Pedometer Prototype Report

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Introduction:

In this project, we aimed to design a distance recording program, with board STM32F4 with Gyroscope I3G4250D. We detail our calibration methodology and the process of converting gyroscope readings into distance measurements.

Methodology abstract:

1. Gyroscope Calibration

Gyroscope is a device that produces a positive-going digital output for counter-clockwise rotation around the axis considered. Since it could measure the angular, after calibration, we could convert the raw data into angular velocity. According to datasheet, the sensitivity of the gyroscope, when FS = 245 dps and typical values at +25 °C, the transfer factor is 8.75 mdps/digit. (Page 10 of the datasheet). So, we decided to use the Z axis as a better measurement output.

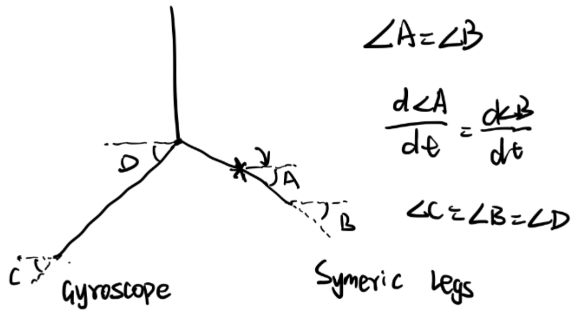
2. Empirical Testing

We discovered that the gyroscope readings indicated 245 degrees per second (dps). To verify this, we design a 4000 sample reads in 20 seconds during which the gyroscope is spined 5 whole rotations around the Z axis of the board (1800 degrees) and test the total amount of readings. Our analysis revealed that the cumulative readings over these 20 seconds amounted to approximately 19,000,000. This suggests that the gyroscope rotates at a rate of 1800 degrees every 20 seconds.

a. Distance Calculation

To estimate the distance traveled, the approach used angular velocity and leg length. This includes the presumption that a person's two legs are symmetrical as they walk. Therefore, while testing on the side of the leg, we decide to use data from the Z axis. Furthermore, we raised the board above the knee to prevent challenging data processing.

The calculation mode is shown on the below:



Given that reading is effective for both legs, albeit in distinct ways, we may do the following analysis. As we can see from the picture below, there is always one foot that is stationary as a person walks. This gives us the following formula: Distance change is calculated as reading (with offset removed) *2πr*0.05 (sampling frequency) *0.00875.
Because we want 20 seconds recording in total, so we set a 400 iterations threshold (20 iterations take 1 sec).

The reading $\cdot$ 8.75 mdps/digit $= \frac{dD}{dt}$

So $dD = \frac{d\angle A}{dt} \cdot \frac{2\pi leg}{360} dt$

leg is the Length of leg.

then formular = Reading $\cdot \frac{2\pi leg}{360} \cdot 0.05 \cdot 0.875$ dps/digit.

note:0.00875 comes from I3G4250D user manual page 10 as typical value of sensitivity and leg are the length of leg using apple distance measure App and rule.

b. Velocity Calculation

As we all know, the magnitude of velocity is affected by two factors: Angular Velocity and the length of leg "leg", since we already read the Angular Velocity from the Gyroscope, and we have measured the length of leg, so we can calculate the Velocity at that time by the formula: Angular Velocity times leg. Because we need the Velocity data every 0.5 sec, we set the timer k, which will calculate the Velocity every 10 iterations, then we can print the results every 0.5 seconds (per 10 iterations). In order to obtain the results of speed and total moving distance more accurately, we use the unit of centimeters through conversion in the code, which will make our results more accurate.

c. Creativity: Bluetooth Integration

To creatively display data on an LCD using an STM32 microcontroller, we adopt the Buffered Method, where a section of the microcontroller's RAM is allocated as a buffer, sized according to the LCD's display capacity. Data destined for display is written into this buffer, enabling processing or modification before it appears on the LCD. To enhance this setup, we have incorporated a wireless aspect using a Buck converter. This converter efficiently transforms the 9V input from the battery into a suitable 4.5-5V range to power the STM32, ensuring efficient operation.

Result:

The below pictures are from video. Figure 1 is of the prototype pedometer made by the team which is displaying final measurement after the 20 second walk. The distance walked was roughly 150 inches or 380 cms(as shown in figure 2). The 20 seconds sampling stops after taking roughly 3 laps of the measured distance.

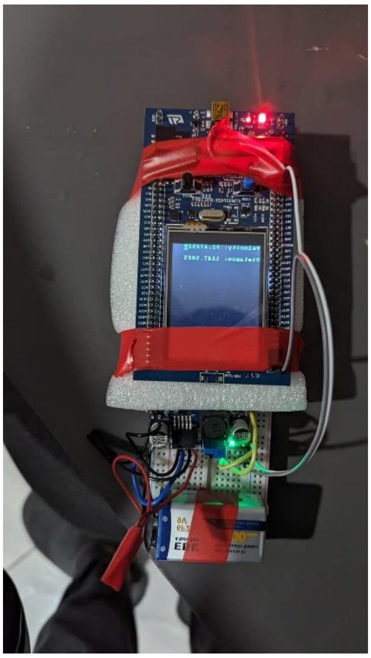


Figure 1: Prototype pedometer

Figure 2: Measurement of track

Summary

The project involves estimating walking distance and velocity using an STM32F4 board equipped with a gyroscope. For distance estimation, angular velocity and leg length are used, assuming symmetrical leg movement. The device, positioned above the knee, collects Z-axis data to calculate distance, using a specific formula that accounts for sampling frequency. The velocity is calculated based on gyroscope data, considering both angular velocity and leg length, with updates every 0.5 seconds. Innovatively, the project integrates a HC-05 Bluetooth module for data transmission, allowing the STM32F4 board to communicate with a mobile phone. This setup enables real-time data transfer and monitoring of the calculated distance and velocity.