LOCALIZATION AND POSITIONING via Wi-Fi SIGNALS

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Supervisor's Name : **ABD. SHUKUR BIN JA'AFAR**

Date : **10th June 2013**

Special thanks to my parents and family, my colleagues and friends, and project supervisor who have been supporting me all the time.

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ABSTRACT

Global Positioning System (GPS) is widely used as public location and positioning system in locating and localizing geo-location coordinates of user. However, this application signal is limited, not operational, not available and inefficient for indoor environment. Therefore, the purpose of this project is to develop localization and positioning system utilizing Wi-Fi signals. Wireless position estimation is based on distance measurement in determining the coordinates of user. Scene analysis which called fingerprinting technique is chosen in this project with measurement of received signal strength at specific locations. This fingerprint positioning algorithm has two phases to go through which is surveying phase and online phase. The unknown location of user will be located during online phase based on database comparison that has been collected on surveying phase. MATLAB Graphic User Interface was developing as user interface for simulation purpose. Several analysis has been done to determine the accuracy and effectiveness of the positioning error due to numbers of access point and environment traffic condition.

ABSTRAK

Sistem Kedudukan Global (GPS) telah digunakan secara meluas sebagai penunjuk lokasi awam dan sistem kedudukan dalam mencari dan menentu koordinat lokasi geografi pengguna. Walaubagaimanapun, isyarat aplikasi penerima ini adalah terhad, tidak beroperasi, tidak berfungsi dan tidak cekap untuk persekitaran dalaman. Oleh itu, tujuan projek ini adalah untuk membangunkan menentu dan sistem mencari kedudukan menggunakan isyarat Wi-Fi. Anggaran kedudukan tanpa wayar berdasarkan ukuran jarak digunakan dalam menentukan koordinat pengguna. Analisis pemandangan iaitu algoritma *fingerprint* teknik telah dipilih dalam projek ini dengan pengukuran kekuatan isyarat yang diterima. Algoritma kedudukan *fingerprint* ini mempunyai dua fasa yang perlu dilalui iaitu fasa pengukuran dan fasa dalam talian. Lokasi yang tidak diketahui pengguna akan terletak semasa fasa dalam talian berdasarkan perbandingan pangkalan data yang telah dikumpul semasa fasa pengukuran. MATLAB Grafik Antara Muka Pengguna dibangunkan sebagai antara pengguna bagi tujuan simulasi. Beberapa analisis telah dilakukan untuk menentukan ketepatan dan keberkesanan kedudukan terhadap jumlah akses pusat dan keadaan lalu lintas persekitaran.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
GPS	Global Positioning System
RFID	Radio Frequency IDentification
laser	Light Amplification by Stimulated Emission of Radiation
WLAN	Wireless Local Area Network
RSS	Received Signal Strength
AP	Access Point
FKEKK	Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
PSM	Projek Sarjana Muda
UTeM	Universiti Teknikal Malaysia Melak
RSS	Received Signal Strength
AoA	Angle Of Arrival
2D	Two Dimensions
ToA	Time Of Arrival
TDoA	Time Difference Of Arrival
TOF	Time Of Flight
WLAN	Wireless Local Area Network
UWB	Ultra-Wideband
Wi-Fi	Wireless Fidelity
A-GPS	Assisted Global Positioning System
GNSS	Global Navigation Satellite System
RTLS	Real-time Locating System
ANSI	American National Standards Institute
ISO	International Organization for Standardization
SSID	Service Set Identifier
LBS	Location-based Service

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will discuss briefly the background of the project that has been chosen. It will also discuss the problem statement, main objective and the scope of the project.

1.1 Overview of Technologies

Positioning system is a technology that is used in locating and tracking user or property. Location, defined as coordinates or places either room, street, building and house. Position, is refer to the distance or location from some area. *Positioning*, usually refers to the process of finding the two-or-three-dimensional coordinates of a terminal but can mean determination of distance or range [1]. A *beacon* is a

continuous or periodic transmission that facilitates timing synchronization or position measurements between terminals. Terminal refers to the either side of the communication link.

