Finding Your Own Way: An Autonomous Navigation System

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Abstract

Location services such as the Global Positioning System (GPS) have become an integral part of many people's lives. Systems that rely on a WiFi connection or GPS have their shortcomings, however, as functionality is greatly decreased in areas with poor coverage, such as underground or inside buildings. The indoor localization project (ILP) is aimed at developing an accurate indoor positioning system in situations where GPS is not available or sufficiently precise. The ILP operates through the use of an Android application, which collects data from the phone's sensors and transfers that data to using the Sensibility Testbed platform. Ultimately, an indoor positioning system can be created that takes a step towards a more advanced location services system.

Fig. 1: Acceleration plot with step count

Background Information

Attempts have been made in the past to develop similar indoor localization methods. Though several use mechanisms that are also employed in this project, most differ slightly in their methodology. For example, Woodman and Harle required the phone to be in a specific position and orientation on the user's body in their research [1], and Tanawongsuwan and Bobick were more focused on human gait analysis [2]. Some of the challenges past investigations have faced include the following:

- Step length estimation in staircases [3]
- Detection of walking versus running [2,3,4]
- Degradation of accuracy over time [1,3]

For an effective indoor navigation system to be created, these issues will need to be addressed. Though this research has not yet incorporated step length estimation on stairs, a mechanism to differentiate between walking and running has been included, as well as extensive filtering to mitigate signal noise.

Methodology

There are two primary components to the proposed system: **distance** and **heading**. Sensor data is obtained through the Android application, WhereAbility, which is then analyzed through a MATLAB script.

DISTANCE:

- Accelerometer is used to determine stride length and step count by measuring acceleration forces on the phone
- Each step causes acceleration or deceleration (see Figure 1)
- Acceleration forces can have random spikes due to irrelevant motion or electromagnetic noise
- Data is analyzed in several ways to combat this
  - Low Pass and Moving Average Filters: used to remove the frequencies of electromagnetic noise
  - Dynamic Time Warping (DTW) Algorithm: compares the experimental data with the reference data to eliminate any irrelevant motion such as shaking of the device

HEADING:

- Functions through the analysis of accelerometer, gyroscope, and magnetometer data, yielding orientation
- Kalman filter used to reduce drift by correcting gyroscope with accelerometer and magnetometer

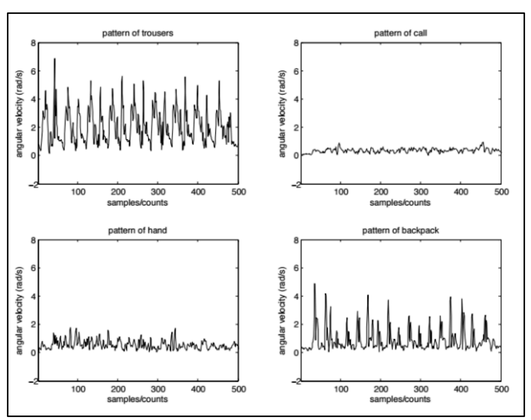

Fig. 2: Gyroscope data patterns with different carrying modes

Experimentation

Though the data collected thus far is preliminary, the results are promising. The variation in data plots seen under different carrying modes is visible in Figure 2. As seen in Figure 3, the trajectory has an error of two to three meters, which is much more accurate than GPS and WiFi-based systems.

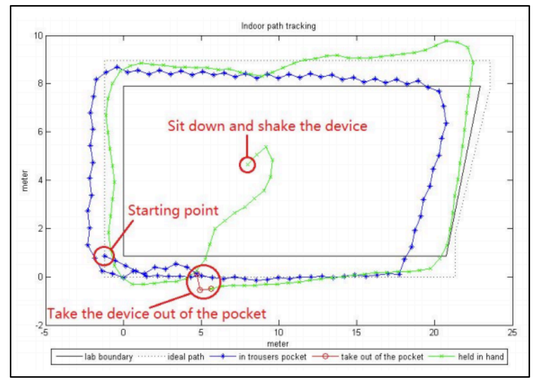

Fig. 3: Path tracking plot showing accuracy of localization

Future Work

Although the project is still in its early stages, the potential for creating a more accurate indoor navigation system is clear. Further work will be done in the coming semesters and will focus on several areas

- Improving the ability to eliminate irrelevant motion
- Improving the ability to fix the heading bias
- Creating an Android/IOS app for public use

References

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