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Indoor Positioning System

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Abstract:

The advances in smartphone innovation lately is prompting the take-up of another class of Indoor Navigation system (INS), which may before long reduce the need for Satellite-based advancements in closed urban situations. Indoor Navigation system depend on geolocation databases that store indoor models including floor-maps and points of-interest alongside with wireless, light and attractive signs used to localize the clients. Location based services and individual navigation require the area assurance of a client in open environment situations as well as indoor. For indoor area officially established wireless framework, for example, WLAN (Wireless Local Area Networks) can be utilized. This methodology has the preferred standpoint that no exorbitant equipment establishments are fundamental inside a structure if WLAN is as of now accessible.

Keywords: Indoor navigation system, location-based services, WLAN, WI-FI, RSSi.

I. INTRODUCTION

The present innovative market and gadget culture takes into consideration the acknowledgment of indoor services with the omni-nearness of sensor-rich cell phones in indoor situations. Portable gadgets can gauge an assortment of signs, for example, wireless, magnetic, sound and light, all in respect to known areas in space (e.g., cell-towers, Wi-Fi Access Points (APs) [1] or BLE Beacons[2]). Sorting out these signs in enormous information geolocation databases, by potentially combining the signs, permits to offer room level (1-5 meters) or even sub-meter area exactness [3].

The easy access and accessibility of wireless advances and mobile computing and internet have to lead to new open doors in creating portable applications which reason for existing are to make individuals life progressively simpler. These days, an individual can have more than one cell phone means for various use, for example, correspondence, stimulation, office works. Amid the most recent decade, scientists have been dealing with different potential outcomes on the best way to make your mobile phone a specialized communication tool as well as a navigation device. Navigation framework is winding up increasingly more essential in our regular day to day existence as they make life simpler and progressively agreeable.

Global Positioning System (GPS) is the most conspicuous commitment in deciding position of client and in directing him to his goal. This framework utilizes satellites to triangulate the area of the GPS gadget. Despite the fact that this framework has established a decent connection as far as exactness and is the liked location-based framework for open situating, with regards to indoor condition, GPS has turned out to be inefficient. The explanation behind its inefficiency is that with the end goal for GPS to play out a triangulation, the gadget should be in the observable pathway from the satellites. In addition, GPS framework has a low accuracy which makes it not appropriate for indoor zones. Therefore, with regards to indoor navigating framework, different options, for example, Bluetooth, WIFI, RFID, and Ultra-Wide Bands are more preferable.

When we take into account localization systems for turn-by-turn navigation in real world, the necessities are quite challenging. We identify four key challenges, that are often overlooked in the research literature.

Accurate and Continuous Localization. It is vital to attain both accuracy and continuous localization when giving turn-by-turn instructions. whereas probabilistic localization algorithms are designed to deal with a particular level of noise, many approaches may fail catastrophically when the fidelity of the present state estimate degrades. Remedies to such failures (e.g., modifications to the state sampling process) have been proposed, however, such approaches can cause the location estimates to jump around discontinuously. There is no tolerance for such instability once guiding folks with visual impairments.

Scaling to Multi-Story Buildings. GPS works based on 2 Dimension model. However, most buildings in metropolitan square measures are multi-story buildings. In particular, in public facilities such as shopping malls or subway stations, people perpetually transition from floor to floor and from one building to other. It is therefore critical to develop an application which works in 3D environment[19].

Signal Bias Adaptation [19] at Scale. Different mobile devices observe different RSSi values from the same signal transmitter at the same location due to differences in reception sensitivity of the underlying radio hardware.. In real world applications, the number and strength of noticeable

transmitters, e.g., beacons, changes dynamically over time. There is limited prior work addressing this challenge, i.e., varying RSS values over multiple devices in dynamic situations.

Scaling to Large Numbers of Measurements. As the size of deployment grows to building-scale so does the database and work related to indoor positioning. Large database leads to large space usage and in turn larger time for algorithm to work

on. Thus optimal solution needs to be found to maintain a relative small database or increase the speed of algorithms.

