SmartGuide: A Smart Campus Guide using BLE based Indoor Localization

by Tooba Naseer

Submission date: 17-Jun-2020 08:40PM (UTC+0500)
Submission ID: 1345431101
File name: uet_thesis_2.pdf (2.88M)
Word count: 19063
Character count: 98012

SmartGuide: A Smart Campus Guide using BLE based Indoor Localization

Session: 2016 – 2020

Submitted by:

Rida Mahmood 2016-CE-54

Tooba Naseer 2016-CE-72

Rabeya Hamood 2016-CE-81

Ayesha Jabbar 2016-CS-159

Supervised by:

Dr. Shiekh Faisal Rasheed

Department of Computer Engineering

University of Engineering and Technology

Lahore Pakistan

SmartGuide: A Smart Campus Guide using BLE based Indoor Localization

(Session 2016 Computer Engineering)

The thesis is to be submitted to the Department of Computer Engineering, University of Engineering and Technology, Lahore for the partial fulfillment of the requirement for the Bachelors degree in Computer Engineering.

Internal Examiner	**External Examiner**
Signature: _____	Signature: _____
Name: _____	Name: _____
Designation: _____	Designation: _____
Chairman	**Dean**
Signature: _____	Signature: _____
Prof. Irfan Ullah Chaudhary	Name:

Department of Computer Engineering

University of Engineering and Technology

Lahore Pakistan

Declaration

I declare that the work contained in this thesis is my own, except where explicitly stated otherwise. In addition this work has not been submitted to obtain another degree or professional qualification.

Signed: _____

Date: _____

Acknowledgments

67
I am deeply indebted to my supervisor Dr. Shiekh Faisal and co-advisor Dr. Beenish who have the substance of genius: they convincingly guided and encouraged us to do the right. The moral contribution of my institute is truly appreciated. I also wish to acknowledge the emotional support and the prayers of my parents otherwise this project never reached its goal.

It is our genuine gratefulness and warmest regard that we dedicate this first-fruit to Allah Almighty, the strong pillar, our creator who gave us the power of mind, strength, skills, guidance and healthy life duing timeline of our project.

To our beloved parents who spiritually, financially and emotionally support us, taught us the value of hard work and lighten our paths of study.

It's been incredible to dedicate the efforts pushed by our supervisor Dr. Shiekh Faisal and co-advisor Dr. Beenish Ayesha Akram. Thier encouragement and words of advice will always regulate our lives.

To our organizational staff, who gave us moral support and taught us that even the largest task can be accomplished if it is done one step at a time.
Lat but not least, this thesis is going to be dedicated to my group members who cooperates each other all the time.. . .

Contents

Acknowledgments iii

List of Figures ix

Abbreviations xi

Abstract xiii

1 Introduction 1

1.1 Introduction . . . 1

1.1.1 Overview of Project . . . 1

1.1.2 Background . . . 3

1.2 Motivation . . . 4

1.3 Objectives of the project . . . 5

1.3.1 Industry Objectives . . . 5

1.3.2 Research Objectives . . . 5

1.3.3 Academic Objectives . . . 5

1.4 Scope of the project . . . 6

1.5 Target Audience . . . 6

1.6 Possible Applications of work . . . 6

2 Related Literature and Problem Statement 8

2.1 Description and scope of the related literature . . . 8

2.2 General findings and availability of the literature . . . 9

2.3 GPS Outdoor Technology . . . 9

2.4 Indoor Localization Techniques . . . 10

2.4.1 Triangulation . . . 10

2.4.2 Trilateration . . . 11

2.4.3 Proximity . . . 12

2.4.4 Fingerprinting technique (Our Selected Approach) . . . 12

2.5 Indoor Positioning Approaches . . . 12

2.6 Conclusion . . . 15

2.7 Problem Statement . . . 15

3 Dataset and Research Methodology 17

3.1 Dataset Description . . . 17

3.2 Experimental Area Description . . . 17
3.3 Collected Dataset . . . 18
3.3.1 Preparation of data set . . . 19
3.3.2 Preprocessing of data . . . 20
3.3.3 Performance Measures criterion for the comparison of algorithms . . . 20
3.4 Introduction to Research Methodology . . . 21
3.5 Research Methodology . . . 21
3.6 Proposed Work to develop the Android Application . . . 22
3.7 Related Work . . . 23
3.7.1 Comparison of Existing Work . . . 25
3.7.2 Limitations of Existing System . . . 25
3.7.3 Software Architecture . . . 26
3.8 Software Development Life Cycle Used . . . 26
3.8.1 AGILE SDLC . . . 27
3.8.2 Justification for AGILE SDLC . . . 28
3.9 Requirement Analysis . . . 29
3.9.1 Hardware Functional Requirements . . . 29
3.9.2 Software Functional Requirements . . . 29
3.9.2.1 Data Capturing Application . . . 29
3.9.2.2 SmartGuide: Android Application . . . 30
3.9.3 Non Functional Requirements . . . 31
3.9.4 Use Case Diagram . . . 32
3.9.5 Use Case Texts . . . 34
3.9.6 Test Cases . . . 37
3.10 Proposed System . . . 39
3.10.1 Deployment of BLE Beacons . . . 40
3.10.2 Data Acquisition . . . 40
3.10.3 Data Pre-processing and Training . . . 42
3.10.4 Room Level Prediction . . . 42
3.10.5 Location Information . . . 42

4 Implementation **43**
4.1 Tools for implementation . . . 43
4.1.1 Android 3.5 or above with java . . . 43
4.1.2 Php MySQL . . . 43
4.1.3 Php Storm . . . 44
4.1.4 Postman . . . 44
4.1.5 MATLAB . . . 44
4.1.6 Python IDE . . . 44
4.2 Implementation of Machine Learning Algorithms . . . 45
4.2.1 k- Nearest Neighbours . . . 45
4.2.1.1 Hyper-parameters tuning: . . . 46
4.2.1.2 Methodology for data training . . . 47

4.2.2 Random Forest Classifier . . . 47
4.2.2.1 Description of Hyper-Parameters: . . . 48
4.2.2.2 Methodology for data training . . . 49
4.2.3 ANN . . . 50
4.2.3.1 Hyper-parameters tuning: . . . 51
4.2.3.2 Methodology for data training . . . 54
4.3 Implementation of Android applications . . . 55
4.3.1 Data Capturing Application . . . 55
4.3.1.1 User can enter his name or ID . . . 55
4.3.1.2 Scanning of nearby BLE Bluetooth devices . . . 55
4.3.1.3 Restart scan and capture RSSI fingerprints . . . 55
4.3.1.4 Generate csv file of captured data . . . 56
4.3.1.5 Add delay function to slower the process . . . 56
4.3.1.6 Allow user to generate files in iterations according to delay time . . . 56
4.3.2 Admin Android Application . . . 56
4.3.2.1 Design Database of Admin App . . . 56
4.3.2.2 Creating Web services for our App . . . 58
4.3.2.3 Login and Signup of Admin App . . . 59
4.3.2.4 Add/Edit/del Room information . . . 60
4.3.2.5 Add/Edit/del Room Member information . . . 61
4.3.2.6 Add/Edit/del Office Hours of Room Member . . . 62
4.3.2.7 Add Pictures of Room . . . 62
4.3.3 User Android Application . . . 63
4.3.3.1 Integrate trained ML model with user app. . . . 63
4.3.3.2 Functionality to turn ON bluetooth when users install the app . . . 64
4.3.3.3 Make java classes to save RSSI values . . . 65
4.3.3.4 Function to pass RSSI values to trained model . . . 65
4.3.3.5 Show location of user . . . 66
4.3.3.6 Show all information of current room . . . 66
4.3.3.7 Update location of the user . . . 67
4.3.3.8 Show nearby location of the user . . . 67
4.3.3.9 Show all information of nearby rooms . . . 67

5 Results and Discussions **69**
5.1 Graphs . . . 72
5.2 Confusion Matrix . . . 73

6 Thesis Contribution and Future Work **75**
6.1 Introduction . . . 75
6.1.1 Thesis Contribution . . . 75
6.1.2 Future Work . . . 76

References **78**

List of Figures

1.1 Beacons 3

2.1 GPS working scenario 10
2.2 Illustration of triangulation technique 11
2.3 Internal circuitry of beacon 15

3.1 Dataset format with each label and its corresponding RSSI value . . 18
3.2 Map of ground floor of the building where beacons are installed . . 18
3.3 Map of first floor of the building where beacons are installed 19
3.4 Number of samples collected for each label 19
3.5 Accuracy 20
3.6 Precision 20
3.7 Recall 20
3.8 Precision and processing time of features 23
3.9 System Architecture 24
3.10 Precision and recall of different algorithms 24
3.11 Precision and recall of different algorithms 25
3.12 Precision and recall of different algorithms 25
3.13 Precision and recall of different algorithms 25
3.14 Comparison between existing systems 26
3.15 Software Architecture Diagram 27
3.16 Agile Development Methodology 28
3.17 Usecase Diagram 33
3.18 Usecase(1) 34
3.19 Usecase(2) 34
3.20 Usecase(3) 35
3.21 Usecase(4) 35
3.22 Usecase(5) 36
3.23 Usecase(6) 36
3.24 Usecase(7) 37
3.25 Testcase(1) 37
3.26 Testcase(2a) 38
3.27 Testcase(2a) 38
3.28 Proposed System 39
3.29 Beacons labeling 40
3.30 Small portion of dataset 41

4.1 Impact of choosing the weight assigning criterion on accuracy score. 46
4.2 Impact of choosing the distance measure on accuracy score. 46
4.3 Impact of choosing the number of neighbors on accuracy score . . . 47
4.4 Feature Importance Graph 48
4.5 Impact of different number of random states 49
4.6 Impact of different number of batch sizes 49
4.7 Structure of neural network 50
4.8 Impact of batch sizes on accuracy score. 51
4.9 Impact of epochs on accuracy score. 52
4.10 Impact of number of neurons on accuracy score. 52
4.11 Impact of weight initalization methods on accuracy score. 53
4.12 Impact of different optimization algorithms. 53
4.13 Database design diagram 57
4.14 Relationship between database server and android application . . . 58
4.15 Format of URL of php scripts in Android application 60
4.16 Scenario to upload image to the server 63
4.17 Steps to integrate the trained model 64
4.18 Steps to get RSSI values and MAC address 65
4.19 Steps to save RSSI values and MAC address in the array 65
4.20 Steps to pass RSSI values to trained model 66
4.21 Steps to show location of user 66

5.1 Impact of distance measure on accuracy score 69
5.2 Impact of different number of trees on testing dataset 70
5.3 Accuracy score on different optimization algorithms 71
5.4 Accuracy, precision and recall graph of knn on training and testing sets 72
5.5 Accuracy, precision and recall graph of ann on training and testing sets 72
5.6 Confusion matrix for the evaluation of knn 73
5.7 Confusion matrix for the evaluation of ann 74

Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
FP	**F**inger **P**rints
BLE	**B**luetooth **L**ow **E**nergy
RSSI	**R**educed **S**ignal **S**trength **I**ndicator
GPS	**G**lobal **P**ositioning **S**ystem
TOA	**T**ime **O**f **A**rrival
TDOA	**T**ime **D**ifference **O**f **A**rrival
AOA	**A**ngle **O**f **A**rrival
IR	**I**nfrared **R**adiations
TOF	**T**ime **O**f **F**light
CNN	**C**onvolution **N**eural **N**etwork
ARM	**A**dvance **RISC** **M**achine
AP	**A**ccess **p**oint
LAN	**L**ocal **A**rea **N**etwork
dbm	**d**ecibles **p**er **m**inute
MACAddress	**M**edia **A**ccess **C**ontrol Address
ML	**M**achine **L**earning
CSV	**C**omma **S**eperated **V**alues
KNN	**k**- **N**earest **N**eighbours
RF	**R**andom **F**orest
ANN	**A**rtificial **N**eural **N**etworks
API	**A**pplication**P**rogram **I**nterface
SIFT	**S**cale **I**nvariant **F**eature **T**ransform
PCA-SIFT	**P**rincipal **C**omponent **A**nalysis **SIFT**

SURF	**S**peeded **U**p **R**obust **F**eature
LSH	**L**ocality **S**ensitive **H**ashing
SVM	**S**upport **V**ector **M**achine
NB	**N**aive **B**ayes
SDLC	**S**oftware **D**evelopment **L**ife **C**ycle
IR	**I**nfrared **R**adiation

Abstract

Our society can save their precious time but they have less resources. The new people who are visiting the new area of the city or country have no information about that particular area. Infact when students newly get admitted to the university, they need guidance about the department admin room, classrooms, labs and much more. There is not only the need of outdoor location guidance to the student but also of the indoor environment so he can adjust easily. On the other hand, the visitors of the shopping mall or the passangers going to the airport need full guidance about their surroundings i.e. which shop is nearby. To provide guidance to those people we decided to establiash an Android Application through which they can seek guidance. In past, there exists work about indoor localization but not for the purpose of guidance so we provide much facilities to users so they seek help and can save their time and money.

Chapter 1

Introduction

1.1 Introduction

1.1.1 Overview of Project

Outdoor and indoor localization is an integral component of IoT (Internet of Things) in this era of mobile computing. Indoor localization can open new horizons for ubiquitous applications targeting university departments, government small institutes, software houses, airports, shopping malls, museums etc. Our project will find the location of a specific person by using appropriate machine learning approach using BLE based Android application. This location will be used to provide guided tour of the indoor building (Computer Science and Engineering Department at UET, Lahore) we will use to validate our work.

This project will guide persons who are not much familiar with visiting place. It has an android application that will predict the indoor location of a person at room level and also gives information of current room location and nearby rooms in the form of text, images, audio and videos. In our case visiting place will be CSE dept at UET LHR. For room prediction, RSSI fingerprints of BLE beacons will be captured for training of model. After finding the location of the person, guidelines of that certain room/area will be provided to the user on user end Android application. Indoor positioning has numerous applications. We can use indoor positioning of people to guide them inside shopping malls, airports or museums.

Indoor positioning systems can be broadly classified into two main parts: Systems that need some infrastructure which are further categorized into those which needs ad-hoc deployment like BLE beacons and systems which takes profit of previously

installed infrastructure like WiFi fingerprinting technique. Those technologies which do not need any infrastructure deployment are based on magnetic field fingerprinting. Ad-hoc deployment can be initiate in new areas where there is need to save environment from magnetic rays or in those areas where WAPs are weak so we choose to detect indoor location using BLE beacons.Also, BLE based indoor localization is wireless, consumes low power because it works on battery and mostly available in smart mobile devices.

BLE can be used from two different approaches: trilateration and fingerprinting. In tilateration relationship between the user's RSSI measurement and its distance to the BLE beacon station is considered. By estimating distances to multiple beacon stations, the user's location can be predicted using a least square algorithm. The fingerprinting approach is implemented in two phases: an ofliine phase and an online phase. The ofline phase is called the training phase. During this phase, fingerprint RSSI values are determined of every beacon from each device location. The online phase is known as the localization phase which is the actual prediction of the user's device location.

What are BLE beacons?

Beacons are small, wireless transmitters that use low-energy Bluetooth technology to send signals to other smart devices nearby.They are probably the most recent advancement in area innovation and closeness advertising. Set forth plainly, they associate and transmit data to savvy devices making area based prediction and are progressively precise.Each tool contains a CPU, radio, and batteries, and it really works by means of again and again broadcasting out an identifier. This identifier is picked up by way of your tool, commonly a cellular, and marks out an crucial area for your surroundings. The identifier is a unique ID variety that your phone recognizes as specific to the beacon. Once related, the beacon will carry out the signals for what we are using it.

Why we are using BLE beacons?

In this evergoing techinal era, everyone wants leisure and his needs in less time and cost. He wants to become smart.So, due to mentioned reasons we are using this technology.

- Beacons are small, wireless sensors that are normally placed in a casing, have low power consumption because they work on battery.
- The technology uses Bluetooth Low Energy (also called Bluetooth Smart or Bluetooth Version 4.0+) to broadcast radio signals or, simply put, to

]

FIGURE 1.1: Beacons

communicate with other smart devices.

- The broadcasted beacon signals can be captured by smart gadgets, like phones, to call ad-hoc actions.
- Under the beacons casing, there is a small ARM computer with a Bluetooth Smart connectivity module, which is powered by a battery.
- The module runs on firmware, a piece of software installed on beacons.
- As the computing power is limited, it can be used for processing sensor data (information about signal power) and encrypting a beacons ID. There is a small antenna from the CPU.
- The antenna is built in to broadcast electromagnetic waves with specific length and frequency (2.4 GHz radio waves).
- This technology is primarily used for mapping and location services using the RSSI (received signal strength indicator) estimate.

1.1.2 Background

Outdoor localization has been formalized by using satellite-based technologies i.e. GPS[3], BeiDou[12], GLONASS[12], and GALILEO[2]. It is hard for finding the indoor location by using conventional GPS technology because of no direct (Line of Sight)[9] in indoors, so we cannot use these technologies for indoor positioning. Up to date, the technologies used for indoor localization approach are: TOA (Time of Arrival), TDOA (Time Difference of Arrival), AOA (angle of arrival) but they have some limitations. TOA and TDOA require precise clock count

and its synchronization and AOA-based systems require special antennas for their propagation. By keeping in view the evergreen trend of engaging users towards something is through mobile computing.So, there exists some systems which used magnetic rays, time of arival of specific signals, some used WiFi based localization and also deployed on Apple and Android smart phones but due to coherence and interference of different signals in determining the RSSI of fixed WAPs, crucial errors occurred. By analyzing these calculations, we are able to avoid multiiteration(which predict location of device by determining the distance between the AP and mobile device) and capture fingerprints from multiple mobile devices.

