ABSTRACT

The growing commercial interest in indoor location-based services (ILBS) has spurred recent development of many indoor positioning techniques. Due to the absence of global positioning system (GPS) signal, many other signals have been proposed for indoor usage. As GPS signal cannot penetrate well in indoor environment, various other signals have been investigated for localization purpose. Among many signals, the use of Wi-Fi signal Wi-Fi (802.11) emerges as a promising one due to the pervasive deployment of wireless LANs (WLANs). In particular, Wi-Fi fingerprinting has been attracting much attention recently because it does not require line-of-sight measurement of access points (APs) and achieves high applicability in complex indoor environment. Using Wi-Fi signals and their RSSI (received signal strength intensity) the location of a mobile user in indoor environment is estimated and displayed in a map like platform. In addition to that Heat map of a Wi-Fi access point and walking trajectories of the mobile user is also displayed.

CHAPTER 1

INTRODUCTION

Indoor location-based service (ILBS) has attracted much attention in recent years due to its social and commercial values, with market value predicted to worth US$10 billion by2020 [1]. Indoor environment is often complex, characterized by non-line-of-sight (NLoS) of reference objects, presence of obstacles, signal fluctuation or noise, environmental changes, etc. Despite such complex environment, high localization accuracy (within meter range) is still expected in order to offer satisfactory ILBS. As GPS signal cannot penetrate well in indoor environment, various other signals have been investigated for localization purpose. Such signals include Wi-Fi, Bluetooth, FM radio, radio frequency identification (RFID). Among all these, the use of Wi-Fi signal has attracted continuous attention because of pervasive penetration of wireless LANs (WLANs) and Wi-Fi enabled mobile devices. The deployment of Wi-Fi positioning systems is hence cost-effective without the need of extra infrastructure investment. Wi-Fi fingerprinting, a process of signal collection and association with indoor locations, has become a promising approach. In the scheme, a position is characterized by its detected signal patterns (i.e, a vector of RSSIs from different Wi-Fi APs). Thus, without knowing exact AP locations, fingerprinting requires neither distance nor angle measurement, leading to its high feasibility in indoor deployment. Wi-Fi fingerprinting is usually conducted in two phases: an offline phase (survey) followed by an online phase (query). In Fig. 1.1, we show its basic operation. In the offline phase, a site survey is conducted to collect the vectors of received signal strength indicator (RSSI) of all the detected Wi-Fi signals from different access points (APs) at many reference points (RPs) of known locations. Hence, each RP is represented by its fingerprint. All the RSSI vectors form the fingerprints of the site and are stored at a database for online query. In the online (query) phase, a user (or target) samples or measures an RSSI vector at his/her position and reports it to the server. The server compares the received target vector with the stored fingerprints. The target position is estimated based on the most similar "neighbors", the set of RPs whose fingerprints closely match the target's RSSI

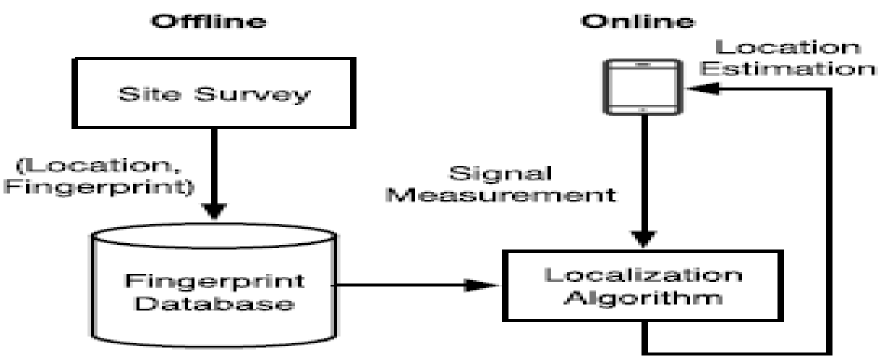


Fig 1.1

CHAPTER 2

<u>POSITIONING SYSTEM</u>

2.1 OFFLINE PHASE

In the offline phase, a site survey is conducted to collect the vectors of received signal strength indicator (RSSI) of all the detected Wi-Fi signals from different access points (APs) at many reference points (RPs) of known locations. Hence, each RP is represented by its fingerprint.

```
data_base =

  6×9 table
```