II. RELATED WORK

Prior to beginning our work, we have learned about the different technologies utilized for creating of Indoor Navigation System and some of them are WIFI, RFID, Bluetooth all these technologies vary regarding precision, cost, and endeavors, by all accounts improving these days.

RFID has exhibited its ability in the location-based framework. One of the acclaimed locations detecting framework utilizing RFID innovation is known as mTag . The mTag engineering utilizes fixed RFID reader situated inside the earth and a latent RFID label appended to a cell phone or PDA. The hindrance of utilizing RFID is that the expense of sending and executing this sort of framework can be high.

Wifi : The inescapable appropriation of WIFI in indoor situations has given a chance to create indoor navigating frameworks that won't requires putting additional resources into particular equipment. A portion of the outstanding frameworks utilizing WIFI are Any place, RADAR, Place Lab. Anyplace [7] is one of the principal indoor navigating frameworks, is a foundation for free Indoor navigation services that use shared detecting and the accessibility of rich location dependent information on cell phones to decide client area through local processing .This stage comprises of five primary parts, including the Server, the Architect, the Viewer, a datastore, and a customer application running on Android cell phones going about as a Logger and a Navigator.

Advantages:

- Longer range and speed compared to other technologies like BLE Beacons.
- Cost Effective has most buildings have wifi systems installed within them.

Disadvantages:

- Not every device allows access to wifi information. For example all IOS device denies the request to access information regarding wifi, like RSSI value.
- Despite having greater speed as compared to others Wifi band is busy and shared among many other devices and used for other uses such as LAN and internet.

BLE Beacons is another technology in this field that has tremendous scope. In Bluetooth Low Energy (BLE) signals from battery driven Beacons are at the center of the indoor location technology. It's one of the most recent advancements that has risen and turned into an industry standard accessible on most gadgets today. It utilizes purported BLE beacon (or iBeacons) that are cheap, little, have a long battery life and don't require an outer vitality source. The gadget recognizes the signal from the reference points and can calculate the separation to the beacon and henceforth gauge the location. Like other technologies BLE Beacons have their both advantage and disadvantages:

Advantages:

- Unlike Wifi the bluetooth band is free of other data traffic leaving it for sole purpose of indoor positioning.
- Information is accessible on both android and IOS devices,thus leading to development of a common application for both the devices.

Disadvantages:

- Lower bandwidth speed and shorter range as compared to Wifi.
- BLE beacons need to be purchased and installed separately which leads to extra cost.

The above memton were the technologies which can be used for Indoor Positioning the other important factor is localization technique. It is the combination of these two which completes the system. There many localization technique but the important two which are most widely research and used are RSSI Lateration and Fingerprinting.

RSSI Lateration is based on measuring signal strength from a client device to several different access points, and then combining this information with a propagation model to determine the distance between the client device and the access points. Trilateration (sometimes known as multilateration) techniques may be used to calculate the estimated the client's device position relative to the notable position of access points.

This is one of the cheapest and easiest methods to implement, its disadvantage is that it does not provide very good accuracy (median of 2-4m), because the RSSI measurements can change depending on the changes in the environment or multipath fading.

Traditional fingerprinting is also RSSI-based; however, it merely depends on the recording of the signal strength from many access points in range and storing this information in the database along with the known coordinates of the client device in the offline phase. This information can be deterministic or probabilistic During the online tracking phase, the present RSSI vector at an unknown location is compared to those stored within the fingerprint and therefore the closest match is returned as the estimated user location.

Its main disadvantage is that any modifications of the surroundings like adding or removing furniture or buildings could change the "fingerprint" that corresponds to every location, requiring an update to the fingerprint database.

Indoor Navigation System is a new field which has seen tremendous research and technological development in recent years and , by all accounts, to be balanced for fast development, and we are seeing expanded enthusiasm by industry members. Many big companies are expanding effort in this area for instance, Google Maps is soliciting indoor floor plans , The formation of the In-Location Alliance additionally exhibits mounting action.