The indoor positioning system which we are using is communicating with hardware device so we require a technique which translates the signal into a location. There are three categories to transform this: proximity, geometric and scene analysis,. Proximity methods create zones and assigns the users location when they enter that zone. Geometric method uses signal measurements from device locations and put them in geometrical equations to predict the location but scene analysis method measures the signal from different refence points by standing at one location and then predicts location by passing that fingerprint to trained model which is called fingerprinting technique. A fingerprint is a collection of signals received at a certain location in the scene, in this way they aim to make the fingerprint location specific, such fingerprints are often based on the RSSI values collected from beacons.

So, we are going to implement a system which employs suitable machine learning approach to find the location by using RSSI (Received Signal Strength Indicator) fingerprinting technique because there is less hinderance of other signals in using this technique.. This RSSI values will pass to the trained model (a model which is trained on a given set of input and output values by using appropriate machine learning algorithm) which gives the location of the user's mobile device.

1.2 Motivation

People/visitors who go to an unknown place find it difficult to traverse and wants to find places/people of interest easily. Such problems motivate us to provide ease and leverage facility to users so that they can see the information of a particular indoor environment on his mobile application automatically. BLE is available on nearly every smart device so no additional hardware required at user end. Hence by utilizing their indoor location determined using machine learning on BLE fingerprints, guided tours of smart campus to visitors can be provided and facilitating them. We are using latest technology of BLE beacons because they

work on battery and consume less energy than Wi-Fi signals[13].

1.3 Objectives of the project

1.3.1 Industry Objectives

- Implement a system that takes into account the demands of university campus exploration.
- This project leads to visitors of any organization or store to save their time and effort by providing them textual and pictorial information of organization or store.
- Administrators seek advantage of their time by providing much information to their customers in less time which automatically increase the sales and profit of their product.

1.3.2 Research Objectives

- To find the location of the user that will be connected to his Android app via Bluetooth technology[6].
- To monitor and provide guidelines to user who is connected to the BLE beacon via Bluetooth and mobile application, we need to find user location inside buildings.
- To understand the concept of Android application development which provide textual and pictorial information of particular area and its nearby areas to the user who is located in that indoor environment.

1.3.3 Academic Objectives

- This project enables us to understand the concepts of following subjects:
  a. Machine learning
  b. Networking
  c. Android development
  d. Front-end design
  e. Client server communication management
- To complete a whole real world project , utilizing concepts from computer networking, databases, machine learning, software development life cycle of SE , testing and mobile development.

- To develop the understanding and connection between the Android app and the hardware structure.
- To find the best Machine Learning algorithms which are used to train the model of fingerprints.
- To make an Android application which use as an interface to provide guidelines to the user who is located in a particular indoor environment.
- To ensure the use of latest technologies in implementing the project which helps technical persons and students to enhance their academic skills via learning new features

1.4 Scope of the project

In this project, android application runs on a users mobile device and and will capture BLE RSSI fingerprints. The fingerprints collected at the initial stage will be processed and used to train suitable machine learning model, after training of the ML based location prediction model, based on the room prediction relevant information of nearby rooms, facilities and personnel available will be prepared to be displayed to user at run time , the user will be guided to install our Android app on their phone, their mobile device will capture BLE fingerprint and the fingerprint will be sent to back end server where our trained model will predict their current location inside building in terms of room[7]. The relevant information will be delivered and shown on user mobile device providing guided tour. The placement of Bluetooth low energy beacons will be held in CSE dept at UET Lahore.

1.5 Target Audience

Targeted audience will be the:

- Visitors of the University campus
- New Students and Staff of the campus

1.6 Possible Applications of work

The possible application of work for our project are as follows:

- Software house information (Development, QA, Frontier)
- Airport assisting system

- University Campus smart information system
- Government small Institutes
- Medical departments exploration in hospitals

Chapter 2

Related Literature and Problem Statement

2.1 Description and scope of the related literature

This study aimed to focus on detailed analysis of existing literature related to our project that includes literature review of indoor and outdoor localization techniques, their performance, their contributions and their shortcomings.

In recent times, indoor localization can open new horizons for fascinating and useful applications targeting university campuses, government institutes, airports, shopping malls, museums etc. We can provide different kinds of information by using indoor location of the person. This will be extremely beneficial not only in university campus but also in airports and shopping malls. Shopping malls can use this kind of application by providing much information to their customers in less time which automatically increase the sales and profit of their product. But our purpose is that to provide the ease to the users who visit our department. Our project can be extensible to other areas where it can provide huge benefits to the businesses. But we are specifically focused on providing guidance to the visitors of our department. In this way our project will be used as a guidance tool.

Our project is innovative in the sense that we use indoor location of a person by providing him/her smart guided tour of our department but mostly existing systems uses indoor location of a person for different purposes like providing assistance to older age people. We are not interested in their purposes, but we have great interest in existing indoor localization techniques. So the scope of this literature review will cover all well-known existing indoor localization techniques.

But before going on detailed study of indoor localization, we have to study about outdoor localization in order to find how they work and why we cant use outdoor localization technique in indoor environment and then we delve into indoor localization techniques.

2.2 General findings and availability of the literature

As I stated, that mostly existing systems uses indoor location of a person for different purposes like providing assistance to older age people. But there exist a research[10] that presents a mobile campus tour application based on augmented reality in various universities and the features of application are the information about points of interest, location search and navigation, but it provides outdoor locations of large university campus using GPS, because it is not based on room level prediction and information about indoor locations. But the huge literature related to indoor localization presented various indoor techniques and analysis of their performance measures is available on internet in which we are interested.

2.3 GPS Outdoor Technology

GPS (which is known as Global Positioning System) is the satellite navigation system. It is used for outdoor localization. It tells us where you are on the earth. It retrieves information of time and position where you are on the earth in all weathers. GPS was developed by United States military in 1960 and it is used in next few decades.First of all, it is used for civilian purpose. Today, we use GPS in many technological devices such as GIS device, mobile phones and many watches. The area of application of GPS includes land, space, air and marine. The GPS system is made up of 5 ground stations and 24 satellites where each satellite placed in precise orbit at an altitude of 10,900 miles [4]. As we all know, we used GPS as outdoor locating services. It receives signals from at least three satellites and uses triangulation and trilateration technique which is used to calculate the position of the object. It calculates the distance of a receiver from each satellite where distance is calculated by time it takes for a radio wave to reach the receiver end. GPS can be used in any type of weather and it also provides timing information. Here is the illustration of how GPS works in the figure below:

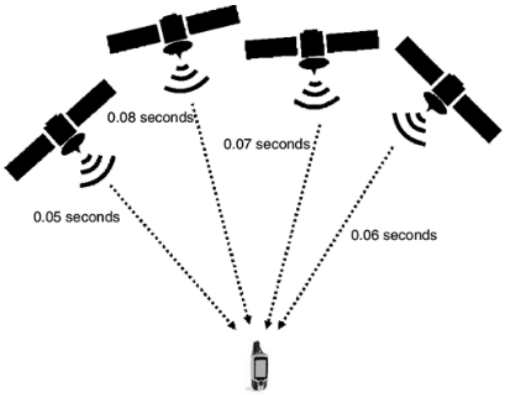

FIGURE 2.1: GPS working scenario

Why we cant use outdoor localization technology in indoor environment?

GPS does not work in indoor location because of no direct line of sight in indoor area. Here are some limitations:

- GPS signals carry waves at a frequency that is scattered by solid objects usually by buildings and walls.
- Actually, satellites sent the signals that are not easily penetrate all kinds of barriers.
- When signal enters into the building, then it gets distorted due to construction material such as wood, bricks, cements etc because it serve as hindrance to the satellite signal.[5]

  Hence, we cant use outdoor localization technology like GPS in indoor environment.

2.4 Indoor Localization Techniques

Indoor localization techniques become popular day by day because it can provide ubiquitous location based services to people. Indoor positioning systems consist of a network of transmitters used for locating persons inside buildings. Here are the popular approaches:

2.4.1 Triangulation

Triangulation technique uses the geometric properties of triangles in order to find the position of the object. In triangulation, AOA (Angle of Arrival)[15] technique

is used to measure the angle and distance relative to two or multiple fixed points through the intersection of direction lines between the fixed points and then this information is used to calculate the position of transmitters which in turn describes the actual location of object. In other words, position of target object is determined by the intersection of direction lines. Here is the illustration of this technique.

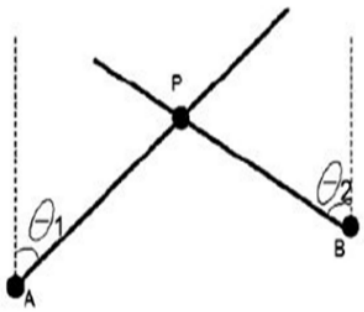

FIGURE 2.2: Illustration of triangulation technique

Drawbacks of Triangulation

This method achieves good results outdoors but it gives weak results inside the building because the radio signals emitted by transmitters get attenuated by several obstacles hence it gives poor estimation of distance calculated. Moreover hardware requires special antennas for signal propagation and hardware requirement for the coverage of large area tends to be expensive and complex[15]. When the area becomes large with multiple reference points, accuracy will decreases due to some errors in the estimation of distance calculated.

2.4.2 Trilateration

Trilateration is also used to estimate the position of object using geometric properties of triangles. The position of target object is determined by TOA (Time of Arrival) and TDOA (Time difference of arrival) [15]. TOA is used to estimate the position of target object by calculating the time taken by a signal to reach the receiver from transmitter. TDOA is the improved version of TOA that considers the difference in TOA at two different receivers and then finds the relative position of transmitter based on the difference which further used to estimate the location of target object. This results in higher accuracy.

Drawbacks of Trilateration

The cost and complexity of hardware is high and it does not give good enough estimates in indoor area because of the inherent error of the distance measure calculations, hence most results have several meters of error[12]. The accuracy is also affected by environmental conditions. In order to get good results both transmitter and receiver require precise clocks that should be synchronized.

2.4.3 Proximity

Proximity technique is also used to estimate the location of target object. It requires a grid of antennas with known locations. When mobile device is detected by more than one antenna, then the antenna with the strongest signal is used to calculate its position. The position of target object (mobile device) is determined by using RSSI (Received Signal Strength Indication) to estimate the distance between mobile devices in order to get the position information of device.

Drawbacks of Proximity

Although proximity is applied on the systems using Bluetooth, IR but it requires calibration effort[15]. Also, we need larger spread of readers in order to achieve a reliable system but it increases system complexity and cost.

2.4.4 Fingerprinting technique (Our Selected Approach)

Fingerprinting technique is based on pattern matching technique. It is used to create signal strengths database that are based on the RSSI (Received Signal Strength Indication) values of various APs. These values are collected at different locations of an experimental area. These are called fingerprints, then by applying any machine learning approach we can train the model which further uses to predict the location of target user. Fingerprinting technique has a better positioning performance and accuracy as compared to the others and it doesnt require any software or hardware modifications at transmitters end.

2.5 Indoor Positioning Approaches

Here are the **indoor positioning technologies** which uses mostly any of method described above to predict location:

1. Infrared (IR) positioning systems

This system consists of a network of IR sensors that are linked by wires and then connected to a centralized server. Early badge system uses IR sensors for determining the position of object or people who is wearing badge. Active Badge system uses IR sensors and TOA approach for estimating the location. Theses sensors are cheap and have good battery life. But the problem is that people have

to wear the badge. This problem is solved by using IR thermal sensors[15] that uses the thermal rays emitted from human body for the prediction of location. Because we know that the temperature of human body is differs from room temperature.

Drawbacks of IR positioning systems

We need larger number of IR sensors to cover the large area which in turn increases system complexity and cost. Also these systems have limited accuracy. Thermal IR sensors also have major drawback that human body is not only the source of heat, there are also other heat sources like electronic devices and light bulbs that could affect the signals received from thermal IR sensors.

2. Ultrasonic positioning systems

This system contains ultrasonic sensors that emit ultrasonic signals which are used to estimate the location of object by measuring the TOF (Time of Flight) [8]. The distance between transmitters and receiver is calculated by TOF and then this information is used to estimate the target position.

Drawbacks of ultrasonic positioning systems This system is expensive and difficult to implement and maintain on larger area. Also, the ultrasound signals have low signal propagation speed when compared to speed of light[15]. It also affects by hindrances in indoor environment which in turn reduces its accuracy.

3. Image based indoor localization

It is a visual-based localization method. Early visual based methods require feature detection and matching that require huge computation and also it is affected by environmental conditions. There is a literature that implements this system by different approach. According to this research, firstly we need to build a database that contains collected images of experimental area. CNN (Convolution Neural Network) is used to train the model which is further used to predict the location of target object by inputting it the image of target location.[14]

Drawbacks of image based indoor localization

Clearly, use of camera might be obtrusive for some users. Also time consuming effort is required to build the dataset and it also has scalability issue. Also, if we take image from different point of view which is not present in database, it might be possible that it would be predicted wrongly which in turn results the low accuracy.

4. Zigbee and capacitive sensors

Zigbee sensors [11] are also used for indoor location but they are very expensive

and have medium scalability. Capacitive sensors [11] are also used to estimate location by pressure sensing that detects the presence of a person but this system is very impractical to implement and deployment of sensors in floor is expensive.

5. Wi-Fi based indoor localization

In this, we can use either triangulation technique or fingerprinting technique for the estimation of the location of target user. But in triangulation, we require modification and special software to run on Wi-Fi base stations [11]. But fingerprinting technique with Wi-Fi is a good approach for indoor localization because, we didnt need any additional hardware for this system and we can use already deployed infrastructure.

Drawbacks of Wi-Fi based indoor localization

Its main drawback is that it consumes more power. There are some spots where Wi-Fi access points would be difficult to power. There are some areas where Wi-Fi signals are not accessible. [12]

6. BLE beacons based indoor localization (our approach)

After seeing the drawbacks of existing technologies, we decided to find the indoor location of a person using BLE beacons with fingerprinting technique, because it overcomes many drawbacks in existing systems, also they give better accuracy. BLE beacons are Bluetooth low energy beacons. Classic Bluetooth consumes more power than BLE beacons and transmits to long ranges. BLE beacons are small in size, light weight and cheaper then Wi-Fi. BLE consumes less power than Wi-Fi. BLE beacons are usually battery powered, which are more flexible and easier deployed than sensors used by existing systems. BLE signals have higher sample rate than Wi-Fi signals. BLE consumes much less power because it transmits data over the small range [1]. Bluetooth having version greater than 4.0 are BLE. BLE Beacon is a tiny device with a massively used for broadcasting of signals. It has unique ID (MAC Address). A BLE beacon has three major components: ARM computer, a Bluetooth connectivity module and batteries for powering the entire circuit. The antenna is attached to the CPU of ARM computer. It broadcasts electromagnetic waves with specific length and frequency. Here is the internal circuitry of BLE beacon.

Android phones with 4.3 and 4.3+ version support BLE [1], which makes it easy to implement.

FIGURE 2.3: Internal circuitry of beacon

2.6 Conclusion

As we can see there are many drawbacks in existing systems. In some systems, camera is required for indoor positioning which is obtrusive for some users. High cost and effort is required for the deployment of indoor localization infrastructure. Triangulation and trilateration proximity techniques require modifications at hardware end (Wi-Fi work stations) for the purpose of these techniques to work. These techniques also didnt give satisfactory results in indoor environment due to the errors in distance measure calculations. Proximity technique also requires calibration effort and it is a costly technique to implement. Fingerprinting technique seems to be most suitable thats why in our proposed system we use this technique. Most of the other existing systems have medium or low accuracy. In image based indoor localization, time consuming effort is required to build data sets. Wi-Fi fingerprinting is relatively better than other systems because of finding position by using already deployed infrastructure. But its main drawback is that it consumes more power. There are some spots where Wi-Fi access points would be difficult to power. So, after analyzing the drawbacks of existing technologies, we find out that BLE beacons with fingerprinting approach is most suitable because of various reasons that I have described above.

2.7 Problem Statement

Whenever a visitor goes to university campus or visits a new place, he does not know about the specifications of that area i.e. what happens in that specific room or what courses have been taught in a particular and its nearby labs. So, we are developing a system which assists them in determining the textual and pictorial information of a particular area and its nearby locations. For this purpose, we first find the indoor location of a user by using BLE beacons and RSSI values, and

then provide information to him automatically on his Android application.

Chapter 3

Dataset and Research Methodology

3.1 Dataset Description

To determine the indoor location of the user, we need a trained model on specific dataset through which we can predict his location. In order to train our model, we gathered dataset which contains the fingerprints of BLE beacons in Computer Engineering Department. Each beacon has its own MAC address which is used for its identificati n. We have total 24 beacons, thats why we have 24 input features and each feature contains the RSSI values of specific beacon associated with that feature, and the output is the labeled name of the location. We have total 23 labels which mean we have total 23 classes hence it is a multiclassification problem. RSSI values ranges from -95dBm (low RSSI far off Access point) to -50dBm (demonstrating high RSSI close to Access point).

3.2 Experimental Area Description

The experimental area that we covered is the Computer Engineering building of UET, LHR. We skip some rooms of that building because they are locked most of the time. The representation of the deployment of beacons in dept is shown in the following figures. Figure 2 represents the ground floor and Figure 3 represents 1st floor of the building. Small blue circle represent BLE beacon. Following figures only represents those rooms that we have considered in our experimental area. Each room is assigned a label as shown in the figures. Corridors are divided into 4 portions. Each portion is represented by a dotted box and assigned a label shown in the figures.