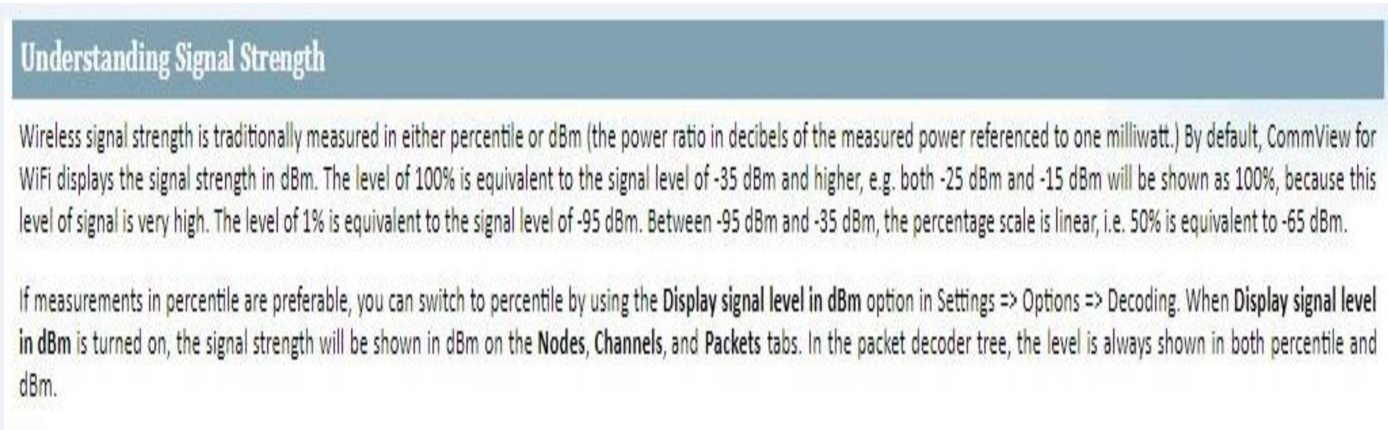
	t3a80	t39a0	t3940	t2ea0	t35e0	t3920	t38e0	t3140	t3960
RP1	-80	-68	-77	-90	-55	-100	-100	-100	-100
RP2	-85	-80	-60	-70	-100	-100	-100	-100	-100
RP3	-88	-72	-85	-100	-52	-90	-84	-100	-100
RP4	-100	-78	-100	-100	-62	-85	-75	-82	-88
RP5	-100	-100	-100	-100	-85	-71	-65	-74	-85
RP6	-100	-100	-100	-100	-100	-83	-79	-60	-72

Figure 2.1

2.2 ONLINE PHASE

In the online (query) phase, a user (or target) samples or measures an RSSI vector at his/her position and reports it to the server. The server compares the received target vector with the stored fingerprints. The target position is estimated based on the most similar "neighbors", the set of RPs whose fingerprints closely match the target's RSSI

RSSI Measurements by CommView:



Understanding Signal Strength

Wireless signal strength is traditionally measured in either percentile or dBm (the power ratio in decibels of the measured power referenced to one milliwatt.) By default, CommView for WiFi displays the signal strength in dBm. The level of 100% is equivalent to the signal level of -35 dBm and higher, e.g. both -25 dBm and -15 dBm will be shown as 100%, because this level of signal is very high. The level of 1% is equivalent to the signal level of -95 dBm. Between -95 dBm and -35 dBm, the percentage scale is linear, i.e. 50% is equivalent to -65 dBm.

If measurements in percentile are preferable, you can switch to percentile by using the **Display signal level in dBm** option in Settings => Options => Decoding. When **Display signal level in dBm** is turned on, the signal strength will be shown in dBm on the **Nodes**, **Channels**, and **Packets** tabs. In the packet decoder tree, the level is always shown in both percentile and dBm.

Figure 2.3

CommView is a software that accesses the wireless adapter to extract data from the access points about various information like MAC address, RSSI, Channel Traffic etc:

data_base =

6×9 table

	t3a80	t39a0	t3940	t2ea0	t35e0	t3920	t38e0	t3140	t3960
RP1	-80	-68	-77	-90	-55	-100	-100	-100	-100
RP2	-85	-80	-60	-70	-100	-100	-100	-100	-100
RP3	-88	-72	-85	-100	-52	-90	-84	-100	-100
RP4	-100	-78	-100	-100	-62	-85	-75	-82	-88
RP5	-100	-100	-100	-100	-85	-71	-65	-74	-85
RP6	-100	-100	-100	-100	-100	-83	-79	-60	-72

```
r =

    25    25    25    13    10     3


z =

     6
```

Figure 2.4

2.3 INPUT/OUTPUT BEHAVIOUR

The inputs given are the access point to which mobile user is connected and the RSSI of the connection. Output is obtained accordingly and displayed.

INPUTS: t3960, -73 dBm

CHAPTER 3

HEAT MAP SYSTEM

3.1 OFFLINE PHASE

For Heat Map the Offline phase is same as that of the Positioning System.

