IndoorPositioning with Bluetooth

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What is Indoor Positioning Systems

The easiest way to describe Indoor Positioning Systems (IPS) is that it's like a GPS for indoor environments.

IPS can be used to locate people or objects inside buildings, typically via a mobile device such as a smart phone or tablet. IPS relies on technologies like wall- or ceiling-mounted beacons that work together in detecting a user's or object's location, deriving an exceptionally accurate position. Like GPS, IPS systems can then detect the direction in which the device is traveling, and can predict the user's pathway based on that information so the positioning remains accurate as the space is traversed.

The Aim of the project

The objective of this project was to implement an indoor positioning system relying on Bluetooth technology. The system compares the signal strengths of surrounding Bluetooth devices to a database of measurements taken across the indoor area, in order to estimate the user's position. Through an evaluation of the system, an accuracy of approximately 1.5 meters has been obtained.

Dead reconing

The afore mentioned 3D environment tracking system also uses RSSI and triangulation for positioning. In order to deal with the slow update rate caused by the inquiry protocol delay and make the positioning more accurate, they make use of the devices' built-in accelerometer and digital compass in order to keep track of the user's position while waiting for the next update. Their proposed solution includes an initial calibration phase where the devices that are to be used must be registered, as well as the RSSI and distance between them. The resulting system was able to obtain fairly accurate positioning (< 1 meter when the accelerometer is correctly configured).

Location Fingerprinting

There are mainly two techniques that are used in Bluetooth indoor positioning today:

triangulation and fingerprinting. The fingerprinting technique has been chosen for this project. Location fingerprinting is a technique in which a location is identified by a record of radio signals. A major advantage of this technique is that if an appropriate radio infrastructure is already in place where the positioning system will be deployed, it can be reused, which avoids the cost of installing new infrastructure.Techniques that derive a distance directly from the signal strength are susceptible errors due to the fact that there is no direct relationship between the signal strength and the distance. Such methods include triangulation and lateration, among others. The fingerprinting technique completely avoids this problem, as it is not at all concerned with the distance, but rather tries to obtain a unique combinations of RSSIs that distinguishes a location from all other locations. In principle, any Bluetooth-enabled device can be used as a beacon since differences in the emitted signals will have no bearing on the accuracy of the position estimation. The fingerprinting technique is based on a radio map, which is a collection of fingerprints. A fingerprint is a set of radio signals measured at a particular location, in which each signal is associated with the device from which it was emitted. This technique comprises an offline phase, in which the radio map is created, and an online phase, where the actual position estimation takes place. The following sections provides a more detailed description of the two phases.

Architecture and Implementation

Having already discussed the methods and algorithms on which the indoor positioning system is based, this chapter presents the architecture and implementation of the Bluetooth GPM provider as well as the projects in which it has been integrated.

Architecture

Since the provider was to be integrated into the already existing software developed at the Institute of Services Science, this section gives a brief overview of this software which consists of three separate projects: Global Positioning Module (GPM), Global Map API (GMA) and LocMap, all developed for the Android platform. 4.1.1

LocMap

The purpose of LocMap is to demonstrate the features of the two aforementioned projects. It is therefor a light application that simply interacts with the APIs provided by GPM and GMA in order to present their features in a concise way. Among other things, it allows to change between different position providers and to configure their respective settings.

The Bluetooth Provider

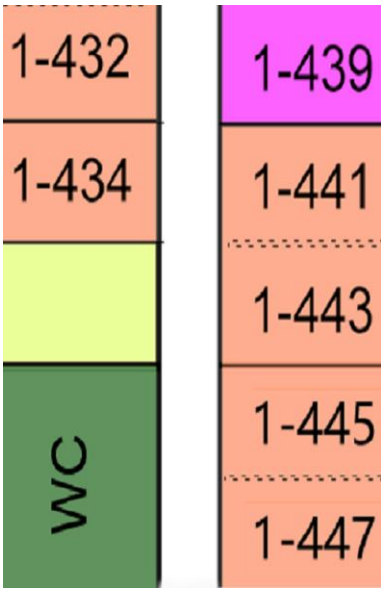
A new package, bluetooth, was added to GPM and it consists of four principal classes as well as two packages containing the implementations of the positioning algorithms and the database access layer. . The class Bluetooth has the main responsibility of starting the Bluetooth inquiry and estimating a position based on the outcome from the inquiry as demonstrated by the sequence diagram which outlines the actions taken during the online phase of the system. Bluetooth inquiries are initiated when the mobile phone detects movement, which is managed

by the MotionDetector, a feature implemented in order to save battery power. It listens to the build-in accelerometer, and inquiries are then launched continuously until the MotionDetector notices that the mobile phone is no longer in motion. While the mobile phone is moving, Bluetooth starts asynchronous inquiries by calling the BluetoothScanner, which provides it with information about all the devices that are within range and in discovery mode. Once the asynchronous call terminates, Bluetooth calls the PositionFinder in order to obtain a position estimate based on the returned devices. This class will use one of the positioning algorithms as well as the radio map stored in the database (not shown in the sequence diagram) in order to come up with an estimation, which is returned to Bluetooth. The Bluetooth class has a similar role during the offline phase, however, each inquiry is explicitly initiated by the user and not by the detection of movement. When an inquiry has finished, instead of running one of the positioning algorithms, the resulting fingerprint is stored directly in the database. Another important aspect of the provider was the selection of beacons. It is necessary to specify which beacons that are to be taken into account by the system in order to avoid that arbitrary devices, such as peoples mobile phones, headsets, laptops etc. are included. Including such devices would break the radio map once the device is moved to a different location. The provider therefore takes this list into account during the position estimation and excludes any device which is not on the list.

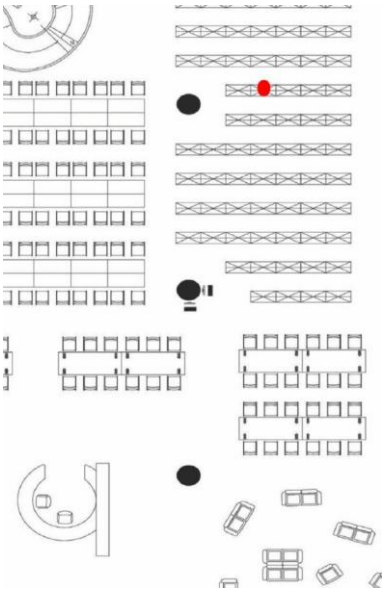
Project Implementation

In our project,we combine Blootooth and DeadReckoning.The name of our project is FindMe. Here are the main function of our app.

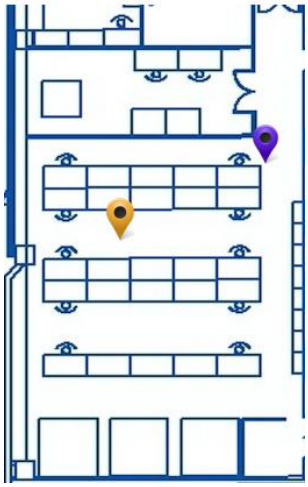
FirstVersion for Room-445:



SecondVersion for Libaray B200:



ThirdVersion for Foxcoon Company:



Precision of localization

Our experiment is better and better every time.

- ☐ 85%-95% with accuracy within 2m
- ✓ First Test： 93%
- ✓ Second Test： 86%
- ✓ Third Test： 88%
- ✓ Forth Test： 91%

Thanks

Thanks for our teacher and teammates' working together!