L1	RSSI 1	RSSI 2	RSSI 3	• •	RSSI M
L2	RSSI 1	RSSI 2	RSSI 3	• •	RSSI M
• •	• •	• •	• •	• •	• •
Ln	RSSI 1	RSSI 2	RSSI 3	• •	RSSI M

FIGURE 3.1: Dataset format with each label and its corresponding RSSI value

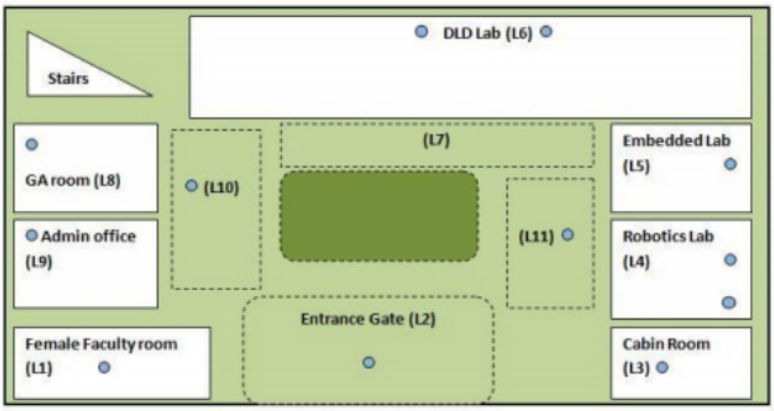

FIGURE 3.2: Map of ground floor of the building where beacons are installed

3.3 Collected Dataset

Our collected dataset contains 6500 samples of 18 locations of selected area out of 23 locations. Each location has its own fingerprint RSSI value with respect to certain beacon which depends on different environmental conditions such as distance of device location from the beacon or signal capturing strength of the device. So, we collect samples to predict different locations. The number of samples collected per location is shown in the following figure.

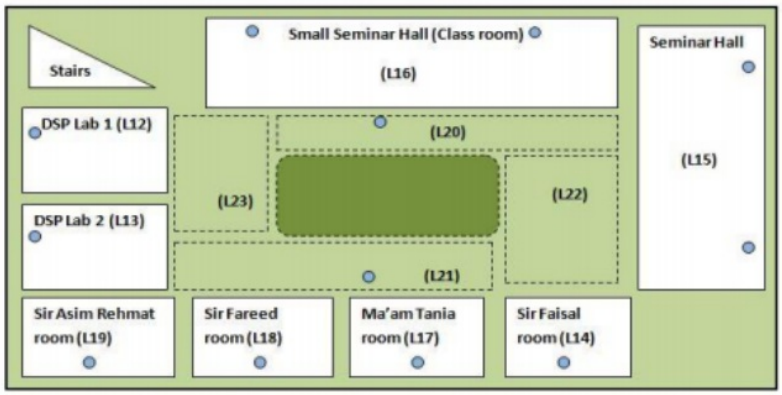

FIGURE 3.3: Map of first floor of the building where beacons are installed

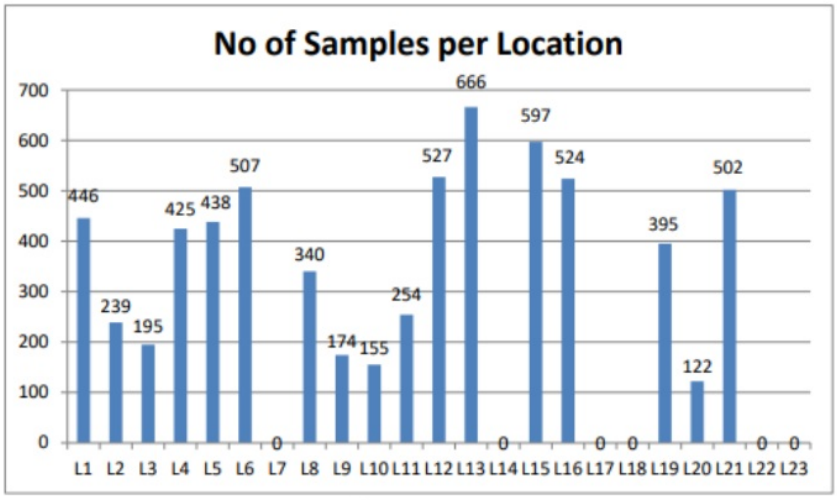

FIGURE 3.4: Number of samples collected for each label

3.3.1 Preparation of data set

When we captured the data, numerous .csv files generated in which each .csv file contain one sample. We used 5 different cell phones for data capturing. Then we compile all the generated .csv files into single .csv file in specific format that we have shown in Figure 1. We discard all those RSSI values of surrounding BLE enable devices which are not from our BLE beacons.

3.3.2 Preprocessing of data

We have done pre-processing on our collected data set. In pre-processing, we have dropped all those rows that have null values in all of their input columns. During data collection some access points are visible, some not hence there were lot of missing values in data set. So, we replace missing values with -100dbm. The reason for replacing the missing values with -100dbm is because it shows extremely weak signal means it is far off from access point. We have not done normalization on our data set because we didnt find it suitable for our collected dataset.

3.3.3 Performance Measures criterion for the comparison of algorithms

Accuracy is the measurement of model performance. It is calculated as the no of samples correctly classified/ total no of samples.

$$\text{Accuracy}(\%) = \frac{Tp + Tn}{Tp + Tn + Ep + Fn}$$

FIGURE 3.5: Accuracy

Precision tells about how accurate your model is out of those predicted positive, how many of them are true positive. Precision is a good measure to determine, when the costs of False Positive is high.

$$\text{Precision} = \frac{Tp}{Tp + Fp}$$

FIGURE 3.6: Precision

Recall actually calculates how many of the Actual Poitives our model captures through labeling it as Positive (True Positive).

$$\text{Recall} = \frac{Tp}{Tp + Fn}$$

FIGURE 3.7: Recall

For calculation of precision and recall for multi-classification, we can calculate the precision and recall separately for each class. Then we calculate the average

precision and recall of all classes and hence we will get the approximate calculation of precision and recall for them.

3.4 Introduction to Research Methodology

After the literature review, we conclude that the most of the applications are based on outdoor localization such as GPS. This application only tells the outdoor locations on the maps. When we are out of the building, its only shows the boundaries of the buildings not the rooms. But we want to create an application which tells about the indoor location. This application is based on room level prediction. Its not only tells the room level prediction but also tells the entire information of the room.

The purpose of writing this chapter is to explain the methodology for making this indoor localization based application. We want to tell that which methods and approaches we used to develop this application. We will also explain that which ML (Machine Learning) algorithms are used, how to collect the data, how to analyze data for this application. We also describe the use cases, use case diagram and test cases of this application.

3.5 Research Methodology

From the literature review, we conclude that the concept of outdoor localization is introduced on the behalf of GPS. People can access anywhere when he is on the GPS which is installed on every smart phone. But people can only see the boundaries of the building not the rooms of the buildings. They did not know the entire information of the building. They do not know the concept of indoor localization. People face the problem to know the entire information of the building. For example, when a student enters the University for Admission, he/she did not know the ways of the university. They have to face the problem where is Admin block? Where is library? Where is department? Furthermore, if people enter to the hospital, offices, buildings etc., than they did not know the indoor location of those places. To answer all of these questions, we want to develop the application which tells the indoor location of the building. It not only tells the room name but also tells the entire information of the room. If we talk about the building of the university, then it also tells us the room member name, its office hours etc. We provide this information in the form of texture, audios and pictures.

3.6 Proposed Work to develop the Android Application

Actually, we cannot refuse that many indoor applications also developed but they all used different technologies. Most of the indoor applications used Wi-Fi for predict the position of the person that tells the indoor location of that person. But we have to develop the system which tells the indoor location of the person which is based on BLE beacons. BLE beacon is the Bluetooth device which consumes less energy. It is light weight and cheaper than Wi-Fi signals. BLE beacons are usually battery powered, which are more flexible. It is easier to sense the signals. We dont have enough resources to make this application globally. Now, we make this application for our computer Engineering department, UET. To develop this system, we consider the number of points which tells the methods to develop the system that is as follows:

- First of all, we deploy the BLE beacons in our department. BLE beacons will be installed on the ceilings of rooms.
- We capture the RSSI fingerprints of BLE beacons at different position using data capturing. By using this application .csv le will be generated.
- Data will be pre-processed and trained by using machine learning algorithm such as KNN, ANN and random forest.
- After capturing and train the data, we integrate the data with our android application. For this purpose, we made two android applications. One is admin application and the other is user application.
- We made the android admin app to add, edit and delete the data of rooms. We can also add, edit and delete the data of room members. Also, we can add, edit, delete office hours of the room members. We can also add pictures and audio of the room
- At the end, we made the android user application. First of all, we integrate the data using different API. We need to make the API to integrate the data.
- After integration of data, when user reach the room of our department, he/she can see the details of rooms, room members and also see the details of office hours of the room members in the form of texture, audios and pictures.

3.7 Related Work

Different Indoor applications are exit. But their functionality is different. One of the indoor applications is Image based indoor localization. The data set of this application is images, image features and annotations. Some of the images features are SIFT, PCA-SIFT and SURF. For capture the image, we have to use omni directional camera. It consists of three wheels tripod stand. But we capture the image from the laptop. System easily covered the wide area. After capture the image, the location of the image is also stored by using the interface. The annotation data consists of (x, y, z) coordinates. It also has the information of room name, floor and show case name for the image. For this Image based indoor localization, they use fast nearest neighbor algorithm that is ANN and LSH (Locality- Sensitive-Hashing). LSH is the nearest neighbor search technique which uses the hash function. It is noticed that LSH is the faster than other algorithms. Here are the some experimental results of this Image based indoor localization. By applying these algorithms, it shows the precision and processing time of each feature.

Feature	Feature extrac-tion	Correspondent point search	Total	Precision
SIFT	1.51s	1.60s	3.11s	91.9%
PCA-SIFT	1.63s	0.56s	2.19s	90.8%
SURF	0.22s	1.54s	1.77s	88.2%

FIGURE 3.8: Precision and processing time of features

Now we discuss about another application of capacitive sensors based on indoor localization. Capacitive sensing is that technique that tracking the conductive and non-conductive objects. This sensor is able to sense the 3D position of human and their interacting objects. By using this technique, we can find the indoor location of the person by using human-body detection technique. It uses capacitive transducers which operate in 3 modes. But in this case, we use only 2 modes known as shunt mode or transmit mode for the detection of the body. Another scientist introduced the load operation mode. In this mode, human body acts as a potential-plate that is shown in Fig (a). Capacitances used in load mode are Cpb (plate-body capacitor), Cbg (body-ground capacitor) and Cpg (plate-ground

capacitor). It is more suitable for deployment. For develop capacitive sensors based application, load operation mode is used.

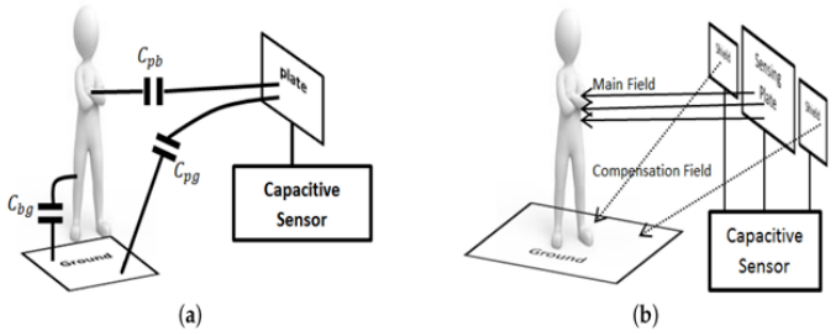

FIGURE 3.9: System Architecture

For develop this system, they also use some algorithms such K-NN (K-Nearest Neighbor), NB (Naive Byes), SVM (Support Vector Machine). To perform the experiment, they have a room in which they place sensor plates of 4cmX4cm. They deploy the sensors on the four sides of the room. After deploy the sensors, they used three algorithms as we explain above. These algorithms used to find the precision and recall of this indoor localization system. The precision and recall are given in table below:

Algorithm	Recall	Precision
1- Nearest Neighbor	52%	53%
56- Nearest Neighbor	51%	50%
Naive Byes	55%	55%
Support Vector Machine	56%	60%

FIGURE 3.10: Precision and recall of different algorithms

They also perform this experiment with the room having sensor plates of 8cmX8cm. The results of precision and recall are different from the above results. They give better result than the above. The precision and recall of 8cmX8cm sensor plates are given in table below:

They also perform this experiment with the room having sensor plates of 16cmX16cm. The results of precision and recall are also different from the above results. They give best result than all of the above. The precision and recall of 16cmX16cm sensor plates are given in table below:

Another most important technology, we discuss here. We have to discuss the indoor based localization using Wi-Fi. This application also tells the user to the

Algorithm	Recall	Precision
1- Nearest Neighbor	45%	45%
56- Nearest Neighbor	65%	65%
Naive Byes	71%	75%
Support Vector Machine	69%	70%

FIGURE 3.11: Precision and recall of different algorithms

Algorithm	Recall	Precision
1- Nearest Neighbor	60%	62%
56- Nearest Neighbor	70%	70%
Naive Byes	71%	74%
Support Vector Machine	69%	72%

FIGURE 3.12: Precision and recall of different algorithms

position of the person where he stands. It also tells the indoor localization of the person. The patterns that connect the different access point of the Wi-Fi which is fixed to the various point and become unique. This pattern is called Wi-Fi finger printing. It consists of Received Signal Strength Indicator (RSSI) values and MAC Address data. RSSI values contain negative numbers. If RSSI values are closest to the zero (0) such as (-5) then It indicates that the signal strength is strong. The data set of this application consists of RSSI value and MAC address. The algorithms of machine learning also apply in this indoor based localization using Wi-Fi application. Due to the large data set. The fastest algorithm is used in this system. The algorithm which is used in this application is deep learning. Meanwhile, the machine learning algorithms such as k-NN, NB, SVM also used for this application. Their precision and recall also shown in table:

Algorithm	Recall	Precision
k- Nearest Neighbor	96.4%	96.4%
Naive Byes	67%	72%
Support Vector Machine	79%	62%
Deep Learning	99.3%	99.3%
Random Forest	99.5%	99.5%

FIGURE 3.13: Precision and recall of different algorithms

3.7.1 Comparison of Existing Work

Here are the comparisons of some of them

3.7.2 Limitations of Existing System

Here are some limitations of existing system which are as follows:

System Type	Methodology	Weakness	Accuracy Achieved
Image based indoor localization	Convolution Neural Network(CNN)	-Time consuming effort required to built data set -Low accuracy	74.09%
By using Capacitive Sensors	Pressure sensing systems that detect presence	-Deployment of sensors in floor is expensive -Impractical	73.01%
By using Zigbee sensors	K- Nearest Neighbors(KNN)	-Expensive -Medium Scalability	76%
By using Wi-Fi	Deep Learning algorithms	-Consumes more power -Wi-Fi signals are not accessible to some areas	71%

FIGURE 3.14: Comparison between existing systems

- In some systems, camera is required for indoor positioning which is not suitable for some users.
- High cost and effort is required for the deployment of indoor localization.
- Most of the existing systems have medium or low accuracy.
- In image based indoor localization, time consuming effort is required for built data sets.
- It consumes more power.
- There are some spots where Wi-Fi access points would be difficult to access.

3.7.3 Software Architecture

Here is our software architecture:

3.8 Software Development Life Cycle Used

To implement a project, one must have to follow some software development life cycle to deliver his project completely according to user requirements in time.

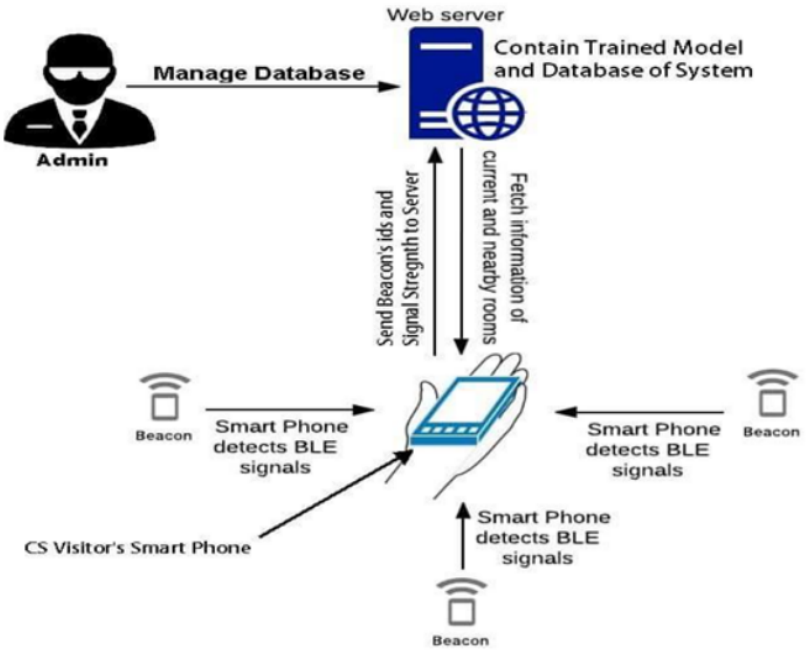

FIGURE 3.15: Software Architecture Diagram

By following a certain SDLC, a project developer feels so comfortable as he have specific tasks and time to implement project timely which meets the users point of view. In our project, there are lots of fluctuations time by time. So, we decided to follow AGILE model.