Yet at the same time the development is yet to reach a stage where it can be deployed on a large scale like GPS as it has not reached the level of simplicity, accuracy and localization where it can be used on daily basis and also there are reasons to be

cautious, as there is still considerable uncertainty around user acceptance and location privacy issues.

III. THE PROPOSED SYSTEM

The proposed project on which we are working will be developed based on Wifi fingerprinting. The work will be divided into two stages; offline stage and online stage. The work will be carried out in UG-2 Phase 1 Building of NIIT University.

The bluetooth based fingerprinting is ignored as it is not feasible to carry out in such a large complex for small scale study as it will lead to huge cost.

The **offline stage** includes making a radio map. The radio map, will stores disseminations of RSSi values from all recognized APs at explicit focuses which are known as marking positions. The marking positions together with the MAC address of each distinguished APs and their comparing RSSi values will be put away in the database to make the radio map.

Pic-1(Android App used to collect data.)

In the **online stage**, when the client will instate the mobile application, the sniffer segment will gather the sample of RSSi values from all recognized APs. To estimate the situation of the client, the information gathered will be compared with the information in the database (radio map).

IV. IMPLEMENTATION

For implementation and testing we have used the following tools and technologies:

1) Android Studio
2) Python
3) Microsoft Excel
4) ESP-32 Modules
5) Standard Wifi routers operating on both 2.4 Ghz and 5Ghz frequency.
6) Mobile Devices (Redmi 3, Redmi Note 4)

1) Offline Stage

For offline stage we developed an android application for the collection of data as shown in Pic 1. For collection of data we used **redmi 3s** mobile working on 2.4GHz frequency.

We created a database (radio map) which comprises of a lot of samples taken at specific location (reference point) on the map called fingerprints. Every unique reference point will comprises of the BSSID, RSSi Value, and Spatial Coordinates.

The location vector for a specific point is represented as;

a = {BSSID, RSSi, x, y, z}

Where 'a' is the reference point, BSSID is MAC address of the router to which the device is connected, RSSi value is the signal strength in dbm, 'x', 'y' are two dimensional coordinates for particular floor and 'z' is the 3 Dimensional coordinate which indicates the floor number of the complex.

For example, if a location is to be taken at the accompanying point on this floor plan. For each sample, the estimation will be taken at four unique directions (north, east, south, and west). This will diminish the error cause by signal attenuation because of human body, obstruction and furniture. In this way, at every particular area, estimation will be taken at four diverse bearing and the mean values of the information get at these directions will be utilized as the final estimation for the location.

bssid	dbm	x	y	z
d4:68:4d:ff:0f:a8	-47	1	1	1
d4:68:4d:ff:0f:a8	-61	4	1	1
d4:68:4d:ff:0f:a8	-52	7	1	1
54:3d:37:d5:07:78	-63	10	1	1
54:3d:37:d5:07:78	-32	13	1	1
54:3d:37:d5:07:78	-30	16	1	1
54:3d:37:d5:07:78	-37	19	1	1
54:3d:37:d5:07:78	-39	22	1	1
54:3d:37:d5:07:78	-44	25	1	1
54:3d:37:d5:07:78	-50	28	1	1
54:3d:37:d5:07:78	-55	31	1	1
54:3d:37:d5:07:78	-54	35	1	1
54:3d:37:d5:07:78	-50	37	1	1
54:3d:37:d5:07:78	-57	37	3	1
54:3d:37:d5:07:78	-67	37	6	1
d4:68:4d:ff:13:dc	-70	37	9	1
54:3d:37:d5:07:78	-41	37	12	1
54:3d:37:d5:07:78	-39	37	15	1
54:3d:37:d5:07:78	-34	37	18	1
54:3d:37:d5:07:78	-57	37	21	1
54:3d:37:d5:07:78	-59	37	24	1
54:3d:37:d5:07:78	-63	37	27	1

Pic-2(Data Base.)

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In some cases RSSi value does not changes from one point to another or is very close to the previous value in such cases interpolation model [11] is used to predict the value between the two reference points. Though such cases are very rare and may not give expected result during online stage.

