Design And Implementation of An Android System For Indoor Positioning Using WLAN Finger Print Scheme

Hitesh Kumar[1], Pallavi N[2], Remya Sivan[3]
[1, 2 ,3]Atria institute of technology

Abstract- *Information about a person's position is a valuable piece of context information on which many application and location services are based upon. In outdoor environments the Global Positioning System (GPS) and Assisted GPS (A-GPS) are widely used and they perform reasonably well, but they underperform when there is no clear access to the sky, i.e. in indoor environments. Most of the research conducted and solutions developed aim for real-time indoor positioning or personal tracking, but to the author's knowledge there are not many studies on the subject of post- processing. Post-processing has many benefits over real-time solutions, like preserving battery life of a mobile device, leveraging bigger processing power, using more complex algorithms that cannot run on mobile devices, and ultimately getting better accuracy on a person's movements tracks. In this thesis, an Indoor Positioning System (IPS) using WLAN fingerprinting with post- processing scheme is proposed. The system uses a large set of fingerprinted Received Signal Strength (RSS) collections obtained in the offline phase and references them in post-processing against data collected in the online phase. A series of field experiments have been conducted in University of Tartu's Faculty of Mathematics and Computer Science building. The results show that with a post-processing scheme more computationally extensive algorithms can be used and better accuracy achieved than in real-time.*

Keywords- Android, Fingerprint, Indoor Positioning, Received Signal Strength, Wi-Fi, Access Points.

I. INTRODUCTION

Background

The project was carried out on the behalf of Sigma, a consulting firm founded in 1986. Sigma operates in the areas of system development, management services, business systems and technical documentation.

The idea of the project was to develop a system for indoor positioning for Android smartphones that works in environments where GPS-based positioning does not. Since GPS uses microwave signals, it is attenuated by walls and similar obstacles and thus, does not perform well in such environments [1]. As requested by Sigma, the system should work with "off-the-shelf" hardware only, mainly to keep costs of potential deployment of the system down. This leaves two technologies as the most promising candidates, Bluetooth and Wireless Local Area Network (WLAN, or Wi-Fi) [2]. Both are radio-based techniques that most Android smartphones have the capabilities to take advantage of [2].

Research of the subject found that several different solutions in the subject had been explored previously. The different solutions can be divided into multiple types, those based on distance measurement, those based on angle of arrival, and fingerprinting.

Distance measurement requires multiple transmitters with known locations. Positioning is done by triangulating the location of the receiver based on the distance to the transmitters, measured by either using propagation time of the radio signals or by using the received signal strengths (RSS) to estimate it. [3]

In angle of arrival systems, like in distance measurement systems, several transmitters with known locations are also needed. The receiver measures the angle it receives signals from, generating a straight line to each transmitter used. The point where those lines all intersect is where the receiver is located. [3]

Finally, fingerprinting is based on the idea of selecting a number of reference points ("fingerprints", hence the name) and measuring the signal strengths of visible transmitters at those points, thus recording the radio signature there. During the actual positioning the signal strengths of the various visible transmitters is compared to those recorded for the fingerprint to find the best match or matches and then use some method of interpolation between those. Unlike the other systems, the locations of the transmitters do not need to be known. [4]

WLAN and Bluetooth

WLAN transmitters, often referred to as access points (or APs), are commonly available in most electronic stores and are already deployed in many locations in sufficient numbers to be usable for positioning [5].

The other option that also would only require "off-the-shelf" hardware is to use Bluetooth-based positioning. It should be possible to position a user using the same techniques for Bluetooth as for WLAN, and as shown by [8] it may be possible to achieve higher accuracy with this technology than with WLAN. Even so, they are both subject to the same difficulties, as Bluetooth also is a radio-based technology that uses the same frequency band. [9][10]

The biggest advantage WLAN has over Bluetooth is however that it is more widespread, with many locations already having dedicated WLAN-networks installed. Also the potential gain in accuracy is caused by the lower range of the Bluetooth device, which means that they may require deployment of more of them to achieve sufficient coverage for accurate positioning in larger areas.

Cellular Positioning

Another possible method to position the client would be using received signal strengths from cellular towers [5]. Unlike WLAN and Bluetooth, GSM operates on a licensed radio band which results in significantly less interference from other electronic devices using the same frequency band [11]. As with WLAN a fingerprinting approach could be used, however the median error is as high as 4-5 meters [5]. Another issue with this method would be if there are few towers within range of the area of interest it would be difficult to extend coverage by adding additional towers.