Positioning system technologies can be divided into two categories, outdoor and indoor positioning. Table 1.1 [6] shows different between indoor and outdoor positioning.

Table 1.1: Indoor versus outdoor positioning [6]

<table>
<tr><th>INDOOR</th><th>OUTDOOR</th></tr>
<tr><td>WLAN
Client-based system design
Client-assisted system design</td><td rowspan="2">GPS
Requires minimal obstructions
Long acquisition times (30s-15min)
Has to be synchronous
High power consumption and high unit cost A-GPS</td></tr>
<tr><td>Sensor Network
Localization with beacons
Localization with moving beacons
Beacon-free localization</td></tr>
<tr><td>UWB
A promising approach for indoor geolocation
Can achieve very accurate short distance estimation</td><td>A-GPS
Much more accurate: accuracy of 10-50m can be used even for indoor positioning
Improves acquisition time (<10s)
Synchronous or asynchronous
More cost effective than GPS
Little/no hardware changes required in base stations</td></tr>
</table>

The most popular outdoor positioning system is Global Positioning System (GPS). This system uses satellites to navigate the location of the target or user. The current indoor positioning systems technology is Wi-Fi, RFID (Radio Frequency IDentification), laser (Light Amplification by Stimulated Emission of Radiation), infrared, and ultrasound. Table 1.2 [14]shows the specification of indoor technologies for nowadays. Figure 1.1 and 1.2 [14] show dependency of accuracy to the coverage and carrier wavelength.

Table 1.2: Indoor Positioning Technologies [14]

Technology	Typical Accuracy	Typical Coverage (m)	Typical Measuring Principle	Typical Application
Cameras	0.1mm - dm	1 – 10	Angle measurements from images	Metrology, robot navigation
Infrared	Cm – m	1 - 5	Thermal imaging, active beacons	People detection, tracking
Tactile & Polar Systems	µm – mm	3 – 2000	Mechanical, interferometry	Automotive, metrology
Sound	cm	2 – 10	Distances from time of arrival	Hospitals, tracking
WLAN/Wi-Fi	m	20 – 50	Fingerprinting	Pedestrian navigation, LBS
RFID	dm - m	1 – 50	Proximity detection, fingerprinting	Pedestrian navigation
Ultra-Wideband	cm - m	1 – 50	Body reflection, time of arrival	Robotics, automation
High Sensitive GNSS	10 m	'global'	Parallel correlation, assistant GPS	Location based services
Pseudolites	cm - dm	10 – 1000	Carrier phase ranging	GNSS challenged pit mines
Other Radio Frequencies	m	10 – 1000	Fingerprinting, proximity	Person tracking
Inertial Navigation	1%	10 – 100	Dead reckoning	Pedestrian navigation
Magnetic Systems	mm – cm	1 – 20	Fingerprinting and ranging	Hospitals, mines
Infrastructure Systems	cm - m	building	Fingerprinting, capacitance	Ambient assisted living