3.8.1 AGILE SDLC

Agile SDLC model is a combination of incremental and iterative process models deals with customer requirements satisfaction and process adaptability by rapid delivery of working product to the customer. This model breaks the whole project in small modules. Do proper testing after completion of each module. Then deliver this working module to the customer and important stakeholders to satisfy them. If that module doesnt meet their point of views properly or to which customer point of view as he didnt explained in the document, then it has to be iterated to fulfill their new recommendations. And the other perspective is that if the customer wants to add some functionality in that particular module then a developer has to follow an incremental technique to add specific functionalities. To complete each deliverable module of the project, developer has to follow these steps

- Planning

- Requirements Analysis
- Design
- Coding
- Unit Testing and
- Acceptance Testing

FIGURE 3.16: Agile Development Methodology

3.8.2 Justification for AGILE SDLC

These steps will justify that our project is based on agile methodology:

- All the requirement specifications and the scope of the project is strictly defined in our documentation but by the time, it may require some amendments, so they will change by ourselves.
- Planning of time, design, implementation and testing is done.
- Hardware and software parts of our project are specified into a work breakdown structure.
- All the Modules of our project are divided in small pieces of time according to estimated time.
- In model training module, we first use Weka and then following TensorFlow to meet the requirements; hence we followed an incremental and iterative model.
- Do unit and acceptance testing after completion of each module.

- Budget plan for our project is defined
- We Add functionality of delay in Data Capturing application which capture data after some seconds when a user change his indoor location.
- Add restart functionality to restart scanning of Bluetooth devices once it stops which leads to incremental change in data capturing application.
- Roles and responsibilities of team members vary according to the prescribed task and time limit.

3.9 Requirement Analysis

The most important section of system requirement specification document is requirement analysis. To start any project, anyone needs to know his system requirements. This section includes all the software, hardware functional requirements of our system, user interfaces, database diagram, use case diagram, use case tests and test cases. Basically, we will discuss all the specifications of our system.

3.9.1 Hardware Functional Requirements

Deployment of BLE beacons

Deployment of BLE beacons on the ceiling is the requirement to capture fingerprints of BLE beacons with different mobile devices. At what angle and at what part of the ceiling these beacons should display, all we get it know before their deployment.

3.9.2 Software Functional Requirements

3.9.2.1 Data Capturing Application

Bluetooth scanning for nearby devices

A scanning function is made in data capturing application to scan BLE beacon for nearby mobile devices. Devices who present/locate near a certain BLE beacon are being scanned.

Capture RSSI values for nearby beacons BLE beacons Bluetooth range exists in a certain region and this region contain different mobile devices far and near to BLE beacon depending upon their indoor location. So, this function will capture RSSI fingerprints for all mobile devices which being scanned in that certain region.

Add delay factor to capture FPs

Once fingerprints of certain mobile device have been captured at a particular location and by determining the indoor location, we provide room information through our application to a users mobile device. The user may change his indoor location after a while. To provide updated room information to the user we are making a delay function which captures user fingerprints after a certain time (seconds) and provide him updated information according to his room location.

Automatic restart Bluetooth scanning for nearby devices once it stops

Automatic restart scanning function will scan for BLE beacon nearby mobile devices once scanning has been stops, because in this way our system will able to automatically find coming and going devices in a particular region and provide rooms information accordingly.

Generate .csv file for each BLE beacon

After capturing the fingerprints of all devices with a single BLE beacon which lie in that certain region, this function will generate .csv file and RSSI values of all devices in that file.

3.9.2.2 SmartGuide: Android Application

The functional requirements of our system for User are as follows:

Load trained model in Android app

There is need to load machine learning trained model in our Android application to predict the room location of a particular person.

Get the prediction of room from trained model

When a trained model receives .csv file of a particular BLE beacon, it gives the particular roomID of that beacon to a mobile device which is receiving higher RSSI value from that BLE beacon.

Allow user to know his indoor location

This function will enable users to see their indoor location i.e. in which room they are.

Fetch information of that particular room

This function will send RoomID of a particular BLE beacon to the database from which room information in image, texts and audio format can be fetched.

Provide information of the room to the user

After fetching the information of a particular room, this function becomes enable and displayed that information on user mobile screen.

Enable user to get information of nearby rooms

This function allow users to see their nearby (left, right, front and back) rooms and textual and pictorial information about that rooms.

The functional requirements of our system for Admin are as follows:

Allow admin to SignUp for our application

To use an Android application, in this case admin has to register on our application to add, update and delete records of certain data in our application.

Provide account activation functionality to the admin

Admin can login on another device; he has no restriction to use our application on a certain device. He may be login or logged out.

Admin has all the records of data

Admin has the ability to get all up-to-date records of data. Data can be of staff members, their visiting hours, room information, lab accessories and much more.

Store information to database in images, audios and text format of rooms and their nearby rooms

This function will store information about rooms in images, audios and text format in the database. Also, the information about nearby rooms of a certain room will also be stored by the admin in the database manually.

Allow admin to edit or update the information about rooms

When After sometime, the specifications and in formations about certain rooms and departments can be changed. So, this function will enable admin to update the information accordingly to provide up-to-date information to the user.

Admin has all those functionalities which a user has

Admin can see the information of a room and nearby rooms in any format provided in our application like user.

3.9.3 Non Functional Requirements

Reliability

Our project will be reliable .The users information will be kept confidential and there will be no worry of losing the information.

Usability

Our application will be usable for the users and easy to use.

Maintainability

This system will have the capability to adapt changes and amendments done in the database by the admin as the information of rooms will be updated or edited.

Security

Our Android application will work under potential risks. It will not be accessible by the malicious user or be crashed by external attacks.

Recoverability

In case of crash, our system information will recoverable

Safety

Optimize safety in the design, development, use and maintainability of the application.

Reusability

Our system will provide reusability factor to the visitors of the department.

Performance

To make a system which gives accurate and up-to-date information about rooms even a user change his indoor location after a while. This system will give results efficiently in small time.

3.9.4 Use Case Diagram

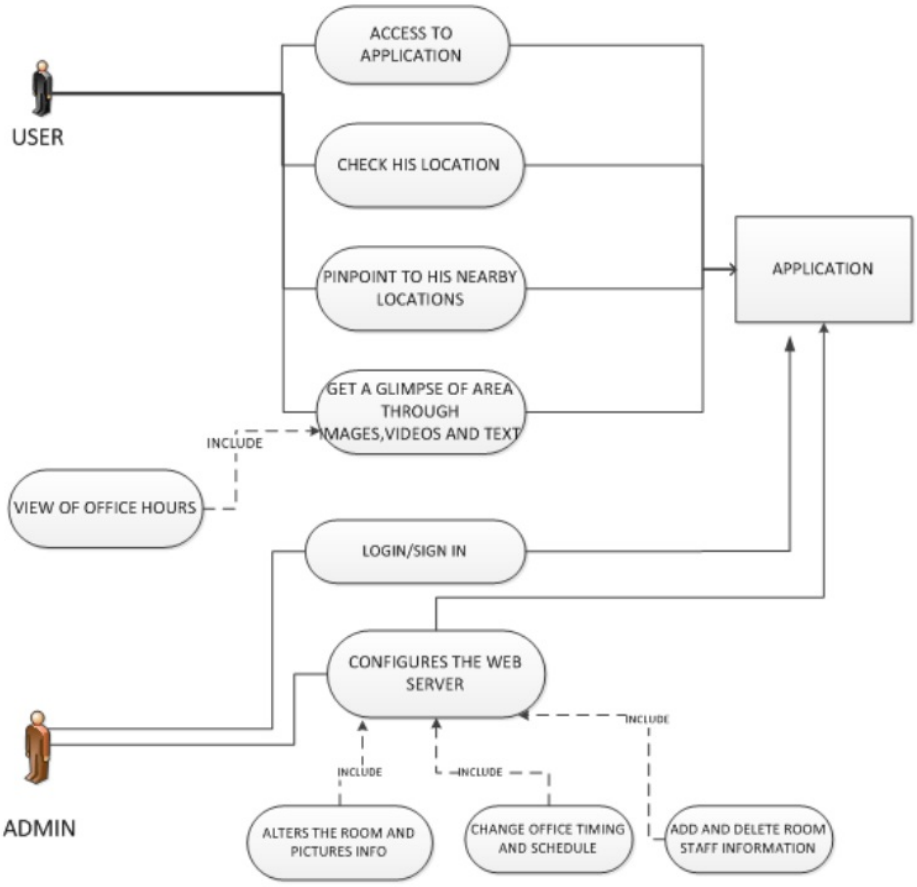

FIGURE 3.17: Usecase Diagram

3.9.5 Use Case Texts

Use Case Name	Access to the application
Actor	User
Description	User has to step into the application for the benefits of the app through his mobile phone.
Pre-conditions	1- The mobile must have Android OS. 2- The application must be downloaded on the phone.
Normal flow	1- The app will be downloaded through Google PlavStore. 2- User opens the app the front page appears showing "Welcome to CE Department".
Post-condition	Application will be opened and front page will show that this app will guide the user in CE department.

FIGURE 3.18: Usecase(1)

Use Case Name	Checking the location and explore nearby places
Actor	User
Description	User can find out where he is standing right now and what the neighboring locations are.
Pre-conditions	1- Bluetooth connectivity must be turned on. 2- Bluetooth must be connected to beacon. 3- User must be in department premises.
Normal flow	1- After main page, another page appears with two buttons. 2- User can check his current location by clicking first button showing "My current location" which gives the user its current location. 3- Next button shows "Nearby Rooms/Labs" by clicking that user get to know about the surrounding rooms and labs around him.
Post-condition	1- User will able to know his location at that moment. 2- He will also know the neighboring rooms and labs.

FIGURE 3.19: Usecase(2)

Use Case Name	Pictures, schedule and office timings of rooms & labs.
Actor	User
Description	The information of current and neighboring rooms and labs through pictures and texts with the extension of office timing of the teacher's room can be seen
Pre-conditions	User must know the location where he is standing and the nearby labs and rooms.
Normal flow	1- When the user clicks current location button, next screen gives 3 buttons. • One gives the pictures of the room. • Second gives the schedule and name of lab attendant if it is lab. • Third gives the office timing if the room belongs to any teacher. 2- When the user clicks the nearby rooms button, then the next screen shows rooms or labs nearby him and when the user clicks any of the room button he will be provided with the images, schedule and office timings.
Post-condition	User will be given the information i.e. pictures, schedule, office timing of his current position and the nearby rooms and labs.

FIGURE 3.20: Usecase(3)

Use Case Name	Room/Lab staff information
Actor	User
Description	In this use case, User can have the knowledge of the working staff or the teacher's name in the room or lab
Pre-conditions	1- User should have the information of his current position by having the pictures, schedule and office timing of that room or lab. 2- He should have the pictures, schedule and office timing about the nearby rooms and labs.
Normal flow	1- When user is checking current location, another button is given which says "Staff Information" and by clicking that the user will know the teacher's name, his skills and which subjects he teaches. 2- When the user clicks nearby rooms/labs it will also give the staff information button and by clicking that user will know the teacher's skill and if it is lab then he will know which teachers are using this lab and for what subjects.
Post-condition	User will know the skills of teacher of specific room and what he teaches as well as he will know which teachers are teaching in specific lab.

FIGURE 3.21: Usecase(4)

Use Case Name	Login/Sign in
Actor	Admin
Description	Admin have to make himself registered as an admin
Pre-conditions	Admin must have his login ID
Normal flow	1- Admin opens webserver. 2- Enter his login ID and password. 3- Click to "login as an admin"
Post-condition	Users have the access to webserver and he can alter the information in the webserver.

FIGURE 3.22: Usecase(5)

Use Case Name	Alteration in rooms and labs information
Actor	Admin
Description	Admin can change the required information w.r.t changing environment i.e. change of any teacher, change of any lab etc.
Pre-conditions	Admin must have the authority to access the webserver of the application.
Normal flow	4- Admin access to the server where he can change picture or the text of specific room/lab. 5- Admin can also change the office timing of teacher's room and schedule of the labs.
Post-condition	Up to date information will be given to the user.

FIGURE 3.23: Usecase(6)

Use Case Name	Amendments in room staff information
Actor	Admin
Description	If the teacher changes his lab, the admin has the authority to change his lab information and if lab attendant is changed then admin can modify it.
Pre-conditions	1- Admin has access to web server. 2- He should have up to date information.
Normal flow	1- Admin opens the server and checks for the specific teacher or staff. 2- Update/delete/insert the information.
Post-condition	Up to date information of the room staff will be provided.

FIGURE 3.24: Usecase(7)

3.9.6 Test Cases

Feature Name	Test Case ID	Summary	Execution Steps	Expected Results
Bluetooth scanning and connecting with device	1	Validate that Bluetooth is connecting to the beacon.	1- Turn Bluetooth connectivity on 2- Scan Bluetooth 3- Connect to the beacon	You are connected to beacon 'X'
Automatic Bluetooth scan	2	Validate that Bluetooth is scanning automatically.	When the person moves Bluetooth scans itself.	You are connected to another beacon 'Y'
Predictions of rooms	3	Validate the predictions of room	1- Get the information of rooms 2- Train that model through tenserflow 3- Predict using weka	Your accuracy is '123%"
Send Room ID to Android App	4	Validate that data capturing app is	After predictions of room the room ID is send to	Room ID 2 is sent to Android app

79

FIGURE 3.25: Testcase(1)

		sending room ID to android app	android app	
User know his indoor location	5	Validate that user will know his location	1- Turn Bluetooth connectivity on 2- Connect to beacon 3- Open the application 4- Click on "your current location"	You are at this place
User is getting nearby locations information	6	Validate that user will know the information of his nearby rooms	1- Turn Bluetooth connectivity on 2- Connect to beacon 3- Open the application 4- Click on "Nearby Locations"	Your nearby rooms are a- Room 'X' b- Lab 'Y'
Login/Sign In by admin	7	Validate that Admin is getting access to webserver	1- Open the webserver 2- In the required area type admin login ID and password	1- Message appears "You are logged in as an admin". 2- Webserver will be opened for admin
Admin change the information	8	Validate that when admin amend anything it will appear	1- Open the webserver 2- Login to the webserver	Room No 'X' information is updated Or

FIGURE 3.26: Testcase(2a)

			3- Update/Modify the database	'xyz' is shifted to room no '123'

FIGURE 3.27: Testcase(2a)

3.10 Proposed System

In our proposed system, an Android application provide guidance to campus isitors and make them familiar with department. Application will not only tell the current indoor location of user but also the information about current indoor location and nearby rooms in textual, image and audio formats. The location of the user is determined by taking predictions from the trained machine learning model on specific dataset. Dataset contains the RSSI fingerprints of BLE beacons which we installed in the department, their MAC addressess and room rabels which we assigned to each room of the department in order to predict the class label. This dataset captured through a seperate Android Application named (BLE Scanner RSSI) which captures the RSSI values of nearby beacons from mobile device. Basically, there are two Android Applications, one is for the user through which we guide the user about the department through pictorial and textual information and the other application is for the admin who can do ammendments in the database. The database contains the information about rooms of the department i.e. the schedule of each lab for each class or the visiting hours and the specifcations of particular teacher and staff members. Semesterwise schedules, timetables and lab attendees varies timely in the department so this was must to update the information accordingly.

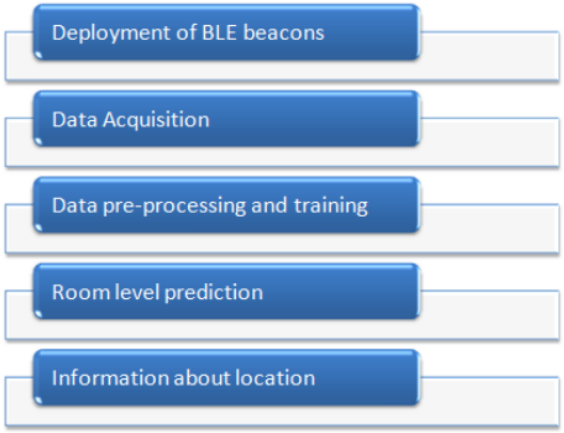

FIGURE 3.28: Proposed System

3.10.1 Deployment of BLE Beacons

BLE beacons deployed in the experimental area which is Computer Engineering department of UET, Lahore. All the rooms of experimental area are assigned with a specific class label through which predict the location of the user's mobile device.Each room has its own lable range from L1 to L23. The detailed descritpion of the installment of BLE beacons in each room and floor of experimental area is shown in the figure below:

BeaconLabel	RoomName&RoomLabel	FeatureName
L1	Faculty Room(L1)	MacAddr1
L2	Entrance Gate(L2)	MacAddr2
L3	Cabin room(L3)	MacAddr3
L4p1	Robotics Lab(L4)	MacAddr4
L4p2	Robotics Lab(L4)	MacAddr5
L5	Embedded Lab(L5)	MacAddr6
L6	DLD Lab(L6)	MacAddr7
L7	DLD Lab(L6)	MacAddr8
L8	GA Room(L8)	MacAddr9
L9	Admin office(L9)	MacAddr10
L10	Outside GA Room(L10)	MacAddr11
L11	Outside Embedded Lab(L11)	MacAddr12
L12	DSP LAB 1(L12)	MacAddr13
L13	DSP LAB 2(L13)	MacAddr14
L14	Dr Faisal Room(L14)	MacAddr15
L15p1	Seminar Hall(L15)	MacAddr16
L15p2	Seminar Hall(L15)	MacAddr17
L16p1	Small Seminar Hall(L16)	MacAddr18
L16p2	Small Seminar Hall(L16)	MacAddr19
L17	Madam Tania(L17)	MacAddr20
L18	Sir Ali Hammad(L18)	MacAddr21
L19	Sir Fareed(L19)	MacAddr22
L20	Outside small seminar hall(L20)	MacAddr23
L21	Outside Madam Tania(L21)	MacAddr24

FIGURE 3.29: Beacons labeling

The placement of BLE beacons in the rooms, labs, corridors of both floors of the department is shown in previous chapter in detail.

