
x	0	-59	-59	-176	-176
y	0	-37	-37	-108	-108
heading	210.5	23.2	82.5	64.6	119.9

x y heading

Figure 2: Performance of 5 trials

Figure 2 shows the results of the X, Y, and heading using 5 test results. The result of the heading was exceptional. The experiment was tested with the LSM303AGR sensor detached from the board after it had been programmed. I have rotated myself holding the sensor in my hand. As I rotated with the sensor, the heading values changed as expected. The value of the angle increases in the anti-clockwise direction and vice versa. However, the x position and the y position values are quite off with respect to the heading and the actual movement I took.

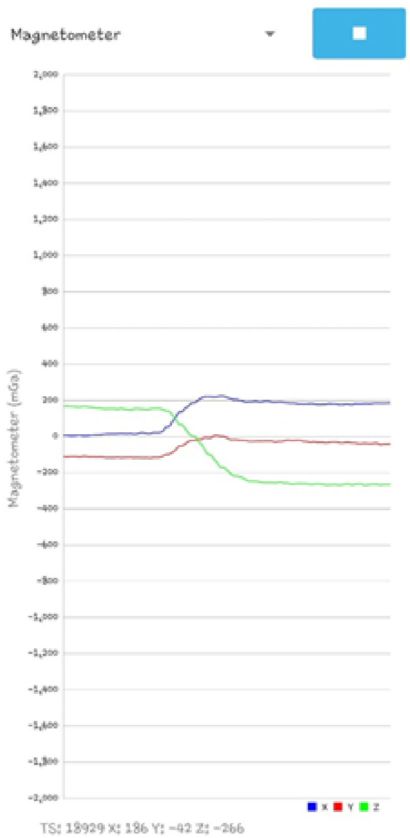


Figure 4: Magnetometer results

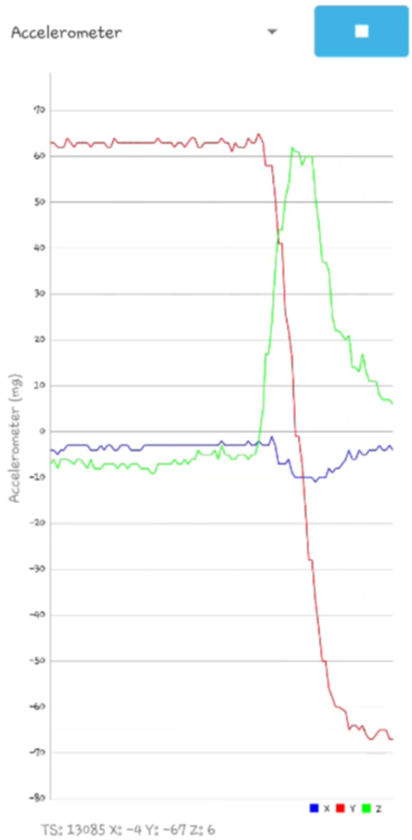


Figure 3: Accelerometer results

Figures 3 and 4 show the results of the magnetometer and accelerometer sensors. The magnetometer and accelerometer results vibrated extremely as the sensor constantly moved to check if the values changed as expected. The magnetometer values for x, y, and z are 0, -150, and 200 in stable mode. When the sensor moves, values for x, y, and z are 200, 0, and -350. The accelerometer values range from 0 to 100 mg, indicating 9.81N of force on the sensor. These sensors' results are reasonable as they show a trend change as the sensor is moved.

Discussion

The current implementation of the indoor positioning tracking system uses arm movement to detect the step. This is due to the limitations of the previous attempt at step-detection implementation. The previous attempt used the set threshold of the averaged values. The theory is that if the person takes a step, a vibration will be sent to the sensor. This vibration will affect the output of the accelerometer values, and with the set threshold, it can be determined if a step was taken.

The future work would be to implement the calculation of the x and y position, as current results are unreliable. Additionally, position accuracy can be identified using two methods: threshold and movement of the arm. A better method with greater accuracy can be selected for final implementation by comparing the accuracy.

Conclusion

This final report proposed the step detection-based indoor position tracking method where the sensor is attached to the arm. This method will detect a step as the arm swings and update the positions' value. The proposed method only gives an accurate result for the heading but lacks a step detection algorithm for position accuracy. However, it showed an excellent opportunity for IMU-based localization through this project. Although the results were not accurate, it has the potential to be used in many fields for entertainment, safety, and convenience.