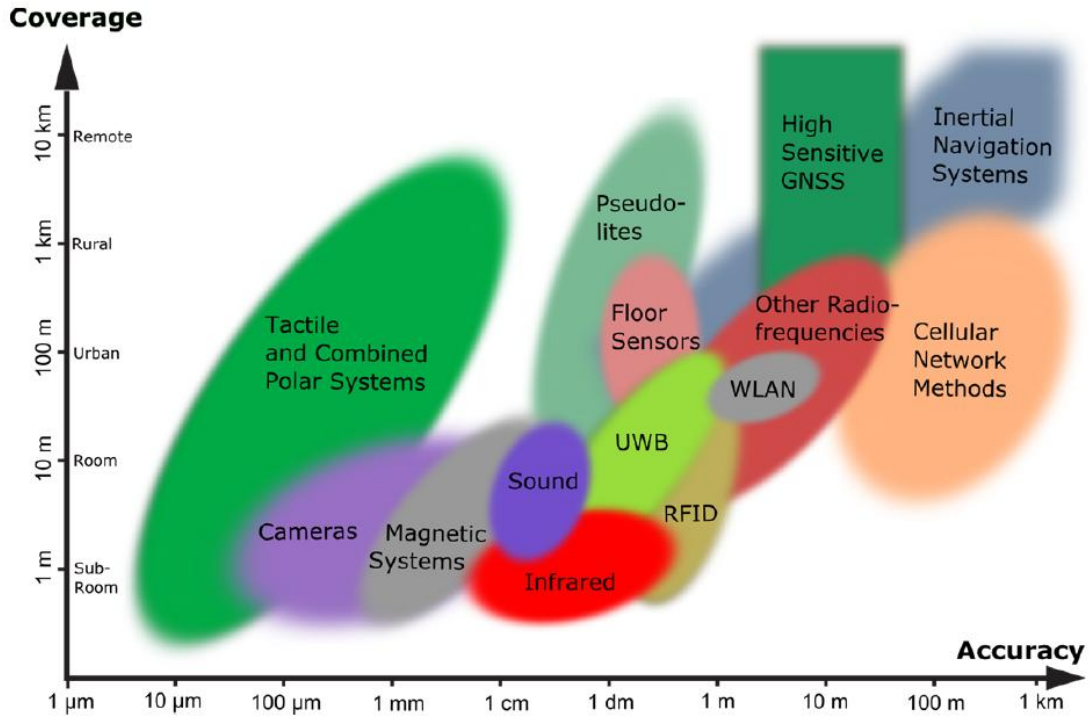

Figure 1.1: Indoor technologies in dependence on accuracy and coverage [14]

