Lab 9: Sensor Processing

Due Dec 3 by 11:59pm **Points** 10 **Submitting** a file upload
Available Nov 17 at 12am - Dec 8 at 11:59pm 22 days

This assignment was locked Dec 8 at 11:59pm.

Lab 9: Sensor Processing

Introduction

In this lab, you will implement basic versions of two algorithms used in Pedestrian Dead-Reckoning (PDR). PDR is a technique to estimate someone's displacement from a certain location based on how far they walk, and what direction they walk. They can be used indoors, where GPS does not work, or even outdoors when the high power-usage of GPS is undesirable. Advanced PDR algorithms have many parts, but most PDR algorithms have 2 basic parts: step detection, and direction detection.

The first part, Step Detection does what its name implies: it detects steps. Step detection is used in a wide variety of applications. Phones and wearable devices commonly have step detection algorithms in them to help them track fitness goals, runs, and other activities. Companies base whole devices on step detection algorithms (ex: Fitbit). For PDR, a good step detector is important because it gives PDR a sense of how far someone has walked. If a user puts in their height, the PDR algorithm can count the number of steps detected and multiply it by the users estimated step length to get an estimate of how far they've walked. Step detection might give you a good estimate of the distance you've traveled, but it doesn't give you any indication of what direction you've traveled.

The second part, direction detection can be implemented using a variety of techniques. Some integrate gyroscope input to see direction differences, some use the magnetometer like a compass to track direction with respect to the Earth's magnetic field, and the most advanced algorithms combine gyroscope and magnetometer data for a more accurate direction estimation.

For this assignment, you will create a **simple step detector** and a **simple direction estimator** and combine them to make a **simple PDR algorithm**.

Three files are provided with this homework at the end, WALKING.csv, TURNING.csv, and WALKING_AND_TURNING.csv. The contents of each file are summarized in the following table:

Filename	***Description***
WALKING.csv	This file contains data for someone walking 38 steps in a straight line. The phone was held face-up in an extended hand. The top of the phone pointed toward the walking direction.
TURNING.csv	This file contains a set of 90 degree turns. The phone was placed face-up on a table and rotated four turns clockwise (1 full circle) and

	then four turns counter-clockwise (another full circle).
WALKING_AND_TURNING.csv	This file also has walking data, but the user walked in a pre-specified path. (So, there's walking and turns in there).

The files are all formatted in the csv (comma-separated values) format. The first row has the title for each row, and every subsequent row is a new sample. The sampling rate is 5ms nominally, but the exact sampling rate varies a little bit. Timestamps (which are expressed in nanoseconds) are provided in case you want to do any integration or anything like that. The files contain data from the Accelerometer, Gyroscope, and Magnetometer. You might not need the data from all sensors, but some techniques require them, so we've included them. Accelerometer values are provided in m/s^2, Gyroscope values in rad/s, and Magnetometer values in uT (micro-Teslas).

Tasks to Complete:

1. Smooth the data with a technique you learned in lecture.
2. Write an algorithm to count the number of steps in WALKING.csv and WALKING_AND_TURNING.csv.
3. Write an algorithm to detect the 90 degree turns in TURNING.csv and WALKING_AND_TURNING.csv.
4. Combine your algorithms from step 2 and 3 to plot the path of the user in WALKING_AND_TURNING.csv.

To accomplish these tasks, there are some assumptions you can make that will make the job easier:

- Each step is 1m in length.
- Every turn is a multiple of 45 degrees in either direction (i.e.: 45, -90, 135).
- The data from the files is all walking or turning. Feel free to use whatever tools you're comfortable with. You can also discuss this homework amongst your group members, and with other students in the class, but each of you will need to independently develop and submit your own solutions.

Some Tips: If you've never worked with sensor data before, this might not seem like a very trivial thing. Here are some tips to help you:

- Before you do anything, plot the various sensor axes in a tool like MATLAB or Excel. CSV files can be imported into these programs, and both provide easy methods of plotting data. This will help you design your algorithms.
- When you make your algorithms, plot the sample different events were detected on, so you can see where your algorithm works and where it does not. This makes it easy to see what's wrong and tweak things to make it work better. You might even want to format your data in csv format so you can add it to your plots more easily.
- You might want to smooth your data first, to remove bumps or jitters that could mess up your algorithm.

- There's a lot of information on step-detection and heading/direction estimation online. Feel free to use it (but write your own code).

Submitting your Lab

Lab will be submitted to Canvas. You will submit two files:

1. A zip file with all your code in it
2. A pdf summary of what you did. The pdf should contain these things:
    1. An explanation of the different algorithms you developed. Talk about some of the problems you had, and solutions to those problems.
    2. A plot of 1 second of 1 axis of your sensor data from WALKING.csv along with a smoothed version of the same data. The scale should be such that we can see how the smoothing worked.
    3. The number of steps for WALKING.csv and WALKING_AND_TURNING.csv.
    4. The number and direction of all turns in WALKING_AND_TURNING.csv.
    5. An x,y plot of the route walked in WALKING_AND_TURNING.csv The plot does not need to be drawn to scale, but you have to indicate the distances and angles of the route walked so that it is clear what the route is.

WALKING.csv (https://canvas.wisc.edu/courses/271716/files/22958663/download?download_frd=1)

TURNING.csv (https://canvas.wisc.edu/courses/271716/files/22958684/download?download_frd=1)

WALKING_AND_TURNING.csv (https://canvas.wisc.edu/courses/271716/files/22958687/download?download_frd=1)