

**Sudan University of Science &  
Technology**

**College of Graduated Studies**



Wi-Fi positioning techniques  
for location based services

تحديد مواقع الخدمات باستخدام

A Research Submitted in Partial  
Fulfillment for The Requirements  
Degree of MSC in Communication  
Engineering

**Prepared By:**

**Mohamed Hamid Ahmed**

**Supervised by:**

**[Dr.Mohammed Hussien Mohammed](#)**

اء  
وذ

**بإله من الشيطان الرجيم**

وَقُلْ اَعْمَلُوا فَسَيَرَى اللّٰهُ عَمَلَكُمْ  
وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ اِلَى  
عَالَمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُمْ بِمَا كُنْتُمْ  
تَعْمَلُونَ { التوبة 105

صدق الله العظيم

## Dedication

**This work is devotedly  
dedicated to  
ALMIGHTY GOD**

**TO GREATEST FATHERS  
AND KIND MOTHERS.**

# Acknowledgement

First and Foremost we give thanks to Allah then , I would like to express my sincere gratitude to my advisor [Dr. Mohammed Hussien Mohmmed](#) for the continuous support of my Msc research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Msc study. I thank my colleagues for stimulating discussions, for the sleepless nights we were working together before deadlines. Last but not the least I would like to thank my family my mother Nawal and my father Hamid my brothers Mazin, Moiz, Mosab and my little sister Mai at first place and supporting me spiritually throughout my life.

## **Abstract**

Location-aware computing becomes an exciting research as recent advancements in RF circuits and wireless communication stacks. In this thesis, we present a fingerprinting based location assessment. The proposed method uses WLAN signal Strength to estimate the global position of mobile users in an indoor environments. The system uses the signal strength from several base stations rather than angle for determining the location of mobile station. The project deal with two algorithms to calibrate signals received from access points and stored it in the radio map (fingerprinting) is called calibration phase. In localization phase the stored values are compared with calibrate one to predict the user locations. Therefore a fingerprinting algorithm that was introduced is used to improvement of the presented work and with multi sensors which enhance the accuracy of fingerprinting algorithms and tracking of the users.

## :المستخلص

التطور الهائل فى تقنية تحديد المواقع وما اشتملت عليه من تطبيقات ساهمت فى تحديث البنية التحتية لسوق العمل. ومع وجود بعض القصور فى بعض التقنيات تم الاستعاضه باخرى لم تكن تستخدم فى نفس النطاق . فى هذا المشروع تم استخدام تقنية اخز البصمة باستخدام خوارزميتين لتحديد مكان المستخدم وتعتمد التقنية على أخز قراءة الاشارات من اجهزة الارسال (نقاط الوصول) فى المنطقة المخصصة للمسح فى المرحلة الاولى لبناء الخريطة الراديويه . فى المرحلة الثانية يتم مقارنة القراءة التى حصل عليها المستخدم مع الخريطة الراديوية .وتصبح القيم التى يرجعها النظام بعد المقارنه اكثر دقة كلما زادت قيم الخريطة الراديوية.

## Content

الآية.....	I
Dedication.....	II
Acknowledgment.....	III
Abstract.....	IV
المستخلص.....	V
Contents.....	VI
List of Tables.....	IX
List of Figures.....	X
List of Abbreviations.....	XII

**Chapter one:**  
**Introduction.....1**

1 .1 Background.....2  
.....2

1.2 Wireless Geolocation.....2  
.....2

1.3 Related  
Work.....5

1.4 Problem Statement.....6  
.....6

1.5 Proposed Solution .....7  
.....7

1.6 Methodology.....7  
.....7

**Chapter two: Location techniques**  
**.....9**

2.1 Positioning .....10  
.....10

2.2  
Proximity.....10

2.3 Dead Reckoning.....11  
.....11

2.4 Absolute Distance.....12  
.....12

2.5 Relative Distance .....13  
.....13

2.6 Angulation.....	14
2.7 Pattern Recognition.....	15
2.8 Measurement Theory.....	18

**Chapter three: fingerprinting and modeling of signal strength .....20**

3.1 Tracking.....	21
3.2 Location Base Service.....	21
3.3 Principle of Wi-Fi Fingerprinting.....	23
3.3.1 Performance.....	25
3.3.2 The Cost.....	26
3.3.3 Scalability.....	28
3.3.4 Signal Variation .....	31
3.3.5 Security and Privacy.....	32
3.3.6 Representation .....	33