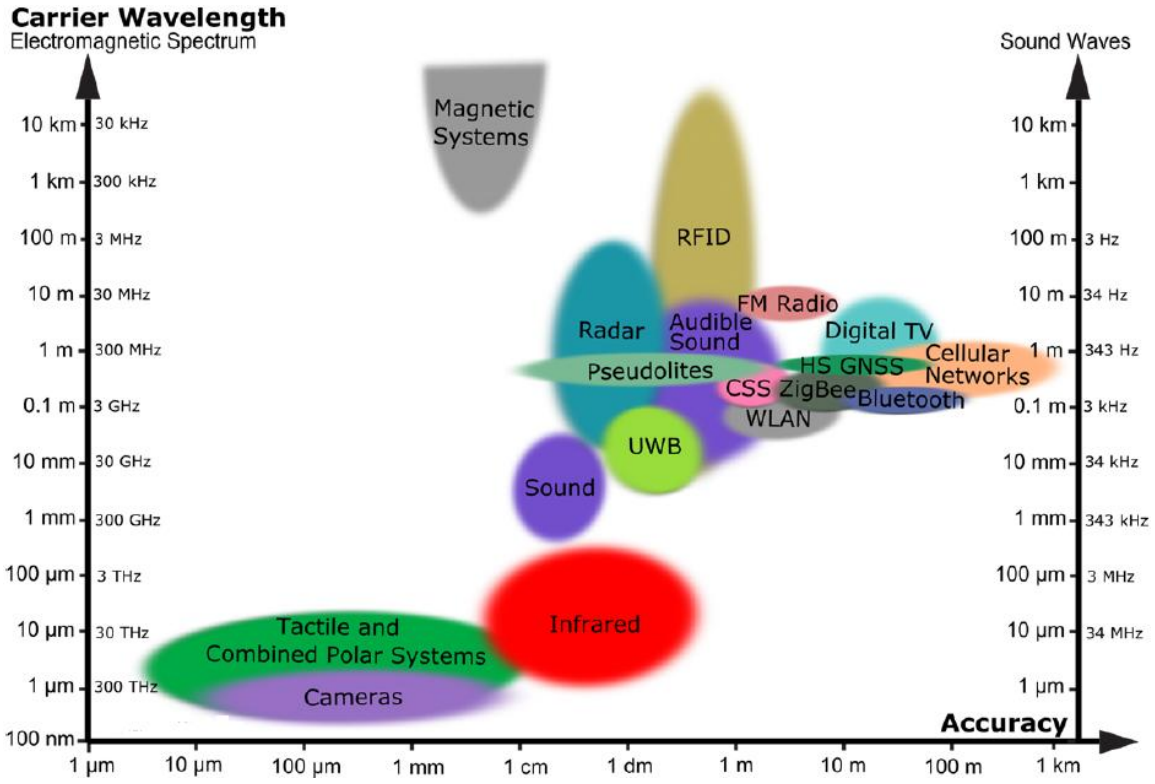

Figure 1.2: Indoor technologies dependence on accuracy and carrier wavelength [14]

1.2 Project Background

WLAN (Wireless Local Area Network), Wi-Fi and IEEE 802.11 all means the same [5]. It is an industrial standard that used for wireless data transmission. Wi-Fi used electromagnetic waves in order to transmit data over the airwaves medium. Obviously, they are not designed and deployed for the purpose of positioning. However, measurements of received signal strength (RSS) of the signal transmitted by either access point (AP) imply the location of any mobile user [9].

There are several positioning algorithms that can be used in determining the current position of user like triangulation, trilateration and scene analysis. From the RSS, it can be used to compute to determine the location or coordinate of the user.

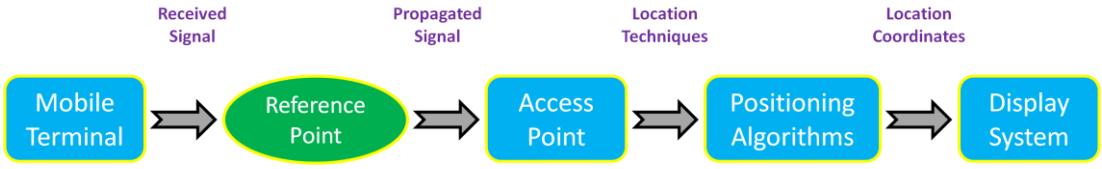

Figure 1.3: Positioning system block diagram

Figure 1.3 shows the block diagram of the system. There is a vector power between the user referenceor target to the AP. This vector can be used to determine the distance by using positioning algorithm that will be discuss in Chapter 2, literature review. Then, the position or coordinates of the user will display on MATLAB Graphic User Interface (GUI).

This project using an existing Wi-Fi infrastructure in localizing and positioning even it was never designed to do so. The coverage area of this project was at Block B, Ground Floor, FKEKK (Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer) because of the number of APs located there.

1.3 Problem Statement

Indoor location sensing systems has become very important and popular in recent years [3][8]. They, gradually play an important role in all aspects of people's daily lives including e.g. living assistant, navigation, emergency detection, surveillance or tracking target-of-interest and many other location-based services [4].

Nowadays, WLAN technology can be found in almost every building [5]. It is because an advancement of technology in developing devices like smartphones which can directly connected to the internet. Internet has become a daily needs especially for getting knowledge.

GPS is the most popular positioning system for outdoor environment and plays a dominant role in localization. It can provide precise locations of mobile devices within worldwide coverage.

However, GPS has shadow problem and is not available, not operate and not suitable for indoor environments [9][10][12]. This inefficiency is due to the weakness of signals emitted and their disability to penetrate most building materials [4]. It performance deteriorates in indoor use and in urban environments [1].

1.4 Objectives

The main objectives of this project can be summarized as follows:

i. To develop a location and positioning simulation estimation using MATLAB software at FKEKK, UTeM.
ii. To analyze the performance of location estimation based on fingerprint technique.