Hence, each Reference Point is represented by its fingerprint.

3.2 ONLINE PHASE

In the online (query) phase, a user (or target) samples or measures an RSSI vector at his/her position and reports it to the server. The server compares the received target vector with the stored fingerprints. The target position is estimated based on the most similar “neighbors”, the set of RPs whose fingerprints closely match the target’s RSSI.

RSSI Measurements by CommView:

Standard / MA...	Channel	Type	SSID	Standard	Encryption	Signal
802.11g						
Binato...	11	AP	Hemhome	802.11g	WPA-CCMP	-63/-57/-51
802.11n						
Netge...	7	AP	orion_ext	802.11n	WPA-CCMP,W...	-93/-93/-92
Netge...	6	AP	Sulochana	802.11n	WPA-CCMP	-67/-56/-44
O...		STA				-43/-41/-39
A...		STA				-68/-67/-67
A...		STA				-51/-50/-49
D-Link...	7	AP	orion	802.11n	WPA-CCMP	-82/-72/-68
D-Link...	11 (7-11@40)	AP	NETGEAR85	802.11n	WPA-CCMP,W...	-90/-85/-82
D-Link...	1	AP	D-Link_DIR-816	802.11n		-91/-89/-87

Figure 3.1

3.3 INPUT/OUTPUT BEHAVIOUR

Inputs given are the access point for which a Heat Map is required and the RSSI vector from the devices connected to the access point. Heat Map of the access point is the output

INPUTS: t3140, [-67 -55 -74 -81 -51 -63 -58 -83 -62 -60]

CHAPTER 4

TRACKING SYSTEM

4.1 OFFLINE PHASE:

In noisy environment, considering a whole sequence of data is more robust than a single peak value. **Walkie-Markie** considers a whole *signal sequence for location classification.* Walkie-Markie first records the Wi-Fi RSSI vectors as patterns in different corridors. As shown in Fig. 4.1, a walking user along the corridor can detect the increase and decrease of signal strength from a nearby AP. The sequence of RSSI data can form the pattern for a given corridor.

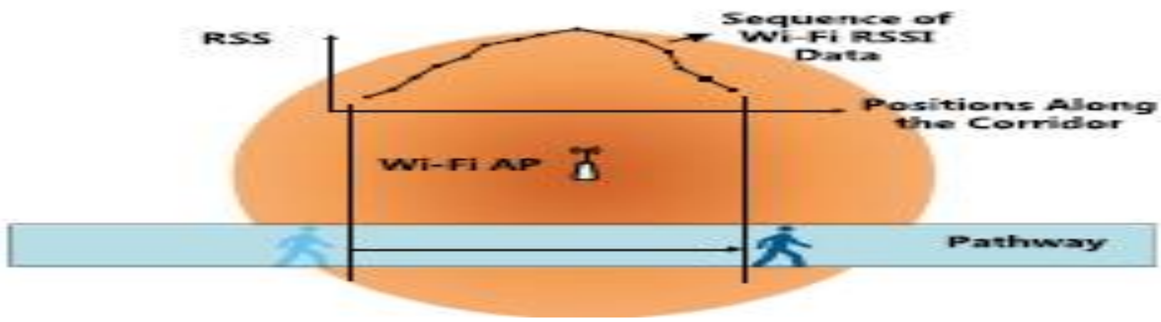


Figure 4.1

4.2 ONLINE PHASE

By matching the user's RSSI sequence during walking, Walkie-Markie knows the location and map information of the target. This matching is done by CommView.

4.3 INPUT/OUTPUT BEHAVIOUR

Input given is the sequence of RSSI data while the user is in motion.

INPUT: [-66 -61 -53 -47]

