Initial Plan

Localising a device in a building using known access points

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CM3203: One Semester Individual Project – 40 credits

Project Description

GPS navigation has become a key part of modern life, with many using mobile map apps to find local buildings and shops. Outdoor navigation works very well, however GPS signals struggle to penetrate the walls of a building, making indoor navigation difficult. One attempt to solve this problem involves using a 'beacon' – a Bluetooth low-energy device that transmits a constant signal. By placing these around a building, an organisation could use the distance from the device to the beacon as a method of localising the user. One of the major pitfalls with this approach is the need for additional hardware to be purchased and placed around the building. This additional expense could make improving navigation cost prohibitive.

This project aims to use the existing hardware in the building to achieve better indoor location tracking, without using existing GPS signals. Specifically, this project aims to use existing access points already installed in the building, to allow a user to track their location on a WiFi-enabled device. By measuring the RSSI (Received Signal Strength Indication) level of each of the known access points within range, we can trilaterate the location of the user's device within these access points. Using the known physical locations of each access point, we can plot the results of the trilateration on a map, and thus locate the user.

This project would seek to deliver a proof of concept mobile app based on a section of Queen's buildings, and an investigation into any limitations, or advantages to this approach.

Project Aims & Objectives

There are three main aims for this project. The first is to develop a mobile application which enables a user to identify their location in the building using a digital map. The second is to develop an algorithm to convert RSSI data of known access points into estimated cartesian map coordinates, based on a map of the building. Finally, to investigate the feasibility of this method of indoor localisation, and the strengths and weaknesses compared to other indoor-localisation approaches.

Aim 1: Mobile Application
I expect this aim to take up a reasonably small amount of time, compared to the other aims. I anticipate spending the majority of my time navigating the built-in device API to retrieve the data that I need, and then implementing a basic map system to plot a location on an image of a map.

Objectives:

- Develop initial app to list access points within range, along with the current RSSI value
- Collect the RSSI data over a period of time and output it in a useful format, e.g. CSV or JSON
- Redevelop app to collect RSSI data, send this to the algorithm and then plot the active location on an image of a map.
- Ensure that the app is built with scalability and efficiency in mind.

Aim 2: Algorithm
This aim will likely take up the majority of my time in this project. Through preliminary research, the complexity of this project lies largely in making sense of the 'noisy' RSSI data. Whilst this is well documented and well researched for identifying a static location using the signal data (e.g. a user not moving the device over a small period of time), this aim is complicated further by needing to identify the location of an actively moving device.

Due to the ambitious nature of this aim, I am unable to guarantee that it will be met in full due to the timescale of the project. Should things take longer than expected, or prove non-viable within the limited scope of this assignment, I will seek to crudely locate a user within 3 access points. I hope to achieve more, but without working on the project it is difficult to estimate how long things will take. Due to this uncertainty, I believe it would be necessary to have a fallback, should things not go to plan.

Objectives:

- Identify existing algorithms or approaches for filtering noisy RSSI data, for example using a Kalman filter
- Develop / implement algorithm for filtering the noisy RSSI data of one access point

- Develop & implement algorithm for calculating the location of a device using this data, with 3 or more access points
- Transform these coordinates into coordinates on the provided map, using the access point locations as reference points

Aim 3: Evaluation of approach

This aim will involve research of alternative approaches, critical evaluations of my approach and identifying improvements that could be made to further improve the viability of the technique.

Objectives:

- Conduct surface-level research into alternative techniques for indoor localisation, comparing the main ideas of each approach, and some advantages / disadvantages
- Set criteria for the project to meet in order for it to be considered successful, in a variety of areas
- Compare the finished project to the other approaches identified and critically evaluate the project based on the success criteria

Work Plan

I have divided my time over 15 weeks, starting from the 27th January 2020.

Week(s)	Goals	Deliverable
1	- Preliminary research into intended approach, identifying possible caveats and areas for further research - Obtain a digital / physical map of the initial test area of the building, where I will be developing the app to initially work in - Write an initial plan of the project, allocating time effectively to achieve the project goals	Initial plan Map of test area
2	- Develop mobile app to scan for access points within range, and display the current RSSI data on screen - Identify MAC addresses of all access points within the test area, and the locations of these access points on the map. This could be done by holding the device close to the access point, and recording the MAC address of the AP with the highest RSSI value. - Add feature to app to enable it to output the RSSI data over a period of time into a useful format, e.g. CSV or JSON - Generate a data dump using this feature with the device in a static location.	Mobile app to scan for APs and output RSSI data, both on screen and into a useful data format. Locations of each access point on the map, along with MAC addresses. Data dump of device in static location.
3-4	- Identify success criteria for the approach, with measurable targets. These milestones will likely consist of efficiency targets (how quickly can we obtain a location given data), scalability targets (how many users could this system scale to) and accuracy targets (how accurate is the location compared to the actual device location) o Should any of these milestones prove far too complex to achieve within the project scope / timeframe, I may have to rethink the project plan in order for the project to have a more meaningful outcome. - Using the output of the RSSI data dump, develop or implement a simple algorithm to output a single RSSI value from a large amount of noisy data for an AP	Success criteria Algorithm to clean noisy RSSI data Stable RSSI values from the data dump taken from the app A location within the APs identified given these values Coordinates for the map

	- Using this algorithm, obtain a single RSSI value for each AP within a certain range of signal - Use these new values to trilaterate the device location within the APs, and convert this location within the APs into coordinates on the map. - Write up initial findings for localising a static device for the report, stating the methods used and the effectiveness. Evaluate approach using success criteria.	Initial findings from localising static device (report)
5-7	- Collect additional data from the app, this time with the device moving within the test area. - Identify ways to improve the algorithm so that it could handle a moving device, and somewhat accurately localise the user. Machine learning may be a good approach for this, however this may require significant additional data. - Implement these improvements to the algorithm, noting the accuracy of the original algorithm over the new one. - Write up adjusted approach for report, evaluating the performance of the new approach compared to the previous one using the success criteria.	Additional test data, this time with a device moving within the test area. Improved algorithm, which could potentially handle a moving device with some accuracy. New findings from the adjust approach for the report
7-8	- Redevelop app, so that it scans for APs and RSSI data automatically, sending this data in real time to the algorithm (local / server based). - Use the output of this algorithm to display location on a map, without the need for user input - Develop intuitive user interface, with ability to pan around map as necessary.	Usable app, which processes RSSI data in the background and displays a location without the need for user interaction.
9	- Identify & implement any adjustments / improvements that could be made to the overall system to improve speed, usability, code quality or to exceed the success criteria. - Test all parts of the completed system to ensure that it meets the goals of the project, and implement fixes / improvements as necessary to ensure this.	Improved / adjusted system (backend / app)

10-11	- Evaluate results of project compared to state-of-the-art solutions, the current solution (using GPS) and to alternative solutions. - Evaluate the results of the solution compared to success criteria. - Draw conclusions based on these evaluations, and identify any further areas for research / improvement. - Reflect on the learning experience the project provided, the knowledge gained and the skills I've gained from it	Sections 5-8 of the final report.
12	- Final adjustments to the report, along with any additional research / formatting that needs to be completed	Completed Final Report
13 - onwards	- Project Viva	