1.5 Scope of Project

Development of the Localization and Positioning via Wi-Fi signals have chosen after doing research from the books, internet, electronic magazine and other resources due to human demand for indoor positioning system. This project needs no hardware modification for Wi-Fi infrastructure and no cost required.

Localization and Positioning via Wi-Fi signals is an innovation of locating and tracking user or property. The scopes of this project require using of hardware and software for measurement phase and software development for testing phase.

For the first phase of the project development, data collection (offline phase) has been done at Block B, Ground Floor, FKEKK, UTeM. The process of collecting data is called surveying phase where at each point need to collect RSS in determining the distance during online phase. The collected data will used as database for applying the location estimation algorithm in MATLAB software. After completed this phase, GUI will be develop to display the current location and position of the user. Figure 1.4 shows an overall flow chart of the scope of project.

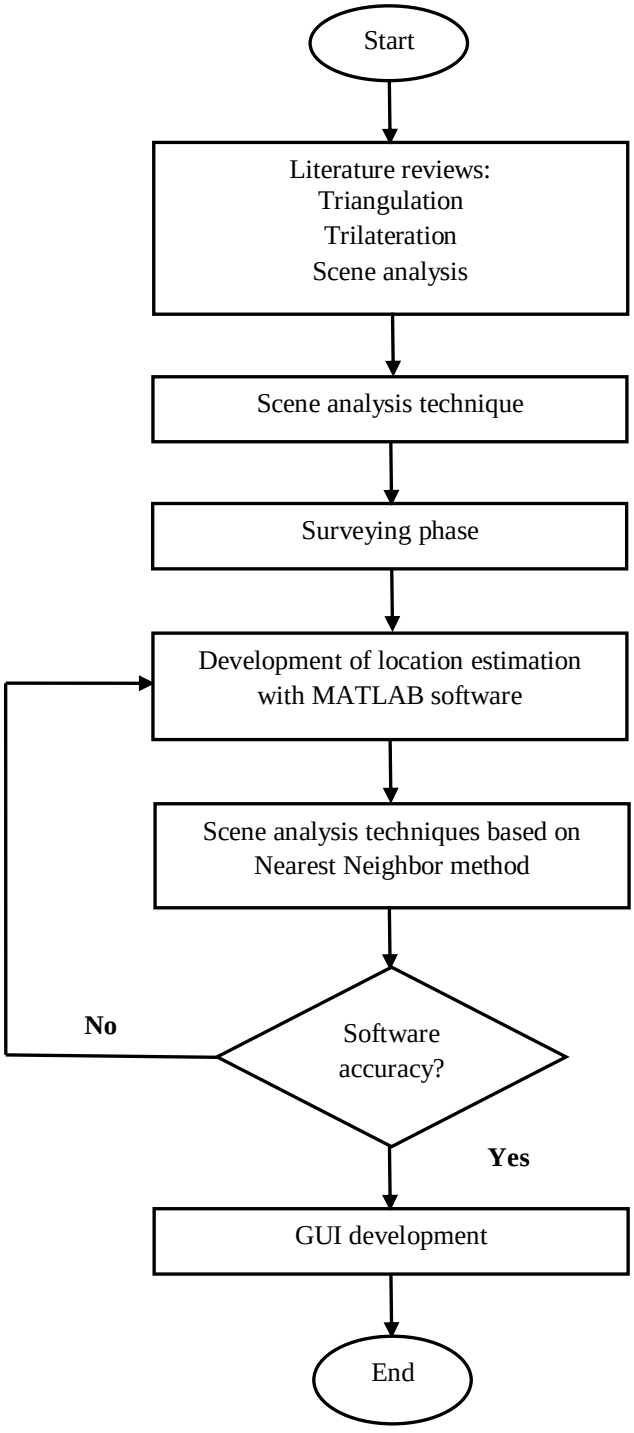

Figure 1.4: Flow chart scope of project