3.10.2 Data Acquisition

BLE beacons broadcasts signals and these signals in the form of RSSI values will be captured at different positions by using Android application named(BLE Scanner RSSI) and then csv file will be generated which contains the MAC addresses of nearby BLE beacons from mobile device, class label and the RSSI fingerprints in the form of numerical values.

MacAddr11	MacAddr12	MacAddr13	MacAddr14	MacAddr15	MacAddr16	MacAddr17	MacAddr18	MacAddr19	MacAddr20	MacAddr21	MacAddr22	MacAddr23	MacAddr24	RoomLabel
-73	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-73	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-67	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-72	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-70	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-70	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-68	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-72	-74	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-73	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-70	-72	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-70	-72	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-70	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10
-70	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	L10

FIGURE 3.30: Small portion of dataset

3.10.3 Data Pre-processing and Training

Pre-processing is done by replacing the null values of dataset by minimum signal strenth a device can recieve from BLE beacon according to our datset which is -100.Also, it includes the concatenation of thousand of csv files in one csv file to place our dataset at one place in file. Then this file is being used as an input to training algorithm, on which a classifier trains its model and make predictions. We trained this dataset by using machine learning algorithms i.e. knn, ann, random forest but artificial neural network gives us the high accuracy of training model as shown in figure. So, we decide to use ann as our selecetd model and deployed this model on server.So, we can integrate our model to our Android application.

3.10.4 Room Level Prediction

An Android application for common users will be developed that capture RSSI signals and send to server. Then trained model will take these values as input for the purpose of prediction of room and then send back the room label and its information to the user's application.

3.10.5 Location Information

Application will fetch information data of current room and nearby rooms in bith textual and pictorial formats from server and then display this information on the screen.

Chapter 4

Implementation

4.1 Tools for implementation

To develop this proposed system, we use some tools to implement this system which is given below:

- Android 3.5 or above with java
- Php MySQL
- Php Storm
- Postman
- MATLAB
- Python IDE (Spyder, Anaconda)

4.1.1 Android 3.5 or above with java

We used an Android studio to develop the android applications. Actually, we have been made three applications on android that is admin app, user app and data capturing app. We used java language to make these applications.

4.1.2 Php MySQL

We use Php MySQL to make the database of our application. It is necessary for our system to make the database because the information of the rooms which the user can see, fetch from database. We deployed the database on the server. So that, when the user connects with the application, information of the room fetch from the server.

4.1.3 Php Storm

We use Php storm for making the scripts in the database. Actually, the android studio could not connect to the Php MySQL database directly. To connect the android studio with Php MySQL, we had to make the scripts of database in Php storm. This tool helps us to connect the database with android studio.

4.1.4 Postman

After creating the scripts of database in php storm, we use this software for testing. For Example, when we make the database connection file in php. We check that this file connect to database or not. In this way, we check one by one all php files either these are working or not.

4.1.5 MATLAB

For the compilation of BLE beacons dataset, we use MATLAB. Actually, the dataset of our department is being captured on different devices, the number of files is generated by data capturing app. To compile all over the files, we use this tool to make our work linier.

4.1.6 Python IDE

We use Python IDE such as Anaconda and Spyder to train the model of machine learning. Actually, we use different libraries of python such as tensor flow, numpy, matplotlib.py, pandas and preprocessing from sklearn. To train the model, these libraries are necessary to import. By using these libraries, we applied different algorithm such as k-NN, ANN and Random Forest (RF) to train the model.

4.2 Implementation of Machine Learning Algorithms

We focused to train our ML model to high precsion because this project aims to predict the indoor location of the user's mobile device. As, we are not predicting the outdoor location on the map, we need to more focus on the signal strength of the devices and the accuracy of our train models. To analyze our dataset, we didn't rely on any one classifier. Three algorithms are used for the purpose of training the model which includes knn, ann and random forest. These three were being decided by analyzing their predicting methods. knn works on the neighbourhood classification, random forest works after making multiple random decision trees by making subsections of the dataset while ann works on neural networks by making hidden layers. We choose three algorithms because after analying their comparison, we choose the best one whose accuracy and precision is high. The detailed implementation and description of these algorithms is described below.

4.2.1 k- Nearest Neighbours

k-NN is the simplest and supervised machine learning algorithm. Here we used it for multi-classification. k-NN uses data and classify new data points based on majority vote of the nearby points. Before the implementation of k-NN, we have to tell the values of the hyper parameters of k-NN. The basic parameters for k-NN algorithm are:

Number of nearest neighbors

We have to choose number of nearest neighbors in order to find the class of new data point based on the majority votes from these nearest neighbors.

Distance measure

There are two major distance measure Euclidean and Manhattan. We have to choose one of them as a distance measure criterion. Figure 6 shows the Euclidean distance measure and Figure 7 shows Manhattan distance measure.

Weights assigned to neighbors

The weight parameter has two choices: distance and uniform. The uniform weight means that each of the k neighbors has equal vote, whatever its distance from target point. The distance measure means that in the k neighbors, the neighbor who is close to target point has given more weight than the neighbor who is far from the target point.

This figure represents impact of choosing the weight assigning criterion on accuracy score.

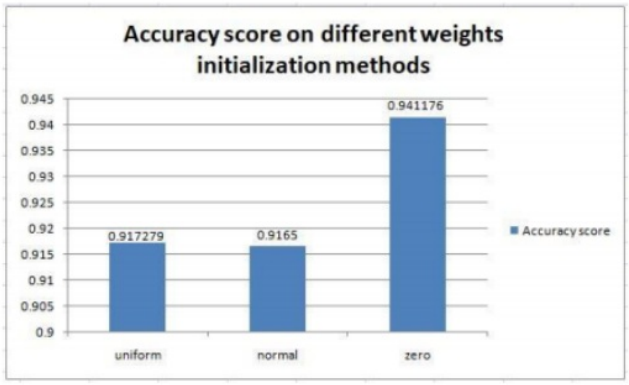

FIGURE 4.1: Impact of choosing the weight assigning criterion on accuracy score.

4.2.1.1 Hyper-parameters tuning:

Before we implement k-NN, we need to find the best values for parameters at which accuracy is maximum. For this purpose, we use GridsearchCV function to test for all possible combinations of n neighbors, weights, distance in order to find out best parameters at which accuracy is maximum. We take values of k neighbors from 1 to 26, weights = uniform, distance and distance measure = euclidean, manhattan, then we try to find the best possible combination. Figure 25 represents the impact of choosing the distance measure on accuracy score.

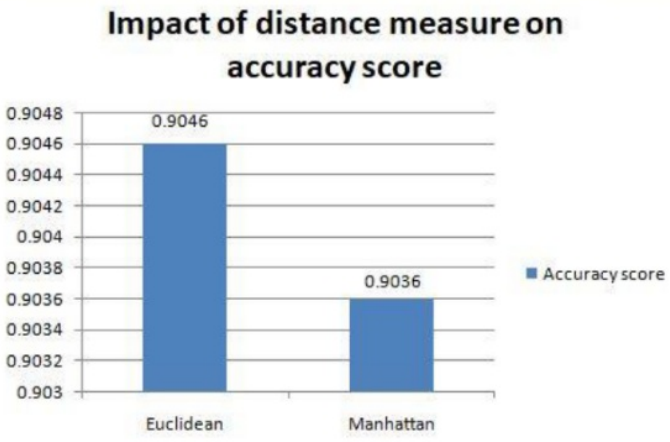

FIGURE 4.2: Impact of choosing the distance measure on accuracy score.

This graph represents the impact of choosing the number of neighbors on accuracy score.

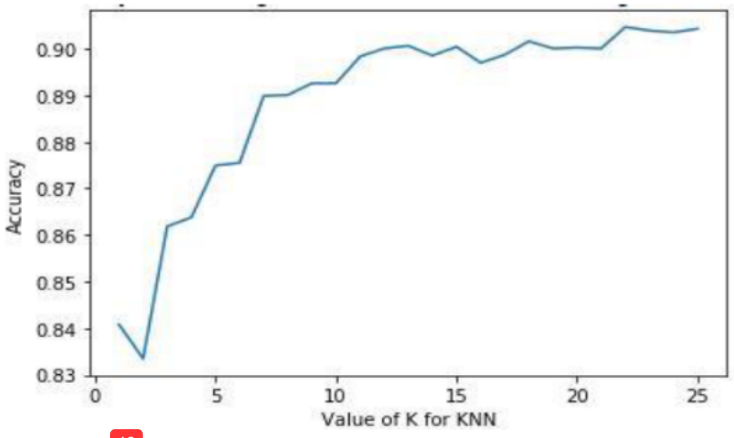

FIGURE 4.3: Impact of choosing the number of neighbors on accuracy score

Hence, after checking the impact of choosing different values of parameters on accuracy score, we find out that best parameters are:
Distance measure: 'euclidean'
Number of neighbors: 22
Weights: 'uniform'

4.2.1.2 Methodology for data training

1-Input: Data set and best parameters for k-NN.
2- Split the data into training set (75 percent) and testing set (25 percent). We use startify so that the train and test sets have approximately the same percentage of samples of each target class as the complete set.
3- Built the k-NN classifier by feeding it with the training data and best parameters.
4- Train the model and store the model on the disk.
5- Plotting of confusion matrix.
6- Calculate accuracy, precision and recall for training and testing data.

4.2.2 Random Forest Classifier

Random forest is one of the most powerful supervised machine learning algorithms. It is capable of performing both classification and regression but here we use this algorithm for multi-classification. For this purpose, it creates multiple decision

trees in the form of forest by selecting random samples from dataset for each decision tree.

Why we are using random forest?

The over fitting problem will never come when we use the random forest algorithm in any classification problem. The random forest algorithm can be used to identify the most important features out of the available features from the training dataset. It means we dont have need to normalize the features. Tree models can handle both continuous and categorical data and can model nonlinear relationships

4.2.2.1 Description of Hyper-Parameters:

To train model on different hyper-parameters, it is necessary to pick out best parameters on which accuracy becomes high. Some parameters are: n estimators are the number of trees in the forest. Higher the number of trees, higher is the prediction accuracy. max features is maximum number of features considered for the best split. max node is the maximum number of nodes in which dataset can split. Batch size indicates the number of samples per batch.random state defines random selection to compare between different models. Except these values, we also trained our model on different values of hyper parameters and plot their accuracy response in the form of graphs as shown below:

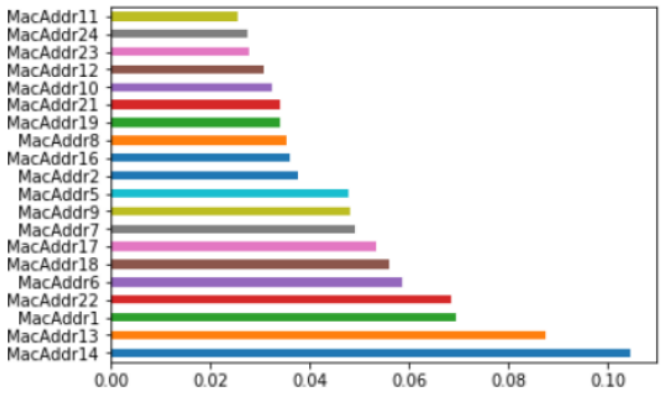

FIGURE 4.4: Feature Importance Graph

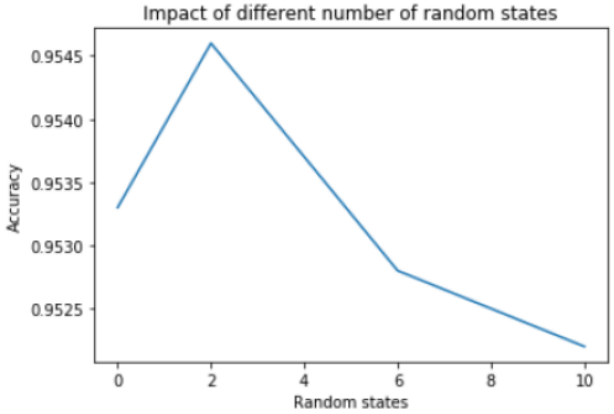

FIGURE 4.5: Impact of different number of random states

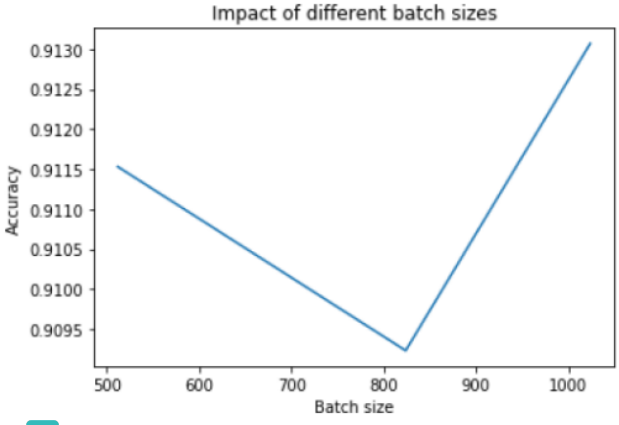

FIGURE 4.6: Impact of different number of batch sizes

Hence, after checking the impact of choosing different values of parameters on accuracy score, we find out that best parameters are: n estimators: 10
max features: 24(all)
max node: 1000
Batch size: 1024
random state: 1

4.2.2.2 Methodology for data training

1. Present a dataset containing number of training samples characterized by multiple features and target feature.

2. Random forest selects m features from the total features randomly.
3. Select the root node using best split and split these nodes into daughter nodes . 4. Repeat above steps to form various decision trees until maximum number of nodes reached.
5. Create leaf nodes which are further used to predict new query instances.
6. Make and initialize a tensorflow session to train the model.
7. Calculate accuracy of training and testing model.
8. Predict the outcome using these decision trees.
9. Measure the outcome or target label predicted by each tree.The target with the highest vote is considered as the final prediction of the random forest algorithm.

4.2.3 ANN

ANN is a powerful deep learning algorithm inspired by biological structure of neurons. Information flows in the hierarchical form. We have used 2-layered neural network for our multi-classification problem because in many internet sources, we find out that 2-layered network is sufficient. The input layer consists of input neurons. Those neurons transmit data to the next layer, which in turn sends the output neurons to the output layer. Figure 30 shows the structure of Neural Network.

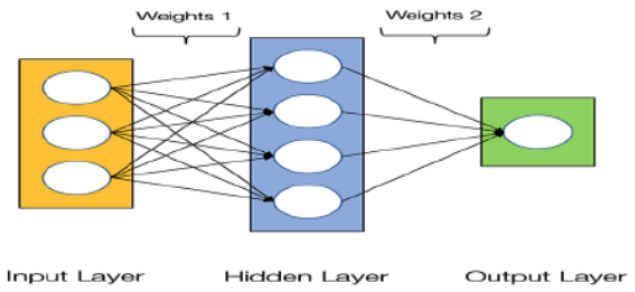

FIGURE 4.7: Structure of neural network

The basic parameters for ANN algorithm are: 1- Batch size and Epochs: Batch size tells that how many samples are used to calculate the error. Number of epochs controls the number of complete passes through training dataset. One epoch is comprised of feed forward and back propagation. In feed forward, we calculate the predicted outputs and then calculate the error using any error measure formula. Then, in back propagation, this error is used to update the weights.
2- Optimization Algorithms:
There are many optimization algorithms like SGD, Adam, Nadam etc. We can use any of the optimization algorithms and it is used for updating the weights.

3- Weight Initialization Methods:
There are many weight initialization methods like zero, normal, uniform. We can use any of the weight initialization methods and it is used for initializing the weight vector. zero method initializes the weight vector with all zeros.
4- Activation Function:
Each neuron has an activation function that gets the input from previous layer which combines with associated weights and then passes to the activation function that produce output and then this output pass to the next layer.
5- Number of neurons:
Each layer has many number of neurons as you can see in the Figure.

4.2.3.1 Hyper-parameters tuning:

Before we implement ANN, we need to find the best values for parameters at which accuracy score is maximum. For this purpose, we use GridsearchCV function to test for all possible combinations. Here are the results: This figure shows the impact of batch sizes on accuracy score.

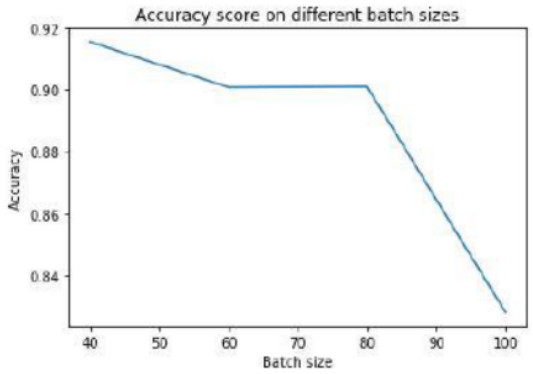

FIGURE 4.8: Impact of batch sizes on accuracy score.

This figure shows the impact of epochs on accuracy score.

