SE 491-sdmay19-27

Smartphone Tracking App for Microsoft HoloLens

Week 8

10/27/18 - 11/02/08
Client: Optical Operations
Faculty Advisor: Daji Qiao

Team Members:

Ben Holmes - *Android Development*
Anthony House - *Website Development/Security*
Ryan Quigley - *Android Development*
Jose Lopez - *Website Development*
Travis Harbaugh - *Hololens Development/Android Development*
Cory Johannes - *Report Management*

Summary:

The goal of this week was to create a Bluetooth beacon that would send a Bluetooth signal to the mobile device and combine the step detection algorithm with phone orientation algorithm. Our Bluetooth team created a prototype of Bluetooth beacon that connects with a paired android device and prepared a demo for the client meeting. Our tracking team made some adjustments for the threshold to give a better estimation for a user's step size. Starting to combine all the different module of our application. Our research team researched IEEE articles to support the tracking and recalibration team. Three position solution to add to our project include Wi-Fi positioning, Ultra-wide band, and Magnetic positioning.

Pending Issues:

Our relocation team had problems with creating a reliable beacon that would transmit a message to android application. The PubNub application didn't emit a beacon signal to the android device. The Altbeacon library didn't emit a message to the android device because the android device didn't support the BLE 4.0 technology. The Tracking team had estimate distance errors with the step tracking. They are making changes to the algorithm to try to eliminate the error under 4% for longer distance traveled.

Past Week accomplishments

- Travis Harbaugh
    - Tried to implement the PubNub SDK to create both an android beacon emitter and an android beacon detector
        - Used the Android BLE package for beacons
        - Used Bluetooth to scan for beacons

        - Use a scan filter and scan settings to detect a beacon
        - Used advertisement data and advertisement setting to emit a beacon signal
            - Was unable to get the beacon emitter to work
    - Tried to implement AltBeacon libraries for an android altbeacon-transmitter and an android-beacon receiver
        - AltBeacon requires BLE technology which is unavailable for Nexus 7 and HTC One provided by our client/advisor and could not run the altBeacon emitter
    - Created Bluetooth application prototype that connects with a paired device and transmits a latitude longitude coordinate
- Ben Holmes
    - Current app now has three important points. PDR, orientation estimation, and data collection.
    - Still need to add Bluetooth, sound, and wifi triangulation into app, but those topics are a little ways from being fully ready.
    - Still studying Kalman filtering, and still unsure about how to model our mathematical system. We may first need to get Bluetooth, sound, and Wifi implemented before we can fully realize a model.
- Anthony House
    - Researched several articles as instructed by our faculty advisor
        - Samsung Electronics proposed a solution that utilizes Wi-Fi based positioning, dead reckoning, barometric pressure sensors, and floor plan data to measure a users location. Formulas used include:
            - $qt = (xt, yt, zt, ft, alpha\ t)$
            - $(xt, yt, zt, at) \in R$
            - $Ft \in N$ where x, y, z represent 3D location on the floor, F is the floor number, alpha is user heading, time is t
            - $wt + 1 = wt : P\ (post\ p, pos\ wifi)$
        - School of Electrical and Electronic Engineering, Technological University, Singapore
            - UWB (ultra wide band) transmits data over a wide frequency band using the following formulas:
                - Channel Impulse Response Formula
                - Root Mean Square Formula
                - Received Power Formula
                - First Path Power Formula
        - Institute of Computing Technology, China
            - Used Wi-Fi and magnetic position to track indoor navigation within 1.6 m accuracy using the following algorithm:
                - Particle Filter Based Single-Step Positioning Algorithm
- Ryan Quigley
    - Made a few adjustments to the distance estimation app for step sizes, added buttons to reset current step/distance count, and added a button to allow recalibration.

        - These adjustments were made to assist in larger testing of the app to determine how accurate it is over short(~10m) and long(~50m) distances. (See tables below)
- Jose Lopez
    - I researched different methods of indoor tracking a localization using light and sound, and using the embedded sensors of a phone. I read these 4 articles
        - RSSI-Based Indoor Localization and Tracking Using Sigma-Point Kalman Smoothers
            - Authors: Anindya S. Paul*, Student Member, IEEE*, and Eric A. Wan*, Member, IEEE*
        - Gradient-based Fingerprinting for Indoor Localization and Tracking
            - Authors: Yuanchao Shu, Member, IEEE, Yinghua Huang, Jiaqi Zhang, Philippe Coue, Peng Cheng, Member, IEEE, Jiming Chen, Senior Member, IEEE, and Kang G. Shin, Life Fellow, IEEE
        - **A smart-phone based hand-held indoor tracking system**
            - Authors: Dihong Wu School of Information Science and Engineering, Xiamen University, Xiamen, China. Ao Peng, Lingxiang Zheng, Zhenyang Wu, Yizhen Wang, Biyu Tang, Hai Lu, Haibin Shi. Huiru Zheng School of Computing and Mathematics, University of Ulster, Newtownabbey, UK
        - **Time-of-arrival-based smartphone localization using visible light communication**
            - Authors: Takayuki Akiyama, Masanori Sugimoto, Hiromichi Hashizume
    - The First 2 article I concluded that they weren't not as useful to us since they didn't specify any hardware they used and they were primarily focused on algorithms. The 3rd article talked about using the phone sensors(accelerometer, gyroscope, barometer, and gravity sensor to collect data, and to use ZUPT to correct any errors of the sensors. They used step length and heading angle to draw the pedestrian trajectory in a 3D space. The 4th article used sound to estimate TOA and light to get the TOF at every moment of TOA. Using this they analysed the frame captured from the video camera to estimate where in the space was the user. Both of the last two articles used Kalman filtering.
- Cory Johannes
    - Researched an IEEE article as constructed by our advisor
    - Concluded research on using lighting input for determining location/recalibration. Not a viable option, since it would be a large commitment of resources, especially for larger spaces, place with many rooms, and work that would be mostly outdoor.
        - Location Estimation method formulas:
            - $d = m \sin B$
            - $m - h_1 * cot(alpha + theta) - n$
        - Measuring Point coordinate calculation using three fluorescent lights with the following formula:
            - $`X_B(d_1, d_2) = X_B(d_2, d_3) = X_B(d_1, d_2)$