3.3.7 Training the Radio Map.....	34
3.4 WI-FI Technology.....	35
3.5 Fundamentals for Wi-Fi.....	35
3.5.1 Advantages of Wi-Fi.....	36
3.5.2 Challenges.....	36
3.6 Signal Attenuation of Static Environment and Users.....	37
3.7 The Modeling and Signal Strength .....	38
<b>Chapter four: Simulation and Results .....</b>	<b>40</b>
4.1 Simulation Design .....	41
4.2 Localization Phases .....	41
4.2.1 Offline Phase .....	41
4.2.2 Online Phase .....	43
4.3 Based on Method one: Count Method.....	43

4.4 Based on Method Two: Least Sum of Square.....44

4.5 Count Method and Least Sum of Square Compared.....55

**Chapter five: Conclusion and Recommendation**  
.....**56**

5.1 Conclusion .....  
...57

5.2 Recommendation .....  
.....58

Reference .....  
.....60

Appendix .....  
.....62

**List of Tables**

Table 2.1 comparison between the positioning techniques ..  
.....17

Table 4.1 sample of three locations in radio-map .....  
.....41

Table 4.2 Example of comparing recorded and received  
signal strengths...43

## **List of Figures**

Figure (1.1) sort the three different positioning method ...	5
Figure (2.1) show basic of proximity .....	11
Figure (2.2) show the basic of Dead Reckoning .....	12
Figure (2.3) show the basic of Absolute Distance .....	13
Figure (2.4) show the basic of Relative Distance .....	14
Figure (2.6) show the basic of Angulation .....	15
Figure (2.7) show the basic of Pattern Recognition .....	16
Figure (3.1) Ekahau products .....	23
Figure (3.2) Basic concept terminal-assisted location fingerprinting.....	25
Figure (3.3) layout of the floor where the experiment was implementing...	39
Figure (4.1) diagram show the experiment steps.....	42
Figure (4.2) show the radio map when using count method when acquire value is [-62;-61;-78;-68] .....	45
Figure (4.3) predicted location when using count method	

when acquire value is [-62;-61;-78;-68] .....  
.....46

Figure (4.4) radio map when using least sum of square when  
acquire value is [-62;-61;-78;-68] .....  
.....47

Figure (4.5) predicted location when using sum of square  
when  
acquire value is [-62;-61;-78;-68] .....  
.....48

Figure (4.6) count method predicted location when recorded  
values is [-60;-72;-70;-64] .....  
.....49

Figure (4.7) maximum values show the predicted location  
when acquire values is [-60;-72;-70;-64] .....  
.....49

Figure (4.8) minimum value at location [6] determines the  
predicted location when acquire values is [-60;-72;-70;-64]  
.....50

Figure (4.9) Least Sum Square show location (6) as predicted  
location when acquire values is [-60;-72;-70;-64] ....  
.....50

Figure (4.10) count method predicted location .....  
.....51

Figure (4.11) maximum values show the predicted location  
.....51

Figure (4.12) radio map when using least sum of square .....52

Figure (4.13) Least Sum Square show location (11) as predicted location .....52

Figure (4.14) count method predicted location .....53

Figure (4.15) maximum values show the predicted location .....53

Figure (4.16) radio map when using least sum of square .....54

Figure (4.17) Least Sum Square show location (2) as predicted location....54

### **List of Abbreviations**

MS	Mobile Station
FCC	Federal Communications Commission
4G	Forth Generation

GPS	Global Positioning System
ITS	Intelligent Transportation Systems
WLAN	Wireless Local Area Network
WI-FI	Wireless Fidelity
LBS	Location-Based Services
SS	Signal Strength
RTLS	<a href="#"><u>Real-Time Locating System</u></a>
API	Application Programming Interface
PDA	Personal Digital Assistance
VOIP	Voice Over IP
SSID	Service Set Identifier
MAC	Media Access Control
RF	Radio Frequency
TDOA	Time Distance Of Arrival
RFID	Radio Frequency Identification
TOA	Time Of Arrival
VHF	Very High Frequency
VOR	VHF Omni Directional Ranging
AOA	Angle Of Arrival
RSS	Received Signal Strength
IPS	Indoor Positioning System
SVM	Support Vector Machine
UWB	Ultra Wide Band
OSL	Opportunistic Seamless Localization

AP	Access Point
SS	Sum of Square