Using Artificial Neural Networks in Indoor Positioning System (IPS) In non-Empty spaces

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Bil 684 Project

Using Artificial Neural Networks in Indoor Positioning System (IPS) In non-Empty spaces

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I. INTRODUCTION

IPS systems are often used in real-time location systems that come up with the problems like multipath phenomenon and layout changing [1]. These make locating difficult because most of the location systems are based on fixed mathematical calculation that cannot take these situations into account. Using artificial neural network, our location scheme can learn the geography features to adapt to the real world. It could avoid multipath phenomenon effect and be flexibly applied to any environment [1].

II. THE SOLUTİON PROPOSED

The solution proposed is to use the ANN to help us to improve the quality of the measurement of the X and Y (Position) of a Bluetooth tag within the plan, by firstly collect some data from the plan (Here Plan is a room) and train the neural network with this data to get better prediction of the position of the Bluetooth tag.

(HARDWARE AND İMPLEMENTATİON)

In this project we used :

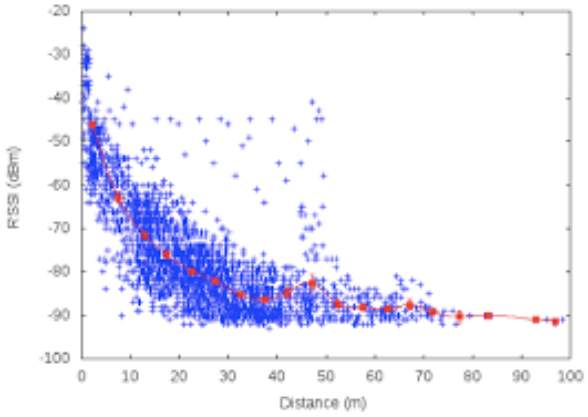
- 3* Raspberry PI 3,
- 1 * Nut BLE(Bluetooth low Energy) tag
- 1 * Wi-Fi router to create a network between the PIs.

Nut 3

Raspberry PI 3

HOW THİS SYSTEM WORK ?

BLE tag continuously sends signals in known period of time . Then the raspberry pi devices receive this signals and measure its strength (RSSI - Received signal strength indication) by using built-in Bluetooth module.
The following figure show the relation between distance and RSSI signals.



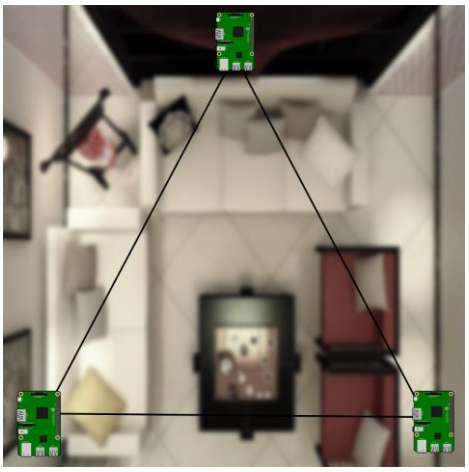
One of the raspberris will be the (server) that collect the RSSI signals from the rest of Raspberries(Clients) and also as a client.

THE WORKSPACE?

To collect the data I choose my sitting room (6*6 meters) as a plane , it contain a lot of furniture that any office or any indoor room might contain (obstacles) .

Panorama Photo (360 degree) of the Room

The 3 raspberries are located in the room as following:



III. EXPERİMENT 1(11 POİNTS)

In this experiment data are collected from 11 Points (Figure 1),

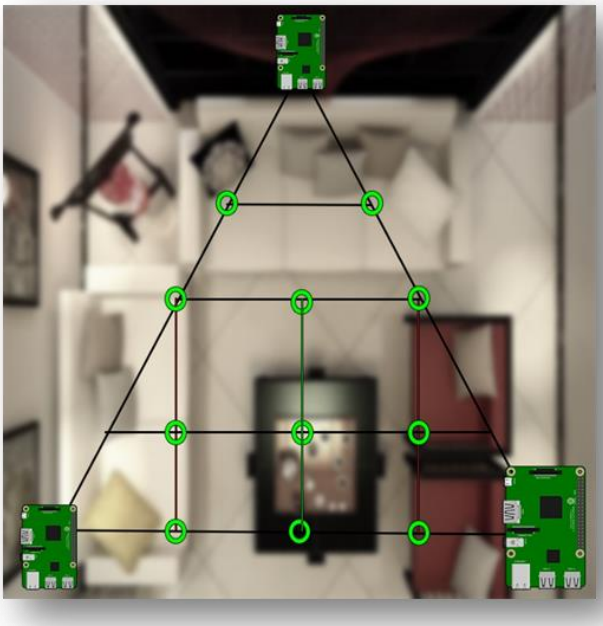
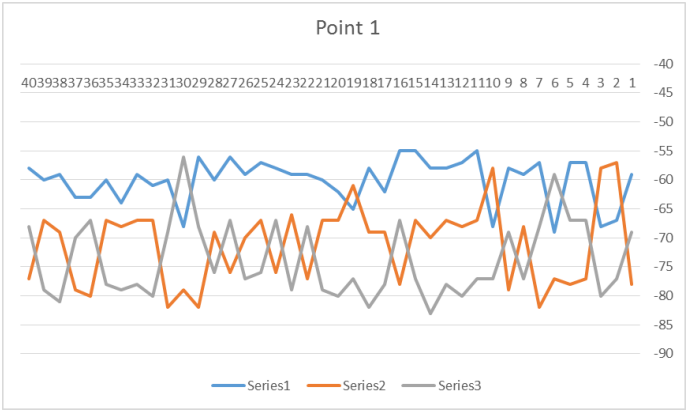


Figure 1

From each point we collect 40 sample, each sample consist of the three RSSI signals received by each Raspberry Pi. The samples collected for the (POINT 1) are shown in the following table:

RSSI 1	RSSI 2	RSSI 3
-59	-78	-69
-67	-57	-77
-68	-58	-80
-57	-77	-67
-57	-78	-67
-69	-77	-59
-57	-82	-68
-59	-68	-77
-58	-79	-69
-68	-58	-77
-55	-67	-77
-57	-68	-80
-58	-67	-78
-58	-70	-83
-55	-67	-77
-55	-78	-67
-62	-69	-78
-58	-69	-82
-65	-61	-77
-62	-67	-80
-60	-67	-79
-59	-77	-68
-59	-66	-79
-58	-76	-67
-57	-67	-76
-59	-70	-77
-56	-76	-67
-60	-69	-76
-56	-82	-68
-68	-79	-56
-60	-82	-69
-61	-67	-80
-59	-67	-78
-64	-68	-79
-60	-67	-78
-63	-80	-67
-63	-79	-70
-59	-69	-81
-60	-67	-79
-58	-77	-68



Unfortunately, as we see, the data collected is not helpful because it contain a lot of noise and the signals are not stable and have a lot of outliers. And the signal is not stable and doesn't give us a useful information that we can analyse this data using ANNs.

Solve the problem:

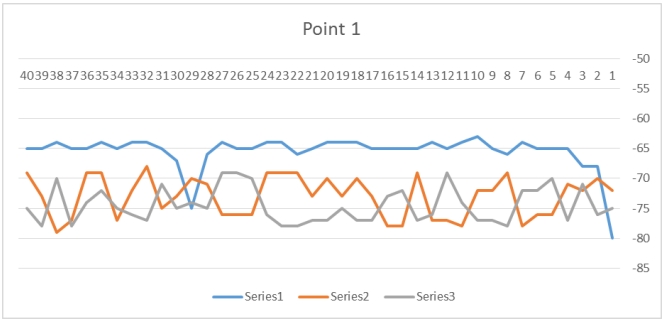
To solve this problem we used "**Kalman filter**" which also known as linear quadratic estimation (LQE), is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more accurate than those based on a single measurement alone . Kalman filter have been used in GPS tracking systems [2, 3].

We also tried to use external Bluetooth module for Raspberry PI, because the RSSI signals may be affected by the electromagnetic field produced by the board.

After using kalman filter we got the best RSSI signals stability, the RSSI Signals received are shown in the following table:

RSSI 1	RSSI 2	RSSI 3
-80	-72	-75
-68	-70	-76
-68	-72	-71
-65	-71	-77

-65	-76	-70
-65	-76	-72
-64	-78	-72
-66	-69	-78
-65	-72	-77
-63	-72	-77
-64	-78	-74
-65	-77	-69
-64	-77	-76
-65	-69	-77
-65	-78	-72
-65	-78	-73
-65	-73	-77
-64	-70	-77
-64	-73	-75
-64	-70	-77
-65	-73	-77
-66	-69	-78
-64	-69	-78
-64	-69	-76
-65	-76	-70
-65	-76	-69
-64	-76	-69
-66	-71	-75
-75	-70	-74
-67	-73	-75
-65	-75	-71
-64	-68	-77
-64	-72	-76
-65	-77	-75
-64	-69	-72
-65	-69	-74
-65	-77	-78
-64	-79	-70
-65	-73	-78
-65	-69	-75