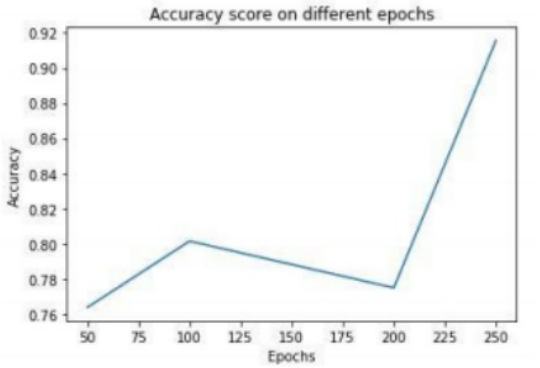

FIGURE 4.9: Impact of epochs on accuracy score.

This figure shows the impact of number of neurons on accuracy score.

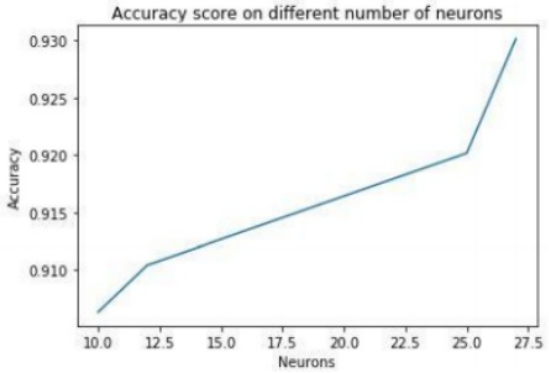

FIGURE 4.10: Impact of number of neurons on accuracy score.

This figure shows impact of weight initalization methods on accuracy score.

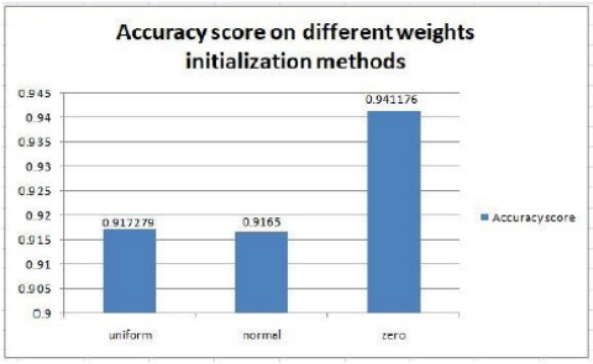

FIGURE 4.11: Impact of weight initalization methods on accuracy score.

This figure shows the impact of different optimization algorithms.

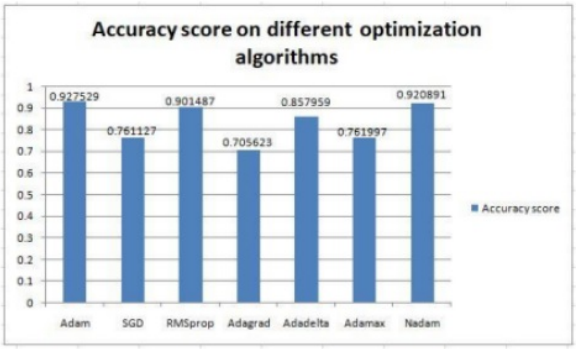

FIGURE 4.12: Impact of different optimization algorithms.

We also tune activation functions 'relu', 'tanh', 'sigmoid', linear. All of them gave same accuracy score. Hence, after checking the impact of choosing different values of parameters on accuracy score, we find out that best combination has following values: Batch size: 40
Epochs: 250
Optimization Algorithm: Adam
Weight Initialization Methods: uniform
Activation Function: relu for hidden layer and sigmoid for output layer
Number of Neurons for hidden layer: 27

4.2.3.2 Methodology for data training

1- Input: Data set and best parameters for ANN.
2- Split the data into training set (75 percent) and testing set (25 percent). We use startify so that the train and test sets have approximately the same percentage of samples of each target class as the complete set.
3- We apply label encoder to the output vector that encode classes that are in string format into integers. Then we apply to categorical that convert a class vector into binary class matrix.
4- Built the 2-layered ANN classifier by feeding it with the training data and best parameters.
5- Train the model and store the model on the disk.
6- Plotting of confusion matrix.
7- Calculate accuracy, precision and recall for training and testing data.

4.3 Implementation of Android applications

Actually, our proposed system has three Android applications.

- Data Capturing App
- Admin Android App
- User Android App

4.3.1 Data Capturing Application

The functional requirements and the implementation of Data Capturing Application are as follows:

4.3.1.1 User can enter his name or ID

The user who is going to capture the fingerprints of RSSI values, he can enter his name or ID because after capturing the data, file saves with users name and time at which he generates file(format is shown in figure). Multiple users and multiple devices of user can capture data for a same project in same working hours. So, at a same time, multiple files can be generated in separate mobile devices. But, replacement issue occurs when we gather all of them, some files would remain and some would be deleted. So, to avoid this issue, we make a tab for user where he can enter his name or ID.

4.3.1.2 Scanning of nearby BLE Bluetooth devices

The scanning of nearby BLE Bluetooth devices starts when a user press a startscan button on the screen of the Android application. This functionality will search the nearby 4.0+ Bluetooth devices and show the signal strength which a mobile device is capturing from each nearby BLE device. Meanwhile, the scan stops after it shows fingerprints of all the nearby devices on the screen as shown in figure.

4.3.1.3 Restart scan and capture RSSI fingerprints

The Bluetooth scanning stops while it scans all the nearby devices, but there is a big problem that occurs. The user can immediately change his location while moving from one room to the other room or corridor or some other location in the room or department. At that time he is near another beacon after changing his location instead of which whose RSSI values he was capturing so there becomes a room label issue. He was not capturing the signal strength of that particular room whose label was assigned at the start. In order to capture the fingerprints of the updated location of the user we need to rescan its nearby devices so that application can capture nearby devices for that updated location.

4.3.1.4 Generate csv file of captured data

When the fingerprints of mobile device from each nearby beacons are captured and they can be seen on the screen. User press the Generate file button in order to save that data in the form of csv format file in his mobile phone storage. The number of files generated per press of the button depends on the number of iterations of scanning (according to delay factor) which we give to the process at the start

4.3.1.5 Add delay function to slower the process

Our application generates a single file after a full scan of nearby devices. Once scanning becomes stop, it will save the data in one csv file and then start the rescanning process. When we generate multiple files without delay factor, it miss some files because the process of file generation is slow than rescanning. In this case, the rescanning of nearby BLE devices starts after before the generation of new file so in order to not miss any file we add a delay factor. Delay factor will start generating the file after rescanning has been done.

4.3.1.6 Allow user to generate files in iterations according to delay time

User allows to generate multiple files by single press for efficiency. In less time and by less effort, he can generate files after some delay. We use a delay of 5 seconds, it means every file is being generated after 5 seconds and this is enough time to rescan the device.

4.3.2 Admin Android Application

4.3.2.1 Design Database of Admin App

It is the rule to develop the software is that create database for our system. So, we also make the database design first. We make 5 tables of database that is:

- Admin
- Room
- Room Members
- Office Hours
- Pictures

Actually, in our system, Admin will do login and signup to handle the administration purpose. For this purpose, we made the Admin Table. Anyone can be

the admin. So, we can get the data of admin when he/she register in our system. Admin table is used to save the record of Admin. Then, we make the table of Room Information. As you know that, the department of every University has rooms. To store the information of every room in the department, we made room information table. After this, we made the Room Members table. As you know, every department has the rooms. The room may be class room, lab and the office of the teacher. If the room is the office of the teacher, then we have to store the information of the teachers. We have to store the information such as teacher name, teacher qualification, teacher designation, teacher office hours. To store the information of the office hours of the room members, we made Office Hours table. This office hours tables have store the information of the starting time, ending time and week day of room member. At the end, we store the images of the room. Actually, we want that user easily access the room. For this purpose, we show images of the specific room in which user stands. To store the pictures of the room, we made Picture Info Table. Our Database design is as follows:

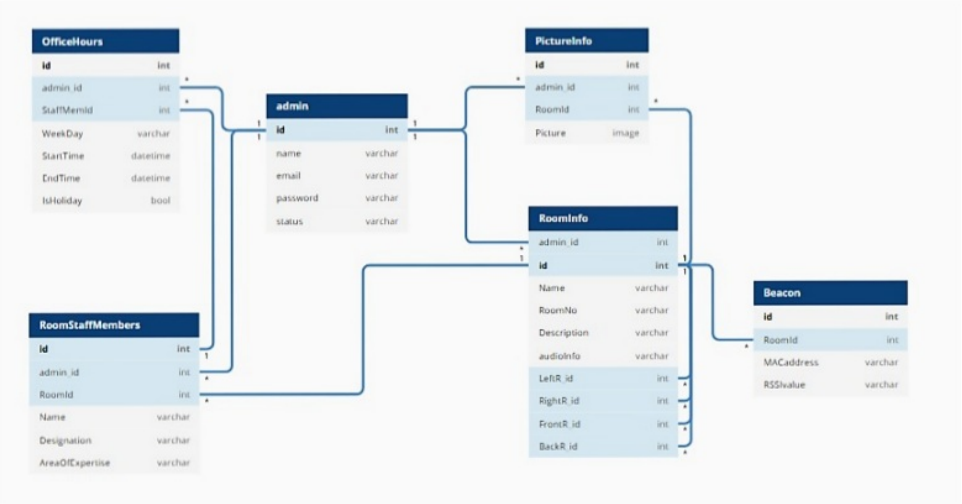

FIGURE 4.13: Database design diagram

4.3.2.2 Creating Web services for our App

After creating the database, we need to create web services for our project. Actually, the problem of our system is that it does not connect to the database directly. So, we need some medium between Admin App and server. For this purpose, we create web services. It is called APIs. It is also called RESTful API. Now, we discuss about how to create web services. To create the web services, we use php only. We can do php code on any framework. But for our system, we do php coding on Php storm. The relationship between the database, server and android app is as follows:

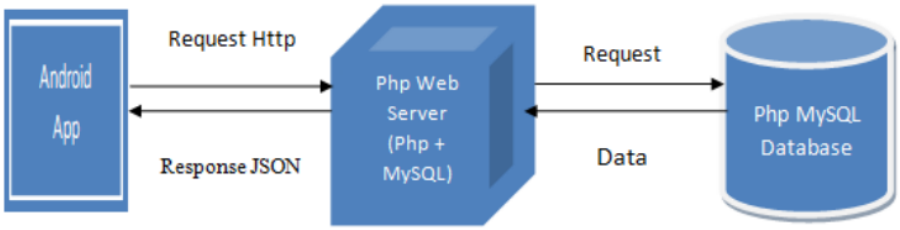

FIGURE 4.14: Relationship between database server and android application

In this way, we connect our Admin App with php MySQL database. There are following steps to create the web services that are as follows:

- First of all, we create a php project. Remember that, we use Php storm for this purpose.
- Then we make the database connection file. Our database filename is Db-Connect.php. We used this file to create the database.
- After this, we create the files for two operations, one is for Admin Signup and the other is for Admin Login. This file name is called API.php. We handle all the API calls in this file.
- We also validate the parameters in the Api.php file. Validating parameters is important for users.
- Because, we wanted to do CRUD operation for rooms. We make another file called RoomOperation.php. The main functions were created in this file. Some database queries are also written in this file. The function of AddRooms(),UpdateRooms() and deleteRooms() are also create in this file.

- In RoomOperation.php, we did not only make the functions for room. We also created the functions of Room members We also created the functions of AddRoomMemberInfo(), UpdateRoomMemberInfo() and deleteRoomMemberInfo().

- In RoomOperation.php, we did not only make the functions for room. We also created the functions of office hours of Room members. We also created the functions of AddOfficeHours(), UpdateOfficeHours () and deleteOfficeHours ().

- After this, we make the file of RoomApi.php. This file handles all the API calls for database operations such as add, edit and delete.

- At the end, we make UploadImgToServer.php file. Because, we wanted to upload rooms images on server. For this purpose, we created this file.

- At the end, we had tested the all file using REST client. In this scenario, our REST client is POSTMAN. This software is used for testing purposes

By follow these steps, we create the web services for our android Application. Now, we move to the android part of our Admin App.

4.3.2.3 Login and Signup of Admin App

After creating the web services, we develop the Admin App on Android Studio.

- First of all, we create the xml file. The xml file in android studio is used to make the front end. So, it is necessary to use xml file for making the Front end of android app. We made the front end which is easy to use for user. Our front end is user friendly. We can use different layouts for frontend. But in our system, we used Relative layout.

- Now, we move to backend coding. We make java classes for this purpose. Actually, we want to connect the android with database. For this purpose, we made the URLs.java file. We give the URL of php scripts in android app.

The format of URL is as follows:

```
private static final String ROOT_URL = "http://192.168.43.3/Admin/Api.php?apicall=";

public static final String URL_REGISTER = ROOT_URL + "signup";
public static final String URL_LOGIN= ROOT_URL + "login";
```

FIGURE 4.15: Format of URL of php scripts in Android application

- By using these URLs, we connect the app to database. Actually, we use online database. Thats why, there are some conditions to connect this app to database that is:

  a) Your mobile is connected to the internet
  b) The IP Address of Wi-Fi is same for server and your mobile phone.
  c) Your mobile is connected with the same internet which is connected to the server.

- After connecting the database, we do some backend code of java. We write the code which helps Admin to Login and Signup in this App. We created two java classes for this purpose. One was AdminLogin.java and other was AdminSignup.java.

- After making the java file of Admin Login and Admin Signup, we tested it.

4.3.2.4 Add/Edit/del Room information

After login, Admin can add, edit and delete the room information. To do this, he/she follow these steps which are given below:

- Admin show the list view in which the information of the room is present. To implement this activity, we use listview in this activity. We add textboxes in the listview in which the room number is shown.

- If Admin click the add button, then it moves to Add Room activity. To implement this, we make the frontend using xml files of android. Then, we do backend code on Add button click event. This button helps us to add the information from the android app to database.

- After clicking the room which is on the listview, the dialogue box is shown. It asks the Admin that do you want to delete or edit. To implement this feature we dynamically create the dialogue box. For this purpose, we used libraries of android which support dialogue box.

- If Admin clicks the delete, then the room from the listview will delete. For this purpose, we get the Room Id which deletes the record of room from database table of Room.
- If Admin clicks the Update button, then another activity is open, in which all data of that room is present. Admin can update the room name, room number and so on. For this, we also get the room id and update the record of that room on the database. The update button helps us to connect to the database. So that, the values of that room is updated.
- It is possible when Admin connect to this Application to the internet.

4.3.2.5 Add/Edit/del Room Member information

After this, Admin can add, edit and delete the room member information. To do this, he/she follow these steps which are given below:

- Admin show the list view in which the information of the room member is present. To implement this activity, we use listview in this activity. We add textboxes in the listview in which the room member name is shown.
- If Admin click the add button, then it moves to Add Room Member activity. To implement this, we make the frontend using xml files of android. Then, we do backend code on Add button click event. This button helps us to add the information from the android app to database table of Room Member Info.
- After clicking the room member name which is on the listview, the dialogue box is shown. It asks the Admin that do you want to delete or edit. To implement this feature we dynamically create the dialogue box. For this purpose, we used libraries of android which support dialogue box.
- If Admin clicks the delete, then the room member name will delete from the listview. For this purpose, we get the Room member Id which deletes the record of room member from database table of Room Member.
- If Admin clicks the Update button, then another activity is open, in which all data of that room member is present. Admin can update the room member name, room member qualification and so on. For this, we also get the room member id and update the record of that room member on the database. The update button helps us to connect to the database table of room member info. So that, the values of that room member is updated.

- It is possible when Admin connect to this Application to the internet.

4.3.2.6 Add/Edit/del Office Hours of Room Member

After this, Admin can add, edit and delete the Office Hours of Room Members. To do this, he/she follow these steps which are given below:

- Admin show the list view in which the information of the Office Hours of Room Members is present. To implement this activity, we use listview. We add textboxes in the listview in which the timings of room members is shown.
- If Admin click the add button, then it moves to Add Office Hours activity. Admin can add the start time, end time, week days and so on To implement this, we make the frontend using xml files of android. Then, we do backend code on Add button click event. This button helps us to add the information from the android app to table of database that name is Office Hours.
- After clicking the timings of room members which is on the listview, the dialogue box is shown. It asks the Admin that do you want to delete or edit. To implement this feature we dynamically create the dialogue box. For this purpose, we used libraries of android which support dialogue box.
- If Admin clicks the delete, then the office timings of room members from the listview will delete. For this purpose, we get the Id of Office Hours. We get this id from the Admin clicks on the listview. The record of this id will delete from database table of Office Hours.
- If Admin clicks the Update button, then another activity is open, in which all data of the office timings of room members is present. Admin can update the start time, end time, week days and so on. For this, we also get the id and update the record from the Office Hours table of database. The update button helps us to connect to the database. So that, the values of that table is updated.
- It is possible when Admin connect to this Application to the internet

4.3.2.7 Add Pictures of Room

At the end of the implementation of Admin App, we add the functionality of Add pictures. For this purpose, we upload the image to the server. It is not easy to upload the image to the server. But we did it. Actually, images are not added directly to the database. So, we save the link of the image which is uploaded to

the server in database. Actually, we made this feature for the ease of user. The user can see the room information in the form of pictures. The scenario to upload image to the server is shown below:

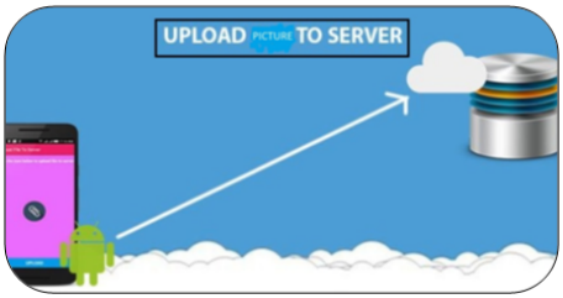

FIGURE 4.16: Scenario to upload image to the server

Due to shortage of time, we dont implement the features of edit/delete. It is very difficult to edit and delete the images from the database indirectly. But in future, we try to add these functionalities. Admin can also edit and delete the pictures from the server.