CHAPTER 5

CODING AND TESTING

5.1 MATLAB Code for Positioning:

```
rp1=table(-80,-68,-77,-90,-55,-100,-100,-100,-
100,'VariableNames',{'t3a80','t39a0','t3940','t2ea0','t35e0','t3920'
,'t38e0','t3140','t3960'},'RowNames',{'RP1'});
rp2=table(-85,-80,-60,-70,-100,-100,-100,-100,-
100,'VariableNames',{'t3a80','t39a0','t3940','t2ea0','t35e0','t3920'
,'t38e0','t3140','t3960'},'RowNames',{'RP2'});
rp3=table(-88,-72,-85,-100,-52,-90,-84,-100,-
100,'VariableNames',{'t3a80','t39a0','t3940','t2ea0','t35e0','t3920'
,'t38e0','t3140','t3960'},'RowNames',{'RP3'});
rp4=table(-100,-78,-100,-100,-62,-85,-75,-82,-
88,'VariableNames',{'t3a80','t39a0','t3940','t2ea0','t35e0','t3920',
't38e0','t3140','t3960'},'RowNames',{'RP4'});
rp5=table(-100,-100,-100,-100,-85,-71,-65,-74,-
85,'VariableNames',{'t3a80','t39a0','t3940','t2ea0','t35e0','t3920',
't38e0','t3140','t3960'},'RowNames',{'RP5'});
rp6=table(-100,-100,-100,-100,-100,-83,-79,-60,-
72,'VariableNames',{'t3a80','t39a0','t3940','t2ea0','t35e0','t3920',
't38e0','t3140','t3960'},'RowNames',{'RP6'});
data_base=vertcat(rp1,rp2,rp3,rp4,rp5,rp6) // Fingerprint Database
r=r';
r=r-rssi;
r=abs(r)
n=6;
m=min(r);
for i=1:n
if(r(i)==m)
        z=I                            // Reference Point output as Data
end
end
i=imread('floorplan.jpg');                     // Imaging the output
imshow(i);
if (z==1)
for k=290:320
for j=700:940
i(j,k,:)=[150 255 100];
end
end
for k=690:720
for j=700:970
i(j,k,:)=[150 255 100];
end
end
for k=290:690
for j=700:730
```

```
i(j,k,:)=[150 255 100];
end
end
for k=290:690
for j=940:970
i(j,k,:)=[150 255 100];
end
end
imshow(i);
elseif (z==2)
for k=290:320
for j=390:630
i(j,k,:)=[150 255 100];
end
end
for k=690:720
for j=390:660
i(j,k,:)=[150 255 100];
end
end
for k=290:690
for j=390:420
i(j,k,:)=[150 255 100];
end
end
for k=290:690
for j=630:660
i(j,k,:)=[150 255 100];
end
end
imshow(i);
elseif (z==3)
for k=970:1000
for j=674:1074
i(j,k,:)=[150 255 100];
end
end
for k=1370:1400
for j=674:1104
i(j,k,:)=[150 255 100];
end
end
for k=970:1370
for j=674:704
i(j,k,:)=[150 255 100];
end
end
for k=970:1370
for j=1074:1104
i(j,k,:)=[150 255 100];
end
end
imshow(i);
elseif (z==4)
for k=1430:1460
for j=674:1074
```

```
i(j,k,:)=[155 255 100];
end
end
for k=1830:1860
for j=674:1104
i(j,k,:)=[150 255 100];
end
end
for k=1430:1830
for j=674:704
i(j,k,:)=[150 255 100];
end
end
for k=1430:1830
for j=1074:1104
i(j,k,:)=[150 255 100];
end
end
imshow(i);
elseif (z==5)
for k=2510:2540
for j=700:970
i(j,k,:)=[150 255 100];
end
end
for k=2110:2140
for j=700:940
i(j,k,:)=[150 255 100];
end
end
for k=2110:2510
for j=940:970
i(j,k,:)=[150 255 100];
end
end
for k=2110:2510
for j=700:730
i(j,k,:)=[150 255 100];
end
end
imshow(i);
elseif (z==6)
for k=2110:2140
for j=390:630
i(j,k,:)=[150 255 100];
end
end
for k=2510:2540
for j=390:660
i(j,k,:)=[150 255 100];
end
end
for k=2110:2540
for j=390:420
i(j,k,:)=[150 255 100];
end
```

```
end
for k=2110:2540
for j=630:660
i(j,k,:)=[150 255 100];
end
end
imshow(i);
end
```