An interpolation model [11] will also lessen the time spent on preparing the system. To calculate information for un-calibrated grid points, they utilized both of the accompanying formulas dependent on the circumstance. For example, point A and B was adjusted and we have to compute for point C which is in between, if just point A is utilized to deduce the location of point C, the main condition is utilized andon the off chance that he two are utilized to induce the area of point C, at that point the second condition is utilized. After the grid points have been determined, Segment process is utilized to isolate the information of each point into m parts.

$$S_{Ci} = \frac{\log d_0}{\log (d_0 + d_1)} \times S_{Ai}$$

$$S_{Ci} = \frac{\log d_2}{\log (d_1 + d_2)} \times S_{Ai} + \frac{\log d_1}{\log (d_1 + d_2)} \times S_{Bi}$$

PIC-3 (Map of the building where Reference Points were taken.)

Interpolation model

Euclidean Distance [12] will be utilized to look at the present fingerprint obtained at the mobile application and the current unique fingerprint put away in the database of the server. The Euclidean distance will figure the insignificant separation between two arrangement of unique fingerprint. For example, accept that the present unique fingerprint is

s = {s_1, s_2 ... s_N}

and a spared unique finger impression is

S = {S_1, S_2... S_N},

at that point the squared Euclidean distance between the vectors s and S is:

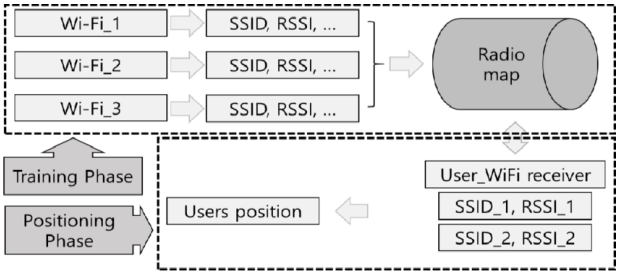
L (s, S) = (s_1 – S_1) ^2 +.... + (s_N – S_N) ^2

This can be represented as:

$$L = \sqrt{\sum_{i=1}^{n} |s_i - S_i|^2}$$

Euclidean Distance Algorithm

2) Online Stage



After completion of offline stage comes the online stage.

In this stage a mobile unit (mobile phone in this case) collects the live data and compares it with the data stored in the database. The value which MU compares in the database are BSSID and RSSi reading. For a particular BSSID, MU compares the RSSi reading with those stored in database and selects the one which is nearest to the live RSSi value and selects the spatial coordinates corresponding to that particular value.

V. RESULTS

When the final testing was carried out the results were as following:

1) Mobile Unit was be

VI. FUTURE WORK

Our future work will focus on improving the overall accuracy of the system. For this we will be working towards the integration of bluetooth and wifi system. Bluetooth can help us narrow down the range of estimation of users location with regard to a particular room. For this we will require installation of bluetooth beacons throughout the building and will need to create a seperate database for bluetooth RSSi value and integrate them with the Wifi Database.

Another addition to the system will be the navigation route. It will allow the user to navigate from one particular room to another one by showing a highlighted path just like in google maps.

VII. CONCLUSION

These days, Positioning System is useful in indoor environment just as it is used in outdoor environment. Indoor environment is expanding in size and is winding up progressively in size and becoming more complex.Therefore, building up an indoor positioning system is fundamental as it will maintain a strategic distance from pressure and decrease time for individuals to search for a particular area in an indoor domains such as airports, hospitals, shopping malls, railway stations, corporate offices.

Additionally, since we are moving to ubiquitous computing and that technologies are expanding, what specialists are visioning is to make the cell phone a specialized device for communication as well as a device for navigation .Another improvement will be to utilize other signal sources, for example, Bluetooth and GSM wireless technologies. By having progressively signal sources, the exactness of the system will increment and the system will most likely be utilized on a greater scale. And by using the various types of sensors such as accelerometer, barometer etc. the exactness can be enhanced.

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