4.3.3 User Android Application

Now, we describe some points of the implementation of user application which are as follows:

4.3.3.1 Integrate trained ML model with user app.

After training the model, we have to integrate this model with user app. For this purpose, we choose tensorflow lite. To execute the trained model with tensorflow lite. We have to convert model file to .tflite .Actually, tensorflow lite only considered .tflite file. In an android application, we have to embedded the .tflite file into Android User App. This is the first step to integrate the model. This file used for loading models and predict output. For loading the model, first of all it get array of RSSI values as an input and give the Room Id as an input. It can take a time to train model of tensor flow lite because of huge data. These are the following steps to integrate the trained the model:

- Training the model.
- Transform it into required format. Such as .tflite
- Embedded .tflite file with android app.
- We can get RSSI values on runtime when user uses the application.

- Retrain the model with new data.
- Get results from the retrained model.
- Show Results on the mobile device such as location of user.

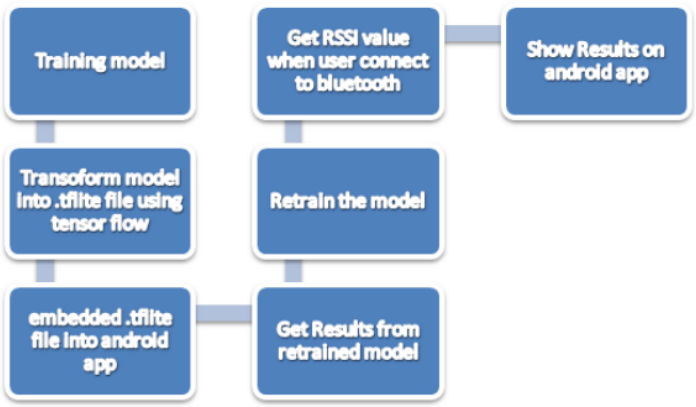

FIGURE 4.17: Steps to integrate the trained model

4.3.3.2 Functionality to turn ON bluetooth when users install the app

When users install the app, he/she have to turn on the bluetooth. For this purpose, we add the functionality on android studio to turn on bluetooth. Actually, Bluetooth is used to send or receive data between two devices. But, we used bluetooth only for scanning. Bluetooth scanned and get data of nearby devices such as Beacons and other bluetooth device. In this ways, we get the RSSI values and MAC Address of our beacons. To implementation of this feature, we use bluetooth API which android provides. Android provides the class of Bluetooth Adapter. By using this class, we call the function of ACTION REQUEST ENABLE. This function used to enable the bluetooth for this app. Bluetooth is on and search nearby devices. To search nearby devices, we use the function ACTION REQUEST DISCOVERABLE. It becomes discoverable for 120 seconds. We can extent it by using the function EXTRA-DISCOVERABLE-DURATION up to 1 hour (3600 seconds). After discover the nearby devices, we can get their RSSI values and MAC Address. The nearby devices which we discover, not only get the RSSI values and MAC Address of the beacons, but also get this data of other devices. Due to other devices our data become misclleneous.To get accurate data, we will remove this data and take it as missing value in data.

FIGURE 4.18: Steps to get RSSI values and MAC address

4.3.3.3 Make java classes to save RSSI values

After scanning the bluetooth devices, we get the data of RSSI values and MAC Address of nearby devices. To save this data, we make java class named as Beacon.java. In this class, we take two strings variable that is as follows:

- RSSI values
- MAC Address.

We can store these two variables in this class by using lists/ arrays. The different device has different RSSI values and MAC Address. Some other discoverable devices which are not our beacons also present. Their RSSI values and MAC Address also store in java class. But we want to remove this. For this purpose, we make the function RemoveMisclleneousData(). In this function, we remove the misclleneous data from the list and take it as missing values.

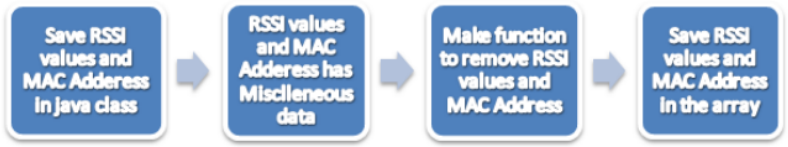

FIGURE 4.19: Steps to save RSSI values and MAC address in the array

4.3.3.4 Function to pass RSSI values to trained model

After removing the misclleneous values from the java class, we pass list to the function. We made the function named passRSSIvalues(array[] RSSI , array MACaddr[]). In this function, we give the array of RSSI values and array of MAC Address as an input and take the Id of room as output in which the user is present. This function returns the Room Id. Actually, in our system, the RSSI values and MAC Addressed is labeled to the Room No. we also used the data labeling process for our system. The annotated data is present in our model file that is model.tflite.

FIGURE 4.20: Steps to pass RSSI values to trained model

4.3.3.5 Show location of user

After getting the Room Id, we give this room Id as an input to php MYSQL database server. We write a select query in php scripts which get data of Rooms, Room Member and their office hours. Using Admin App, we enter all the data of rooms. Now, in this time, we fetch the data from php MYSQL database server against this Room Id. The data is converted into JSON. We use JSON web services to fetch the data from database. Using these services, we get the data from php MYSQL and display this data on users screen. This data show the location of user on our User App.

FIGURE 4.21: Steps to show location of user

4.3.3.6 Show all information of current room

We have to show all the information of the room in which user is present. Actually, the admin app is used to enter the record in database but the user app is used to fetch the record from database. We use these tables to fetch the record from database that is:

- Room
- Room Members
- Office Hours
- Pictures
- To show the information of the current room we follow some steps:
- First of all, we create the activity.

- In this activity we fetch the record of database
- We fetch the pictures of the current room from Pictures table of database.
- We fetch the audio from database of current room from the room table of database
- We also show the description of that room. For this purpose, we fetch the room member name, area of expertise and designation from Room Member table.
- We also fetch the office hour timings of room members of that current room from Office hours table to show the description of current room.

4.3.3.7 Update location of the user

As you all know, when we go to the new place, we want to visit that place. For this purpose, a person changes his position from one place to another. When person changes his position, we need to update the position of the person on android app. To implement this portion, we have to make the function named as UpdateUserLoc(). This function is used to update the location of the person on android App. When user changes his location, the location of the person also changes. We use delay time in this function. After 10 seconds, the location of the user will update.

4.3.3.8 Show nearby location of the user

The room ID which we get from the trained data, we give this room Id as an input to php MYSQL database server. We write a select query in php scripts to get the data of Rooms and nearby Rooms. Using Admin App, we enter all the data of rooms. In room table, Admin also enters the ID of nearby rooms such as room on left side, room on right side, room on front, room on back side of current room. Now, in this time, we fetch the data of nearby rooms from php MYSQL database server against this Room Id. The data is converted into JSON. We use JSON web services to fetch the data from database. Using these services, we get the data from php MYSQL and display this data on users screen. This data shows the nearby location of user on our User Android App.

4.3.3.9 Show all information of nearby rooms

We have to show all the information of the nearby rooms. To show all the information of the nearby rooms we follow some steps:

- First of all, we create the activity for nearby rooms.

- In this activity, we fetch the record of nearby rooms from database.
- We fetch the pictures of the nearby rooms from Pictures table of database.
- We fetch the audio from database of nearby rooms from the room table of database
- We also show the description of nearby rooms. For this purpose, we fetch the room member name, area of expertise and designation from Room Member table.
- We also fetch the office hour timings of room members of nearby rooms from Office hours table to show the description of nearby rooms.

Chapter 5

Results and Discussions

As we have to predict the indoor location of the user, we gathered our dataset by capturing RSSI fingerprints using our data capturing application which we further use to train our machine learning model.To train our machine learning model, we use three different machine learning algorithms. Firstly knn, which we used for supervised machine learning problem i.e.multiclassification problem. After tuning hyper-parameters of knn, it gives us accuracy of 90.04 while measuring Euclidean distance and of 90.03 while measuring Manhattan distance as shown in the Figure 5.1. Secondly, we choose random forest algorithm which works on the principle

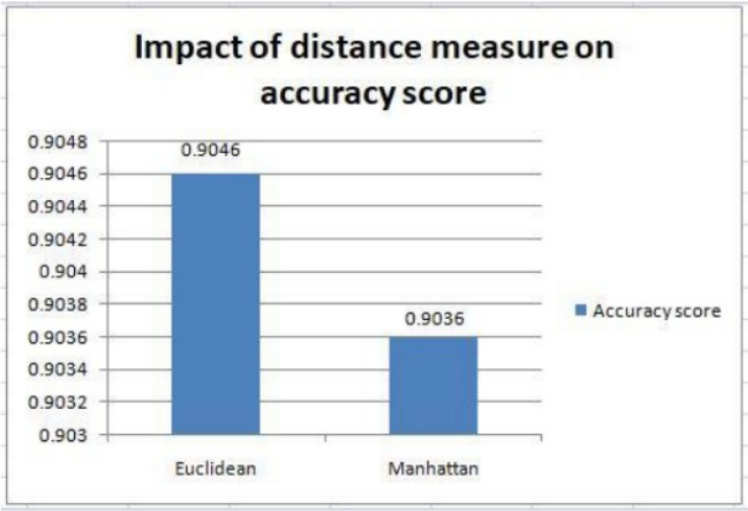

FIGURE 5.1: Impact of distance measure on accuracy score

of random creation of decision trees and gives the final prediction by polling the

score of all decision trees for multiclassification problems. We tuned random forest algorithm on different hyper-parameters i.e. number of decision trees, maximum number of splits and nodes. The best combination of setting these parameters gives us the trainng accuracy of 95.33 and testing accuracy of 90.1. The imapct of different number of trees is shown in the Figure 5.2.

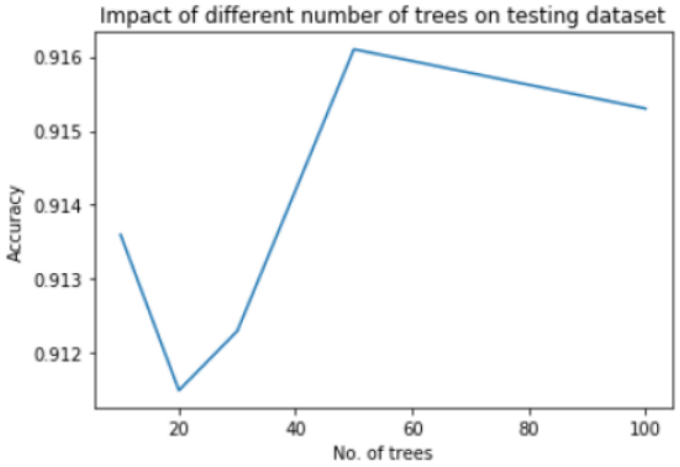

FIGURE 5.2: Impact of different number of trees on testing dataset

For the better prediction of the indoor location of the user, we thirdly use neural networks in which we use 2-layered neural network for our multi-classification problem.The input layer consists of input neurons. Those neurons transmit data to the next layer, which in turn sends the output of the neurons to the output layer. To implement this algorithm, we have to find the best values for parameters at which accuracy score is maximum. For this purpose, we use GridsearchCV function to test for all possible combinations. Here are the results of impact of optimizations algorithms on accuracy score.

We also tune activation functions 'relu', 'tanh', 'sigmoid', linear. All of them gave same accuracy score.Hence, after checking the impact of choosing different values of parameters on accuracy score, we find out that best combination has following values:

- Batch size: 40
- Epochs: 250
- Optimization Algorithm: Adam

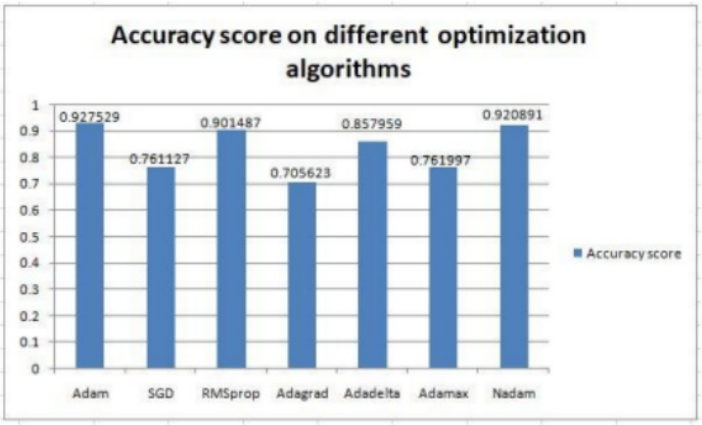

FIGURE 5.3: Accuracy score on different optimization algorithms

- Weight Initialization Methods: uniform
- Activation Function: relu for hidden layer and sigmoid for output layer
- Number of Neurons for hidden layer: 27

So,we conclude that on the basis of accuracy, precision and recall score for k-NN, Random forest and ANN. It is clear that ANN has highest accuracy, precision and recall score. Hence, ANN is our selected mode.

5.1 Graphs

The accuracy, precision and recall graph of knn is as follows:

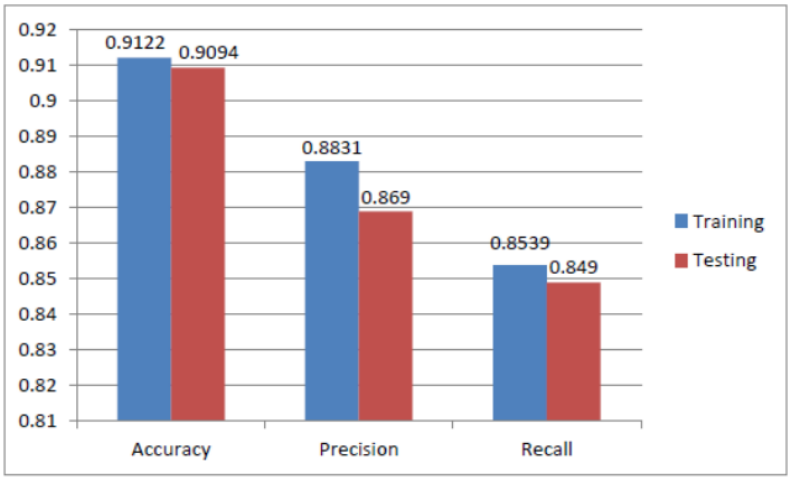

FIGURE 5.4: Accuracy, precision and recall graph of knn on training and testing sets

The accuracy, precision and recall graph of ann is as follows:

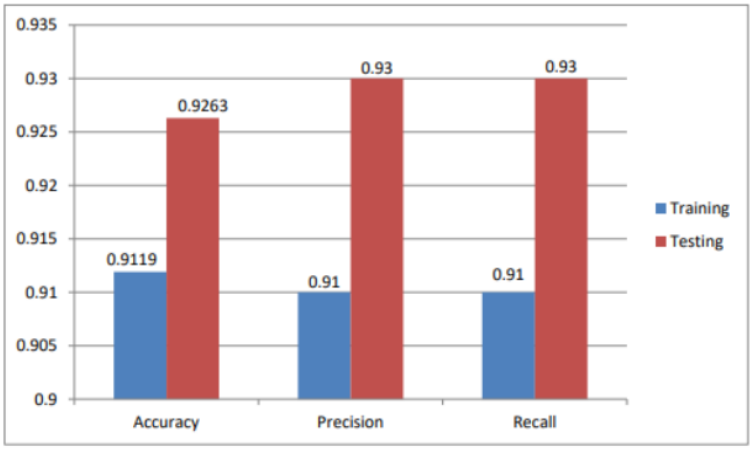

FIGURE 5.5: Accuracy, precision and recall graph of ann on training and testing sets

5.2 Confusion Matrix

For the better prediction of the algorithms, we draw confusion matrix of the algorithims. The confusion matrix for knn is shown in the Figure(a) . As it is a multi-classification problem, it is a little bit different from binary classification. For example: L1 row shows that out of total samples in test data where data is labeled as L1, 92 instances were correctly classify, while 4 samples were wrongly predicted as L9.

