University of Hradec Králové

Faculty of Informatics and Management

Department of Information Technologies

MASTER'S THESIS

Radio Fingerprint Acquisition Using Smartwatch

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Study programme: Applied Informatics

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Prohlášení

Prohlašuji, že jsem diplomovou práci vypracoval samostatně a uvedl jsem všechny použité prameny a literaturu.

Declaration

I declare that I have elaborated this thesis independently and listed all the sources and literature.

Hradec Králové day 26th of April 2018   Bc. David Sucharda

Poděkování

Rád bych zde poděkoval Ing. Pavlu Kříži, Ph.D. za odborné vedení práce, podnětné rady a čas, který mi věnoval.

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I would like to thank to Ing. Pavel Křiž, Ph.D. for professional guidance, incentive advices, and the time he gave me.

Anotace

Název práce: Sběr rádiových fingerprintů pomocí chytrých hodinek

Diplomová práce se zabývá možnostmi sběru rádiových otisků (fingerprintů) za pomoci chytrých hodinek. Tyto otisky se používají k lokalizaci uvnitř budovy. Hlavním cílem této práce je prozkoumat možnosti sběru otisků a návrh aplikace která bude tento sběr umožňovat. V první části práce je potřeba zjistit, jestli je tento sběr na hodinkách vůbec možný. V další části je zpracování aplikace na mobil a hodinky. A jako poslední část této práce je sběr otisků a jejich analýza. Jeden z osobních cílů je zpracovat tuto aplikaci aby byla co nejvíce uživatelky přívětivá.

Annotation

The Master's thesis deals with possibilities of collecting radio fingerprints with the help of smart watches. These prints are used in indoor localization. Main aim of this thesis is to explore possibilities of fingerprint collection and creation of application that will allow it. First part is to figure out if this collection is even possible using smart watch. Next part deals with creation of such application not only for watch but also for the phone. And at the end part there is testing of fingerprint collection and data analysis. One of the personal goal is to make this application as user friendly as possible.

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1 Introduction

As the technology evolves it unlocks more and more possibilities. Just few years back there were no smart watches or phones but at this time they are important part of our lives. As they evolve there is the need for them to have more functions and features. One of them is to locate it's position on the map. This information is very useful since it can prevent people from getting lost, figuring out path to drive, used by military and countless more cases.

Finding out such position is possible using Global Navigation Satellite System (GNSS). Multiple implementations of this system exist like GPS, GLONASS or Galileo. All of these systems provide location using sufficient number (at least 4) of satellites.[1] GNSS solution requires clear path between satellites and the receiving device because signal is not able to pass through buildings. That makes it the main reason why it cannot be used for indoor localization.

There are multiple approaches to find out location inside the building. They can be divided into three main types. First type is using wireless signal ranging approach with multiple kinds of data like Time of Arrival (ToA). Second approach is using special equipment like active bats (Ultrasonic). And final type based on Signal Strength Fingerprint Maps (SSFM), in which first part is to collect signal strengths from the environment and construct fingerprint maps. They are then used to match with current signal to obtain the location.[2]
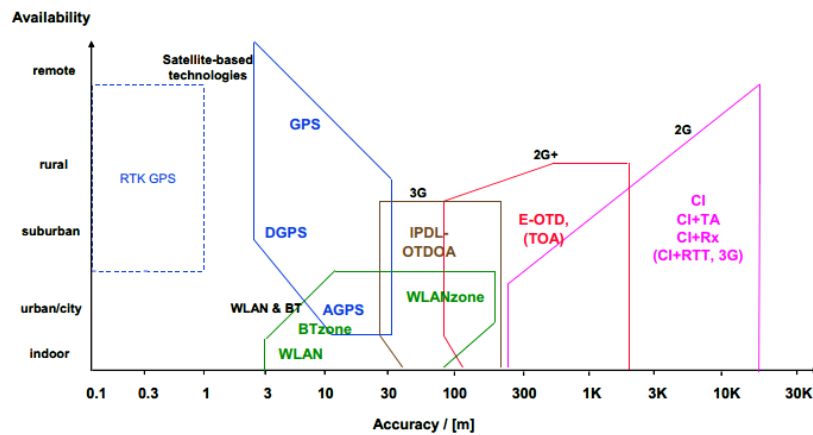

Figure 1.1: Comparison of Positioning Technologies (source: [3])

In addition to these types there are also multiple algorithms used in indoor localization. Some of them are location fingerprinting, triangulation, proximity and dead reckoning.[4] Description of few algorithms can be found in chapter 2.

This thesis is focused on method using radio signal strength (RSS) fingerprinting collecting data from bluetooth, wireless and cellular networks.

1.1 Goals of this thesis

Main goal of this thesis is to explore possibilities of fingerprint collection using smart watch technology. The first question that needs to be answered is if this can be done. Is smart watch capable of RSS data collection? And the answer to this question is yes since smart watches have the similar specifications as low-end smart phones.