Project

The project consisted of three separate parts, evaluation, implementation and evaluation of the implementation. In the evaluation stage, previous solutions were to be explored, their viability evaluated and any potential obstacles were to be identified. The implementation stage involved choosing one of the solutions and implementing it. In the final stage the performance of the implementation was to be evaluated.

Objective

The goal of the project was to develop a system that could be used to position a user in an indoor environment; an example of an application for it (which was given by Sigma) was to help customers navigate in a mall, in order to find specific stores or even shelves. Other possible customers for the system would include companies interested in helping people navigate to the right shelf in a warehouse. However, Sigma did not have any specific application in mind, but simply wanted to get access to the technology.

Requirements

At the end of the project the following requirements were to be satisfied:

- The main requirement was a system that with reasonable reliability could estimate the position of the user, in situations where GPS and similar satellite-based positioning systems are unreliable or unavailable.
- In this case an average error of approximately 3.5 meters was considered reasonable, although the goal was to get a much better result.
- A basic functional implementation of the positioning system was to be done for the Android platform.

Apart from these requirements there were a couple of points that were not requirements for the project to be considered successful, but which should be considered a bonus

- Using existing infrastructure and hardware.
- Cheap infrastructure and hardware.

Android application development

Since the environment that Android applications run in differs significantly from that of a program targeted at a normal PC, a brief introduction to the model follows to introduce the reader to the topic.

While Android applications are written in Java; unlike PC implementations of the language, Android does not actually execute Java byte code. Instead the code is compiled (on the PC of the developer) from Java byte code to a custom byte code format for the Dalvik VM. [12]

Furthermore, Android does not use the complete Java class library. For example, neither of the GUI frameworks, AWT and Swing, are available. Rather Android uses a large subset of the non-GUI parts of the standard library and a custom GUI toolkit. Other Android specific namespaces and classes are included as well.

The GUI toolkit of Android is based on the idea of "activities". As described by the Android SDK documentation:

An Activity is an application component that provides a screen with which users can interact in order to do something, such as dial the phone, take a photo, send an email, or view a map. Each activity is given a window in which to draw its user interface. The window typically fills the screen, but may be smaller than the screen and float on top of other windows. [13]

Another important aspect of Android application development to keep in mind is that when an application is closed, it is in fact not terminated; rather the operating system lets the application continue to exist, until the operating system decides to reclaim the memory from it, at which point the process is killed.

II. METHODOLOGY

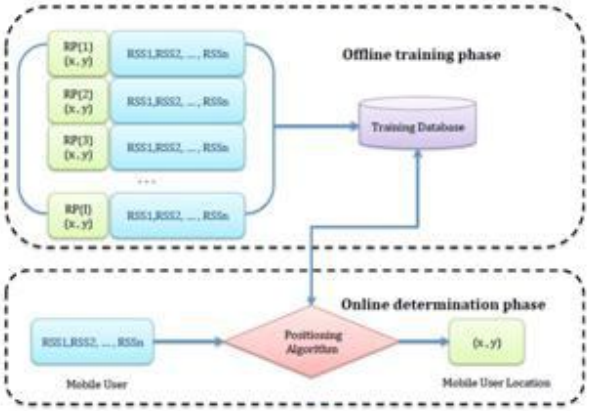
The viability of different solutions were to be evaluated primarily through studying papers detailing their advantages, disadvantages and difficulties, but also through experimentation and data gathering.When a server-based solution was needed later it was written in Java as a JSON-based web service. This solution was selected due to technical limitations in the network setup at Sigma AB. Microsoft SQL Server was used for data storage since it was already installed on the server.

Fingerprinting

The second viable option was a method known as 'fingerprinting'. This method is divided into two phases, a training phase (also known as calibration phase) and a positioning phase.During the training phase, the area that should be calibrated for positioning is prepared by pre-measuring several, well-chosen, points (called fingerprints or reference points), storing the RSS values measured at each. During the positioning phase those values are then compared to the values measured by the client in order to determine a position.The fingerprinting method was concluded to be the most viable method for WLAN-based indoor positioning, as concluded several others as well [4][5].This method bypasses several problems that affect other positioning methods, making the effect of static signal obstructions essentially irrelevant, as the fingerprinting model works by comparing differences and does not care about how high or low a certain RSS value is in absolute terms.