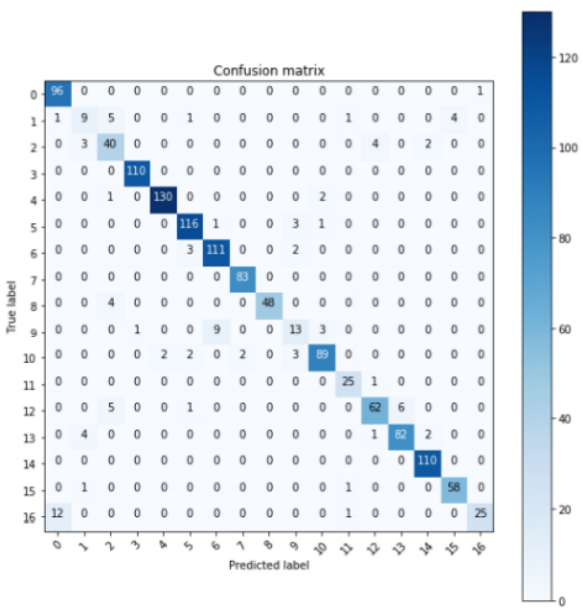

FIGURE 5.6: Confusion matrix for the evaluation of knn

The confusion matrix for ann algorithm is shown in the Figure(b). As we use label encoder, so it encode classes ranges from 0 to 16. Here is the actual sequence, it means L1 encode to 0, L10 encode to 1 and so on:

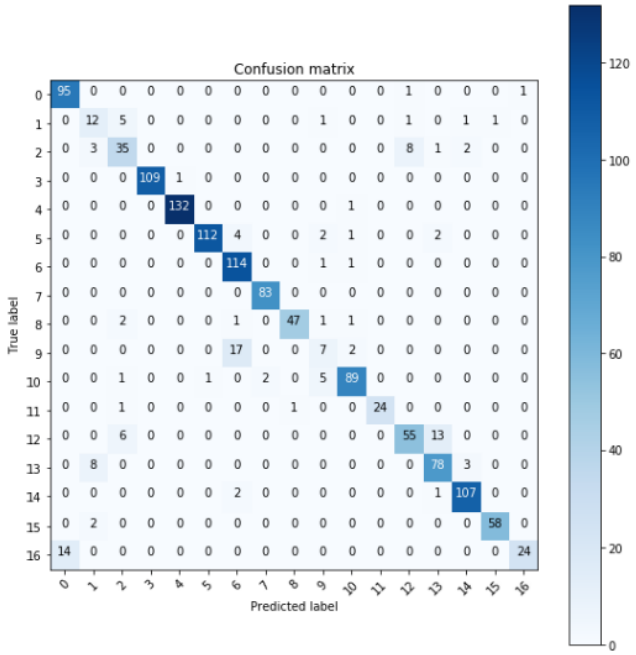

FIGURE 5.7: Confusion matrix for the evaluation of ann

Chapter 6

Thesis Contribution and Future Work

6.1 Introduction

As we have discussed all the parameters in this thesis such as introduction, methodology, implementation, results etc. After results and experiments, this proposed system motivates us to do some more work on it. So, in this chapter, we will discuss the work that we will do in future. But before discuss the future work, we will discuss about the thesis contribution.

6.1.1 Thesis Contribution

According to previous research papers, indoor localization based applications using different techniques. Most of the applications based on Wi-Fi. Image based indoor localization, capacitive sensors, Zigbee Wi-Fi are previous technique for indoor localization. In our research work, we have to make an android application which tells the indoor location of the user using BLE beacons. There are some points which describe that what our contribution in thesis which is as follows:

- Bluetooth beacons are much more compatible than other devices such as Wi-Fi, Image based indoor localization, capacitive sensors, Zigbee Wi-Fi.
- BLE beacon consumes less energy. It is light weight and cheaper than Wi-Fi signals. BLE beacons are usually battery powered, which are more flexible. It is easier to sense the signals.
- Our system is much more compatible than other indoor based localization application.

- Our system provides much more reliability, maintainability, security and safety, reusability than other indoor based localization applications.
- It gives better performance than other indoor based localization applications.
- Our System is user friendly and easy to use.
- Our system well-defined the location of the user than other indoor based localization applications.
- Our system also tells the entire information of the room in which user is present which other indoor based localization applications not tell.
- It also tells the entire information of nearby room which other indoor based localization applications not tell.
- Our system tells the information of the rooms and nearby rooms in the form of texture, pictures and audio format.
- Our proposed system supports the mobile devices such as tablets and smart phones
- Our proposed system supports the Android OS (Operating System).

6.1.2 Future Work

To improve the accuracy and performance of this purposed system, we want to do further work on them. We also want to do this project on commercial level. Actually the idea of our project is world changing. But due to limited resources, we implement this idea on a specific workspace. Here we discuss some points in which we will implement in the future.

- First of all, we want to develop an algorithm which gives more precise accuracy than previous algorithms such as k-NN, ANN and RF (Random Forest).
- We want to work on a big data set such as data set of all over university. For this purpose we will capture the data of all over the university.
- We will develop an application with different database. Actually, the database of one department of the university includes rooms, room members and office hours of the room members. But when we will work on the university, the database is different.

- For our proposed system, we use online database. But in future, we want to make an offline database. So that, when users install the app in the mobile, the overall data is also installed in the mobile.
- We will develop an android application for our CSE department, UET Lahore. But in future we will make this application for whole university.
- If we will have more resources in the future, we will make this system for other places such as hospitals, offices, shopping malls and other universities

.

References

[1] Ble guide [Online] Available at:. https://blog.beaconstac.com/2018/08/ble-made-simple-a-complete-guide-to-ble-bluetooth-beacons/.

[2] Galileo european global navigation satellite system [Online] Available at:. https://www.gsa.europa.eu/european-gnss/galileo/galileo-european-global-satellite-based-navigation-system.

[3] Global positioning system [Online] Available at:. https://www.intechopen.com/books/New-Approach-of-Indoor-and-Outdoor-Localization-Systems, .

[4] How gps works [Online] Available at:. http://1-https//spymonde.com/gps-tracking/how-your-gps-works, .

[5] Indoor positioning [Online] Available at:. https://www.directionsmag.com/article/1598.

[6] Indoor positioning system [Online] Available at:. https://www.cs.waikato.ac.nz/ml/weka/.

[7] Loco guided video [Online] Available at:. https://www.youtube.com/watch?v=bjbSwUveuXs.

[8] Ultrasonic positioning system [Online] Available at:. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5713469/.

[9] Beenish Ayesha Akram, Ali Hammad Akbar, and Ki-Hyung Kim. Censloc: Infrastructure-less indoor localization methodology using gmm clustering-based classification ensembles. *Mobile Information Systems*, 2018, 2018.

[10] Chairil Andri, Mohammed Alkawaz, and Amira Bibo. Adoption of mobile augmented reality as a campus tour application. *International Journal of Engineering and Technology(UAE)*, 7:64–69, 10 2018. doi: 10.14419/ijet.v7i4.11.20689.

[11] Oscar Belmonte Fernndez, Adrian Puertas-Cabedo, Joaqun Torres-Sospedra, Ral Montoliu-Cols, and Sergi Trilles Oliver. An indoor positioning system based on wearables for ambient-assisted living. *Sensors*, 17:36, 12 2016. doi: 10.3390/s17010036.

[12] Matthew Cooper, Jacob Biehl, Gerry Filby, and Sven Kratz. Loco: boosting for indoor location classification combining wi-fi and ble. *Personal and Ubiquitous Computing*, 20(1):83–96, 2016.

[13] Milton Hultgren and Dionysios Papathanopoulos. Evaluating the usage of bluetooth low energy beacons and smartphones for indoor positioning systems. 2015.

[14] Hisato Kawaji, Koki Hatada, Toshihiko Yamasaki, and Kiyoharu Aizawa. Image-based indoor positioning system: Fast image matching using omnidirectional panoramic images. 01 2010. doi: 10.1145/1878039.1878041.

[15] Wilson Sakpere, Michael Adeyeye Oshin, and N. Mlitwa. A state-of-the-art survey of indoor positioning and navigation systems and technologies. *South African Computer Journal*, 29:145–197, 2017.

SmartGuide: A Smart Campus Guide using BLE based Indoor Localization

ORIGINALITY REPORT

13%	7%	6%	10%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Higher Education Commission Pakistan Student Paper	2%
2	dataconomy.com Internet Source	1%
3	mafiadoc.com Internet Source	<1%
4	stepupanalytics.com Internet Source	<1%
5	Chao Xiao, Daiqin Yang, Zhenzhong Chen, Guang Tan. "3D BLE Indoor Localization based on Denoising Autoencoder", IEEE Access, 2017 Publication	<1%
6	Submitted to University of Teesside Student Paper	<1%
7	www.mdpi.com Internet Source	<1%
	gupea.ub.gu.se	

8	Internet Source	<1%
9	Submitted to CONACYT Student Paper	<1%
10	www.wordstream.com Internet Source	<1%
11	Submitted to University of Sydney Student Paper	<1%
12	"Advances in Computing and Data Sciences", Springer Science and Business Media LLC, 2017 Publication	<1%
13	Submitted to Argosy University Student Paper	<1%
14	Submitted to Academy of Information Technology Student Paper	<1%
15	Submitted to University of Wollongong Student Paper	<1%
16	Yibo Yang, Yongkui Ma, Wei Xiang, Xuemai Gu, Honglin Zhao. "Joint Optimization of Energy Consumption and Packet Scheduling for Mobile Edge Computing in Cyber-Physical Networks", IEEE Access, 2018 Publication	<1%

17	Óscar Belmonte-Fernández, Adrian Puertas-Cabedo, Joaquín Torres-Sospedra, Raúl Montoliu-Colás, Sergi Trilles-Oliver. "An Indoor Positioning System Based on Wearables for Ambient-Assisted Living", Sensors, 2016 Publication	<1%
18	Ying Zhao, Junjun Chen, Di Wu, Jian Teng, Nabin Sharma, Atul Sajjanhar, Michael Blumenstein. "Network Anomaly Detection by Using a Time-Decay Closed Frequent Pattern", Information, 2019 Publication	<1%
19	Submitted to Associatie K.U.Leuven Student Paper	<1%
20	Submitted to EDMC Student Paper	<1%
21	dblp.dagstuhl.de Internet Source	<1%
22	Sanish Manandhar, Sushana Bajracharya, Sanjeev Karki, Ashish Kumar Jha. "Hand Gesture Vocalizer for Dumb and Deaf People", SCITECH Nepal, 2019 Publication	<1%
23	Submitted to Monash University Student Paper	<1%

24	Submitted to Coventry University Student Paper	<1%
25	dblp2.uni-trier.de Internet Source	<1%
26	dblp.uni-trier.de Internet Source	<1%
27	Submitted to University of Bedfordshire Student Paper	<1%
28	Submitted to Rutgers University, New Brunswick Student Paper	<1%
29	andresp.me Internet Source	<1%
30	botfactory.in Internet Source	<1%
31	www.sciencepubco.com Internet Source	<1%
32	Submitted to University of Portsmouth Student Paper	<1%
33	Submitted to University of Queensland Student Paper	<1%
34	Dino Ienco, Ruggero G. Pensa. "Positive and unlabeled learning in categorical data", Neurocomputing, 2016 Publication	<1%

35	edoc.ub.uni-muenchen.de Internet Source	<1%
36	Submitted to Technische Universiteit Delft Student Paper	<1%
37	eprints.usm.my Internet Source	<1%
38	arxiv.org Internet Source	<1%
39	Submitted to University of Nevada Reno Student Paper	<1%
40	sintadev.ristekdikti.go.id Internet Source	<1%
41	scholar.sun.ac.za Internet Source	<1%
42	eucivcap.files.wordpress.com Internet Source	<1%
43	Yunjeong Mo, Dong Zhao, Jing Du, Matt Syal, Azizan Aziz, Heng Li. "Automated staff assignment for building maintenance using natural language processing", Automation in Construction, 2020 Publication	<1%
44	Submitted to The University of Manchester Student Paper	<1%

45	Lubana Barodi, Tamer Dag. "The Performance of the RSS-Based Lateration Algorithm for Indoor Localization", 2019 International Conference on Sustainable Information Engineering and Technology (SIET), 2019 Publication	<1%
46	Submitted to University of Warwick Student Paper	<1%
47	core.ac.uk Internet Source	<1%
48	Submitted to University of Exeter Student Paper	<1%
49	Gerd H. Schmitz, Niels Schütze, Uwe Petersohn. "New Strategy for Optimizing Water Application under Trickle Irrigation", Journal of Irrigation and Drainage Engineering, 2002 Publication	<1%
50	Yuan Zhuang, Jun Yang, You Li, Longning Qi, Naser El-Sheimy. "Smartphone-Based Indoor Localization with Bluetooth Low Energy Beacons", Sensors, 2016 Publication	<1%
51	C G Xue, H S Yan. "A study on self-reconfiguration of a knowledgeable manufacturing system", Proceedings of the Institution of Mechanical Engineers, Part B:	<1%

	Journal of Engineering Manufacture, 2005 Publication	
52	Submitted to University of Bristol Student Paper	<1%
53	Ye Tian, Zhirong Tang, Jian Ma. "Sparse sensing data–based participant selection for people finding", International Journal of Distributed Sensor Networks, 2019 Publication	<1%
54	Submitted to Staffordshire University Student Paper	<1%
55	HoSeong Cho, ChulYoung Park, DaeHeon Park, JangWoo Park. "Chapter 30 Accuracy Estimation of Hybrid Mode Localization Method Based on RSSI of Zigbee", Springer Science and Business Media LLC, 2011 Publication	<1%
56	idus.us.es Internet Source	<1%
57	Submitted to INTI University College Student Paper	<1%
58	www.ukessays.com Internet Source	<1%
59	Sunwoo Lee, Qiao Kang, Sandeep Madireddy, Prasanna Balaprakash, Ankit Agrawal, Alok	<1%

Choudhary, Richard Archibald, Wei-keng Liao. "Improving Scalability of Parallel CNN Training by Adjusting Mini-Batch Size at Run-Time", 2019 IEEE International Conference on Big Data (Big Data), 2019
Publication

60	Submitted to Universidad Carlos III de Madrid Student Paper	<1%
61	Submitted to Monash University Sunway Campus Malaysia Sdn Bhd Student Paper	<1%
62	Matthew Cooper, Jacob Biehl, Gerry Filby, Sven Kratz. "LoCo: boosting for indoor location classification combining Wi-Fi and BLE", Personal and Ubiquitous Computing, 2016 Publication	<1%
63	Submitted to RMIT University Student Paper	<1%
64	Submitted to Institute of Technology, Tallaght Student Paper	<1%
65	Song-Kyoo Kim. "Com2uS Mobile Game Development", Journal of Information Technology Case and Application Research, 2015 Publication	<1%
66	eprints.uthm.edu.my	

	Internet Source	<1%
67	Submitted to University of East London Student Paper	<1%
68	doaj.org Internet Source	<1%
69	orca.cf.ac.uk Internet Source	<1%
70	list.waikato.ac.nz Internet Source	<1%
71	Submitted to University of Bath Student Paper	<1%
72	Submitted to Royal Holloway and Bedford New College Student Paper	<1%
73	Submitted to Informatics Education Limited Student Paper	<1%
74	Submitted to University of Southampton Student Paper	<1%
75	www.ijert.org Internet Source	<1%
76	Submitted to University of Birmingham Student Paper	<1%
	Submitted to Imperial College of Science,	

77	Technology and Medicine Student Paper	<1%
78	Submitted to University of Sheffield Student Paper	<1%
79	opac.ll.chiba-u.jp Internet Source	<1%
80	Hisato Kawaji, Koki Hatada, Toshihiko Yamasaki, Kiyoharu Aizawa. "Image-based indoor positioning system", Proceedings of the 1st ACM international workshop on Multimodal pervasive video analysis - MPVA '10, 2010 Publication	<1%
81	Hisato Kawaji, Koki Hatada, Toshihiko Yamasaki, Kiyoharu Aizawa. "An image-based indoor positioning for digital museum applications", 2010 16th International Conference on Virtual Systems and Multimedia, 2010 Publication	<1%
82	Submitted to University of Abertay Dundee Student Paper	<1%
83	Submitted to University of Edinburgh Student Paper	<1%
84	Submitted to University of KwaZulu-Natal Student Paper	<1%

85	eprints.utem.edu.my Internet Source	<1%
86	Submitted to Heriot-Watt University Student Paper	<1%
87	Submitted to University of Malta Student Paper	<1%
88	Submitted to Cranfield University Student Paper	<1%
89	Submitted to INTI International University Student Paper	<1%
90	slidelegend.com Internet Source	<1%
91	Adam Freeman. "Pro ASP.NET 4.5 in C#", Springer Science and Business Media LLC, 2013 Publication	<1%
92	"Advances in Knowledge Discovery and Data Mining", Springer Science and Business Media LLC, 2012 Publication	<1%
93	Submitted to Manchester Metropolitan University Student Paper	<1%
94	Submitted to Brunel University Student Paper	<1%

95	www.eislab.net Internet Source	<1%
96	Submitted to University of Huddersfield Student Paper	<1%
97	downloads.hindawi.com Internet Source	<1%
98	Submitted to University of Mauritius Student Paper	<1%
99	Sourabh R Misal, S R Prajwal, H M Niveditha, H M Vinayaka, S Veena. "Indoor Positioning System (IPS) Using ESP32, MQTT and Bluetooth", 2020 Fourth International Conference on Computing Methodologies and Communication (ICCMC), 2020 Publication	<1%
100	Submitted to CSU, San Jose State University Student Paper	<1%
101	Shinsuke Kobayashi, Yukihiko Shigesada, Noboru Koshizuka, Ken Sakamura. "Interoperable Spatial Information System Architecture Based on Ubiqiutous ID Infrastructure", 2011 IEEE 35th Annual Computer Software and Applications Conference Workshops, 2011 Publication	<1%

102	Yongliang Sun, Yu He, Weixiao Meng, Xinggan Zhang. "Voronoi Diagram and Crowdsourcing-Based Radio Map Interpolation for GRNN Fingerprinting Localization Using WLAN", Sensors, 2018 Publication	<1%
103	Submitted to City University Student Paper	<1%
104	ir.uiowa.edu Internet Source	<1%
105	lup.lub.lu.se Internet Source	<1%
106	Submitted to Management & Science University Student Paper	<1%
107	Submitted to ABV-Indian Institute of Information Technology and Management Gwalior Student Paper	<1%
108	Submitted to De Montfort University Student Paper	<1%
109	Submitted to Bilkent University Student Paper	<1%
110	Jiyang Wang, Yuyang Gao, Xuejun Chen. "A Novel Hybrid Interval Prediction Approach Based on Modified Lower Upper Bound Estimation in Combination with Multi-Objective	<1%

Salp Swarm Algorithm for Short-Term Load Forecasting", Energies, 2018

Publication

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		