- $Y_B(d_1, d_2) = Y_B(d_2, d_3) = Y_B(d_1, d_2)$
- $Z_B = h_1$

Individual Contributions:

Team Member	Contribution	Weekly Hours	Total Hours
Ben Holmes	• Combined top three current developments into our app: Dead Reckoning, orientation estimation, and data collection. • Continued researching Kalman filter implementations in localization papers. • Began focusing primarily on Bluetooth technologies, so that I can finish the time of arrival distance estimation I began back in week 4	12	65
Anthony House	• Researched publication by Samsung Electronics • Wi-Fi-Based solution • Researched publication by School of Electrical and Electronic Engineering • Ultra-Wide-Band solution • Researched publication from Institute of Computing Technology • Wi-Fi and magnetic position solution	6	35
Ryan Quigley	• Adjusted distance estimation • Step counter button • Recalibration button	6	38
Jose Lopez	• Researched more about different techniques used for indoor tracking and localization	5	27
Travis Harbaugh	• Tried to implement a beacon using PubNub SDK • Tried to implement a beacon using AltBeacon libraries • Implemed an android application	10	106
Cory Johannes	• Research on using lighting for location and recalibration	3	24

Plans for Next Week:

- Travis Harbaugh -

    - Program ibeacon that was purchased on amazon to emit long/lat data packets
    - Use Eddystone SDK framework to receive an signal emitted from the ibeacon as the android device goes past it.
    - Coordinate with research team to see what alternate solutions they have discovered about recalibrating the android device.
- Ben Homes
    - Continue developing with the application, and creating test cases for the different sensor implementations.
    - Ultimately we will need some kind of filtering to reduce error, but that is still a couple weeks in the future.
    - I will continue to devote more time towards Bluetooth until it is incorporated into our merged application. As I state in most of these reviews, our current app has step detection, distance estimation, orientation estimation, and data collection. It does not have Bluetooth.
    - I believe I can get time of arrival tested within this month. After that it will be easy to implement WiFi triangulation.
- Anthony House
    - Create a SWOT analysis of our team.
    - Work with Travis to better coordinate development
    - Research more articles for presentation
    - Choose a method of new and innovative solution
    - Figure out what our direction needs to be and how to focus the team to do that.
- Ryan Quigley
    - Merge the orientation and distance measurement apps to estimate displacement in 2d space.
- Jose Lopez
- Cory Johannes
    - Research how using a magnetometer could work with recalibration
    - Research how using sound could work with recalibration

Tables
Short distance:

	Actual Steps	Counted Steps	Distance (m)
Sum	390	373	258.7
Average	16.96	16.2	11.24

Actual Steps	Counted Steps	Distance (m)	Actual Steps	Counted Steps	Distance (m)
16	16	11.5	17	17	12.1

17	16	12.2	17	17	13.6
17	16	10.85	17	17	12.55
17	17	11.95	17	16	11.75
17	16	9.8	17	17	11.2
17	17	12.1	17	17	12.7
17	16	10.55	17	16	12.65
17	16	9.65	17	16	11.45
17	16	8.6	17	16	12.2
17	15	9	17	16	11.75
17	16	9.8	17	15	11.85
17	16	8.9			

Long Distance:

	Actual Steps	Counted Steps	Distance (m)
Sum	1428	1415	976.7
Average	71.4	70.75	48.835

Actual Steps	Counted Steps	Distance (m)	Actual Steps	Counted Steps	Distance (m)
75	72	40.65	71	71	50.8
76	71	54.7	71	71	50.8
71	71	55.45	71	71	49.45
71	70	53.75	71	73	50.75
71	70	50.3	71	72	50.85
72	71	42.4	70	71	50.5
70	69	40.65	71	70	50.75
72	71	40.45	71	71	52.45
71	70	41.15	70	70	50.6
70	67	49.5	72	73	50.75