III. IMMUNE ALGORITHM

Fingerprinting is the widely used method in indoor positioning. Fingerprinting is based on the received power level by the mobile phone from each access points in the wireless network [4, 8]. This technique uses the outputs of a standard Wi-Fi card, which is the RSS from each access point. A list of RSS coming from all the APs covering the area can be obtained where the laptop/mobile is moving. Using this available information, a Wi-Fi device in a WLAN environment is located by approximating its position by the position of the APs received at that location with the strongest signal strength [3]. Fingerprinting method consists of two phases: offline phase and online phase as shown in Figure-1-

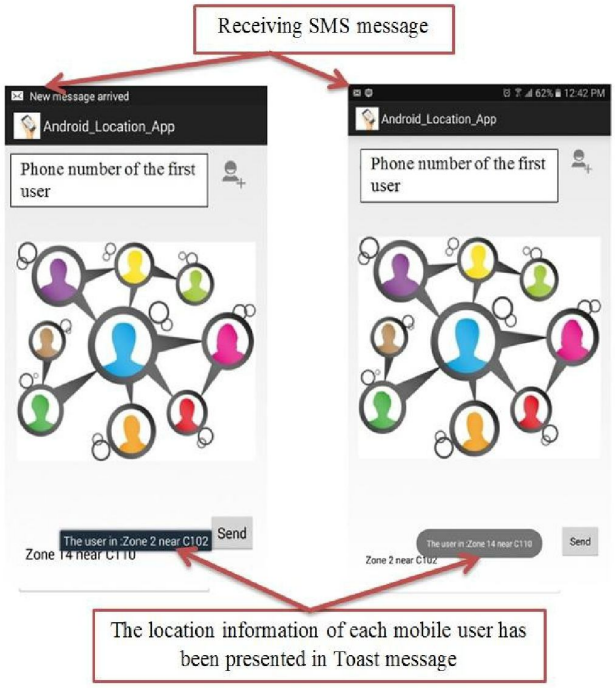


Offline phase or data collection phase is the training period which is used by the positioning system to collect RSSs at the tested area and process it to enable the system for determining the mobile device's position in the online phase [9]. The goal of the training phase is to establish a fingerprint database. To build the database, collection of Reference Points (RP) is selected at the interested area [10]. Then the RSSs values from the existing access points are measured for locating a mobile device at all RPs and these values are stored in the database. In the online phase or positioning phase, the mobile device measures RSS at unknown location. The measurements (which include RSSs and SSIDs of the APs) are compared with the stored data in the database using matching algorithm. The best matching determines the location of mobile user [8].

IV. POSITIONING ALGORITHM

RSS Mean Value Algorithm is applied in two stages: offline stage and online stage. In the first stage, RSS samples are measured in many locations as reference points. Then the mean value of RSSs is calculated and stored in fingerprint database with its reference point coordinates. While in the second stage, the live RSSs values are measured in location

where positioning is required and these values are compared with database values, thereby the best matching is calculated between the mean valuesand the instant values. So, the coordinates of the estimated location can be obtained



V. CONCLUSION

This paper presented a method to calculate the location of a user in indoor area using Wi-Fi signal strength with IEEE 802.11b networking standard based on fingerprint technique and RSS mean value algorithm. The client application is developed and run on Android smartphones to estimate the positioning of mobile user. Fingerprint database is created from the mean value of RSSs in the offline phase and finally the location of user is displayed on the screen of mobile device. Also the tracking of mobile client is done by using laptop server.The results show that the accuracy of the proposed system is about 2-2.5 meters which is the difference between the actual location and the estimated location.

REFERENCES

[1] Velasco and S. Delgado, “Indoor Positioning using the Android Platform”, Blekinge Institute of Technology, Faculty of Computing, Department of Computer Science and Engineering, 2014.

[2] B. Hu, “Wi-Fi Based Indoor Positioning System Using Smartphones”, School of Mathematical and Geospatial Sciences

[3] College of Science, Engineering and Health Royal Melbourne Institute of Technology (RMIT) University, November 2013.

[4] J. Li, “Characterization of WLAN Location Fingerprinting Systems”, Institute of Computing Systems Architecture School of Informatics, University of Edinburgh, 2012.

[5] S. Sand, A. Dammann and C. Mensing, “Positioning in Wireless Communications System”, German Aerospace Center (DLR), Germany, ISBN: 978-0-4707*-7064-1, Feb 2014*