CS/ECE 434 Final Project (Spring 2020)

Choose one project from the following. You are expected to finish the final project in a team of two.

1. IMU dead reckoning with phone in pant pocket

Description: In this project, you are expected to build a fully functional dead-reckoning based indoor localization system using previous MPs as building blocks. Specifically, assume the phone is in the pant pocket, and your code should be able to count the steps n, measure the walking direction θ_i and calculate the step length L_i for each step. Assume at the initial moment the user is at the origin, then after these n steps, the user's position is given by:

$$P(x, y) = \sum_{1}^{n} (L_i \cos(\theta_i), L_i \sin(\theta_i))$$

The step count module has already been built, so your goal is to build the walking direction and step length module.

Walking direction: There are different approaches to this module but the 2 popular ones are:
(1) Principal Component Analysis (PCA) on walking motion, and (2) performing per-step analysis on gyroscope motion. You can choose whichever you like, but in general #2 works better than #1, while #1 is easier to implement. We provide some high-level ideas of how these methods work here:

(1) PCA: Constantly track the orientation of IMU and find the accelerometer representation in the global frame (a_{gx}, a_{gy}, a_{gz}). Perform PCA on the 2D vector (a_{gx}, a_{gy}), and the principal component (which is the direction of the greatest variance) should give the walking direction.

(2) Per-step analysis on gyroscope: Since the phone is in the pant pocket, it will swing together with the leg while walking. Observe that the swing axis of the leg is perpendicular to the walking direction, so if you can pull out the swing axis for each step, you can estimate the per-step walking direction.

Step length: You can use constant step length or dynamic step length. For dynamic step length, one way is to set step length as a function of swing angle, and the other way is to use some empirical formula that relates step frequency, step acceleration etc. with step length. You are free to research and adopt any appropriate empirical formula.

Resources: Section 2 and Section 5.1 in this paper can help you substantially for this project.

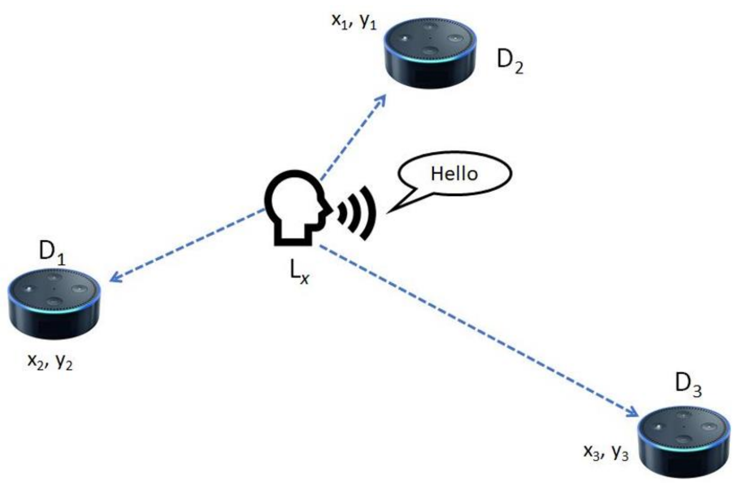
Input/Output for the project: We will provide you with time series data from the accelerometer and gyroscope of the phone, while a user is walking along different paths. Please output the coordinate for each step, and also show the trajectory plot.

Grading:
50% of grade is based on your implementation and the other 50% is determined by performance.
For implementation, entire framework is 10% and walking direction and step length are each 20%.
For performance evaluation, scores vary with the error. We will give you some additional testing data during project demo, and grade on both the training data result and testing data result.

2. AoA Triangulation

Description: Providing voice assistants with location information of the user is very useful in a lot of scenarios, e.g., voice assistants can resolve ambiguity in user's commands or do better speech decoding. In this project, you are expected to create an algorithm that utilizes microphone arrays on multiple voice assistants to localize the user.

Consider the following case: there are eight voice assistants around the user. We will provide you with the location of these eight devices $L_1, L_2, \dots, L_8$ and their microphone array configuration, as well as the recordings from each of these devices $D_1, D_2, \dots, D_8$. Your algorithm should take $D_1, D_2, \dots D_8$ and $L_1, L_2, \dots L_8$ as input and output the location of the user L_x.



You can tackle this problem by doing AoA on all eight devices and then use triangulation to find the user location.

Input/Output for the project: Inputs are recordings and positions of all eight microphone arrays and output is the user location.

Grading: Like the previous project, 50% on algorithm/implementation and 50% on performance. For algorithm/implementation, AoA algorithm is 30% and triangulation is 20%. For performance evaluation, same as previous project.