III. EXPERİMENT 2 (6 POİNTS)

In this experiment we collect data from 6 Points (Figure 2),

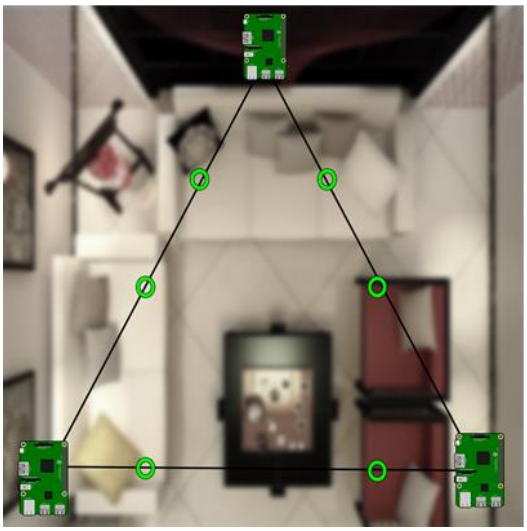


Figure 2

From each point we collected 1 sample, but this time we tried to train the network with input that is mathematically right. I suggest an RSSI signals that is Proportional to the Distances between the point and the three anchors (Raspberry PIs).

RSSI 1	RSSI 2	RSSI 3	X	Y
-55	-67	-77	3.75	4.5
-55	-77	-67	2.25	4.5
-72	-71	-80	4.5	3
-72	-80	-71	1.5	3
-89	-55	-76	4.5	0
-89	-76	-55	1.5	0

The Neural Network used:

We chose a 1 hidden layer ANN architecture, which have the following parameters:

# of neurons in input layer	# of neurons in hidden layer	# of neurons in output layer	# of epochs	Learning rate
3	3	2	20,000	0.1

For implementing this network we used **Synaptic** implementation for ANN which are written in *JavaScript* (Node.JS).

After training the network with the previous samples we got the following results:

Actual X	Actual Y	Observed X	Observed Y
3.75	4.5	3.37	5.2
2.25	4.5	2.7	4.5
4.5	3	3.2	2.5
1.5	3	2.7	2.1
4.5	0	3.6	0.3
1.5	0	2.1	0.2

III. EXPERİMENT 3 (3 POİNTS)

In this experiment we collected the data from 3 Points (Figure 3),

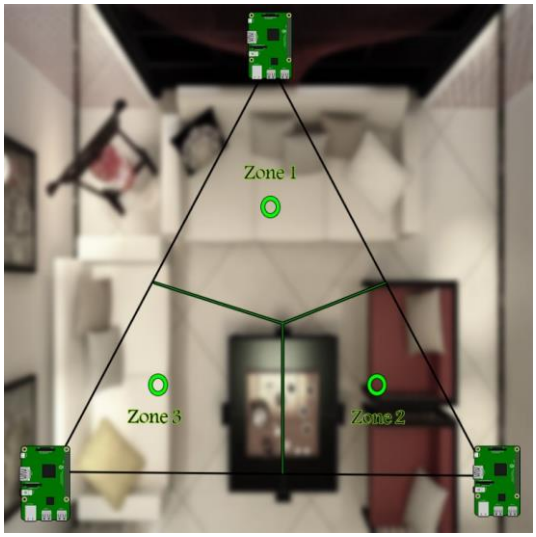


Figure 3

In this experiment plan is separated into 3 areas, and we collected the data from the centres of these areas.
From each point we collect 40 sample, each sample consist of the three RSSI signals received by each Raspberry Pi. And after training the Network I test it and we got the following results:

Actual Zone	Detected Zone
1	1
1	2
2	2
2	2
3	3
3	3

Actual X	Actual Y	Detected X	Detected Y
3	4.5	2.6	3.9
3	4.5	2.8	2.5
4.5	1.5	3.1	1.5
4.5	1.5	3.3	1.9
1.5	1.5	2.1	2.6
1.5	1.5	1.9	2.7

CONCLUSİON

In this project we tried to improve the position prediction used in IPS systems by using ANN networks. We did 3 experiments to collect the data and train the network, after the training the network I got a good improvement in the quality of the results.
Next time we will try to increase the number of Raspberries and make the plan bigger.

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