One of the goals for this thesis is to create an application for Android phone and wear device which handles fingerprint collection. Problem with smart watches is their diversity in operational system because a lot of watch creators build their own custom systems which can complicate things. Luckily there is new system from Android called Wear 2.0 and it is basically port of Android system to wearable devices.

And final goal is to test created application and figure out if it's data are useful for indoor localization or not.

1.2 Reason for selection of this topic

The reason behind selection of this topic is rather simple. I was introduced to Android during my studies at the University but it was not any deep knowledge so I decided to go for a study abroad to deepen my knowledge. Part of that study was to work for a company where we developed rather technical heavy Android application. It's core part was using multiple APIs but it was focused only on a singe device. So next thing I wanted try was working with multiple kinds of devices and since Android Wear 2.0 is rather new I wanted to test it out. So the main reason is to get more experienced with Android and as a developer.

2 RSS Indoor localization

This chapter describes most common techniques and methods for indoor localization using radio signal strength (RSS).

2.1 Triangulation

Methods based on Triangulation use geometric properties of triangles to determine target position. This can further be divided into lateration and angulation. [6] There are multiple sources of data these methods can use like distance estimation between device and specific transmitters, measurements of the signal propagation-time (TOA: Time Of Arrival and TDOA: Time Difference of Arrival[7]) and the direction of received signal (AOA: Angle of Arrival[8]).

2.1.1 Lateration

Lateration refers to the technique of determining position based on distance measurement. There are two main types of lateration and those are Trilateration and Multilateration.

Trilateration uses distance data from multiple reference points, at least 3 in particular as "tri" in the name suggests.[6] This technique can be used in 2D and 3D plane.

Figure 2.1 illustrates usage of Trilateration in 2D and 3D environment. While working in 2D plane will result with only one specific location point. Moving to the 3D plane creates a problem because signal is send in a sphere which will result in two positions instead of one. That is the reason why there is the need to add fourth data source for single position calculation.
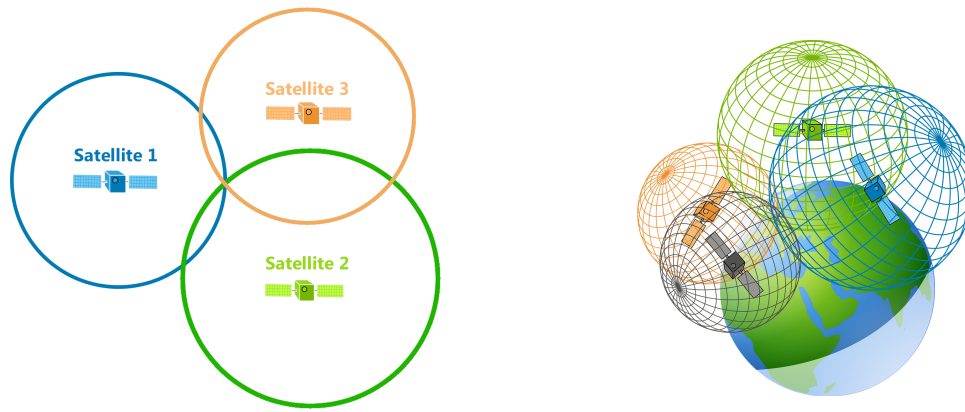
Multilateration

Figure 2.1: 2D and 3D Trilateration (source: [9])

2.1.2 Angulation

2.2 Fingerprinting

This method is a part of already mentioned Signal Strength Fingerprint Maps (SSFM) type. Main point of this method is using previously recorded data to figure out location inside the building. Hence fingerprint term in the name. There is multiple kinds of data that can be recorded like magnetic field strength or light signals but as it was already mentioned this topic is focused RSS. There are also multiple sources of radio signals like bluetooth, wireless or cellular devices and networks.

This method has two main stages where the first one is fingerprint maps construction also called offline stage. They are created using collecting Received Signal Strength (RSS) at different positions with specific coordinates of this place. All fingerprints are saved in the database and this is called fingerprint map. The other part is localization stage also known as online stage where client device measures data and compares them with fingerprint maps to approximate position. [2][5]

2.3 Proximity

Proximity detection also knows as connectivity based positioning is one of the simplest method to implement.

2.4 Other techniques

3 Android Wear 2.0

This chapter will provide information about Android Wear 2.0 technology. Why it was developed and what are the differences between previous version and other wear technologies.

3.1 What is Android Wear 2.0

3.2 Other wear technologies

4 Analysis, design and implementation

This chapter describes all important information about created application. One of the main parts are hardware and software used for developing and testing of the application. Other part is structure and description of core parts used in the application.

4.1 Hardware

4.1.1 Smart Watch

4.2 Software

4.2.1 Android

Android Wear

4.2.2 AltBeacon Library

4.2.3 SQLite database

4.2.4 Couchbase database

4.2.5 TileView

4.3 Application structure

4.3.1 Mobile application

Activities

Model

Utilities

4.3.2 Wear application

5 Testing and data analysis

This chapter goal is to show application testing, data collection and analysis.

5.1 Data collection

5.2 Analysis

6 Conclusion

6.1 Application improvements

Literature

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