5.2 MATLAB Code for Heat Map:

```
h=h';count=0;
c1=0;
c2=0;
c3=0;
c4=0;
c5=0;
c6=0;
temp=h;
for k=1:d
    rssi=v(k);
    h=h-rssi;
    h=abs(h);
    n=6;
    m=min(h);
    for i=1:n
    if(h(i)==m)
        z=i;
    end
    end
    v(k)=z
    h=temp;
end
for j=1:d
    if(v(j)==1)
        c1=c1+1;
    end
end
for j=1:d
    if(v(j)==2)
        c2=c2+1;
    end
end
for j=1:d
    if(v(j)==3)
        c3=c3+1;
    end
end
for j=1:d
    if(v(j)==4)
        c4=c4+1;
    end
end
```

```
for j=1:d
    if(v(j)==5)
        c5=c5+1;
    end
end
for j=1:d
    if(v(j)==6)
        c6=c6+1;
    end
end
hm=[c1 c2 c3 c4 c5 c6];
kv=[390 390 1070 1530 2310 2310];
jv=[700 390 774 774 700 390];
photo=imread('floorplan.jpg');
for p=1:6
    if((hm(p)>0)&&(hm(p)<3))
        for k=kv(p):kv(p)+100
        for j=jv(p):jv(p)+300
        photo(j,k,:)=[0 200 200];
        end
        end
        for k=kv(p)+200:kv(p)+300
        for j=jv(p):jv(p)+200
        photo(j,k,:)=[0 200 200];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p):jv(p)+100
        photo(j,k,:)=[0 200 200];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p)+200:jv(p)+300
        photo(j,k,:)=[0 200 200];
        end
        end
    elseif((hm(p)>=3)&(hm(p)<5))
        for k=kv(p):kv(p)+100
        for j=jv(p):jv(p)+200
        photo(j,k,:)=[0 50 200];
        end
        end
        for k=kv(p)+200:kv(p)+300
        for j=jv(p):jv(p)+200
        photo(j,k,:)=[0 50 200];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p):jv(p)+100
        photo(j,k,:)=[0 50 200];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p)+200:jv(p)+300
        photo(j,k,:)=[0 50 200];
        end
```

```
        end
    elseif((hm(p)>=5)&(hm(p)<7))
        for k=kv(p):kv(p)+100
        for j=jv(p):jv(p)+200
        photo(j,k,:)=[230 100 0];
        end
        end
        for k=kv(p)+200:kv(p)+300
        for j=jv(p):jv(p)+200
        photo(j,k,:)=[230 100 0];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p):jv(p)+100
        photo(j,k,:)=[230 100 0];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p)+200:jv(p)+300
        photo(j,k,:)=[230 100 0];
        end
        end
    elseif(hm(p)>=7)
        for k=kv(p):kv(p)+100
        for j=jv(p):jv(p)+200
        photo(j,k,:)=[255 0 0];
        end
        end
        for k=kv(p)+200:kv(p)+300
        for j=jv(p):jv(p)+200
        photo(j,k,:)=[255 0 0];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p):jv(p)+100
        photo(j,k,:)=[255 0 0];
        end
        end
        for k=kv(p):kv(p)+300
        for j=jv(p)+200:jv(p)+300
        photo(j,k,:)=[255 0 0];
        end
        end
    end
end
imshow(photo);
```

5.2 MATLAB Code for Tracking:

```
i=imread('floorplan.jpg');
t1=[60 63 53 65];
t2=[53 76 78 62];
t3=[63 62 53 50];
```

```
t4=[55 63 66 71];
t5=[66 78 77 60];
t6=[63 60 53 50];
t7=[50 50 63 74];        // database for temporal sequences
p=abs(p);
p1=p-t1;
p1=abs(p1);
p2=p-t2;
p2=abs(p2);
p3=p-t3;
p3=abs(p3);
p4=p-t4;
p4=abs(p4);
p5=p-t5;
p5=abs(p5);
p6=p-t6;
p6=abs(p6);
p7=p-t7;
p7=abs(p7);
p1=sum(p1);
p2=sum(p2);
p3=sum(p3);
p4=sum(p4);
p5=sum(p5);
p6=sum(p6);
p7=sum(p7);
track=[p1 p2 p3 p4 p5 p6 p7]
m=min(track);
for n=1:7
if(track(n)==m)
        t=n
end
end

if(t==1)
    for k=2250:2280
    for j=340:1085
    i(j,k,:)=[255 100 0];
    end
    end

elseif(t==2)
    for k=1930:2180
    for j=500:580
    i(j,k,:)=[255 100 0];
    end
    end
    for k=1930:1960
    for j=500:800
    i(j,k,:)=[255 100 0];
    end
    end

elseif(t==3)
    for k=1390:1900
    for j=870:900
```

```
    i(j,k,:)=[255 100 0];
    end
    end

elseif(t==4)
    for k=530:560
    for j=340:1085
    i(j,k,:)=[255 100 0];
    end
    end

elseif(t==5)
    for k=600:850
    for j=500:530
    i(j,k,:)=[255 100 0];
    end
    end
    for k=850:880
    for j=500:800
    i(j,k,:)=[255 100 0];
    end
    end

elseif(t==6)
    for k=620:1300
    for j=870:900
    i(j,k,:)=[255 100 0];
    end
    end
elseif(t==7)
    for k=1345:1375
    for j=260:810
    i(j,k,:)=[255 100 0];
    end
    end
end
imshow(i);
```

CHAPTER 6

CONCLUSION

Using Wi-Fi fingerprint based Indoor Positioning System we can therefore locate a mobile user's position in an indoor environment along with a Heat map of Access points, and tracking of the user's walking trajectories.