CONSTRUCTION OF INDOOR POSITONING SYSTEM USING TRILATERATION AND RFFI FINGERPRINTS

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ABSTRACT

In our day to day life, we use GPS to locate a person or unknown place. But this technology is limited for outdoors. Indoor postioning system[IPS] is a system to locate objects or people inside a building using lights, radio waves, Bluetooth, Wi-Fi, Li-fi, magnetic field, heat signature , or other sensory information collected by mobile devices. This technology is mainly useful in huge buildings such as airports, hospitals, offices, universities, museums, and so on. By using many higher technologies such as RF fingerprints, magnetic field RSSI, the result is more accurate.

Keywords*: GPS, Indoor Positioning System(IPS), Bluetooth low energy (BLE),Trilaterion, Raffi finger prints***I. INTRODUCTION**

1.1GPS

The Global Positioning System (GPS) is a space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS. The GPS project was launched by the U.S. Department of Defense in 1973 for use by the United States military and became fully operational in 1995. [1]

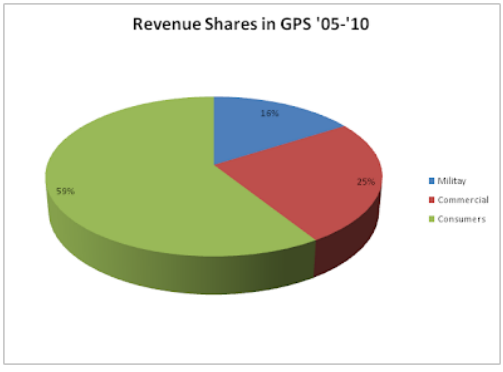

Fig.1Statistcs of application of GPS

Fig.2 GPS global positioning system satellite phone vector image

1.2 Drawbacks of GPS

Sometimes the GPS may fail due to certain reasons and in that case you need to carry a backup map and directions. If GPS using on a battery-operated device, there may be a battery failure and you may need an external power supply which is not always possible.Sometimes the GPS signals are not accurate due to some obstacles to the signals such as buildings, trees and sometimes by extreme atmospheric conditions such as geomagn etic storms.GPS only work for outdoor navigation.[2]

II.INDOOR POSITIONING SYSTEM (IPS)

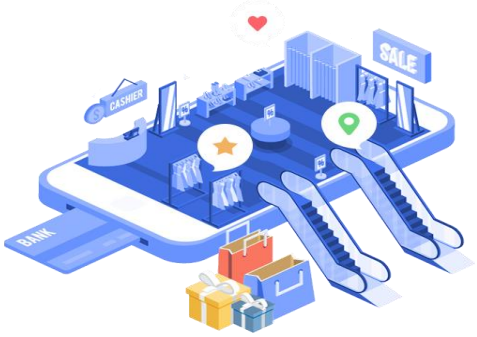

Fig.3 Indoor positioning system(IPS)

Figure 3 shows IPS, IPS can be used to locate people or objects inside buildings, typically via a mobile device such as a smart phone or tablet. Although the technology is newer than GPS, services that leverage IPS are quickly gaining traction in places like shopping malls, hospitals, airports and other indoor venues where navigation and other location based services (LBS) can prove to be indispensable.

2.1 Working of IPS

IPS technology, leverage the internal sensors in smart phones to calculate the device's indoor position using mathematical algorithms. By combining the incoming data from these sensors in a clever way, a very accurate position can be calculated.

IPS typically relies on three distinct elements: the underlying dynamic positioning system platform, the beacons that broadcast signals that are picked up by the smart phone and then fed to the positioning system, and the apps built on top of the positioning system that add value and make the systems indispensable to users.

Indoor positioning technologies fit into the four main following categories: proximity, trilateration, fingerprinting and motion. Some of those technologies can be used alone but can also be combined to provide better accuracy.

Proximity positioning is either based on direct contact or on proximity between a receiver and a device. It is, most of the time, used on the client-side except for Wi-Fi that has server-side detection capabilities. Here are some possible technologies:

QR Codes / NFC tags that can be read by smartphone cameras or NFC readers. QR Code / NFC stickers are then linked to a precise position in the building.

Bluetooth Low Energy (BLE) devices a.k.a. beacons. A beacon sends a signal that can be read when the smartphone is located in the emission area. The more deployed beacons, the more accurate the position. User position is then associated to the location of the BLE device with the strongest signal.

Visible Light Communication (VLC) devices a.k.a. Li-Fi. A led lamp sends an invisible signal that can be read either by smartphone cameras or by dedicated receivers. Since each lamp has a unique ID that can be read only right under the lamp, this makes it easy to provide an accurate position.

Fig. 4 IPS using VLC

Wi-Fi Access Points can be used to locate a smartphone or any kind of Wi-Fi aware device. The user position is determined the same way it would be it for BLE devices.Ultrasound devices are usually deployed on top of existing audio systems inside stores or shopping malls. Again, proximity location works the same way as BLE and Wi-Fi proximity positioning.

Trilateration positioning uses computed distances between several emitters and a receiver to compute position of the latter. Distances are determined either by RSSI or by ToF algorithms. RSSI stands for Relative received Signal Strength Indication. It allows distance calculation based on radio wave attenuation which follows the Inverse-Square Physical Law. Here, computing distances doesn't involve complex calculus but the accuracy is poor due to the sensitivity to obstacles such as walls, doors or even people! Time of Flight a.k.a. ToF is a method that measures the distance between an emitter and a device and is based on the time difference between the emission of a signal and its return to the sender. Unlike RSSI, ToF involves roundtrip communication and complex signal processing that require dedicated chipsets. This comes with both a better accuracy and a higher cost. Here are technologies using trilateration.

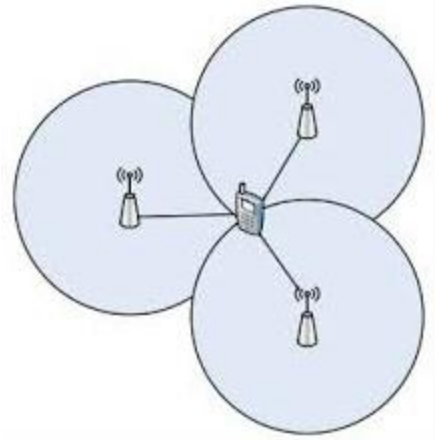

Fig. 5 IPS using Trilateration

Bluetooth Low Energy (BLE) and Ultrasounds, albeit they are proximity technologies, they can still be used to provide trilateration-based positioning. Distances are computed on the client-side using RSSI.

Wi-Fi can use trilateration either on the client-side (Android only) or on the server-side. The latter is far more accurate, but such location services are available only on premium Wi-Fi equipment (e.g. Cisco CMX, Cisco Meraki). Distances are usually computed using RSSI but an extension of the 802.11 standard will provide a ToF support in a near future.

Ultra-Wide Band is another emerging technology which provides very accurate positions thanks to the use of ToF to compute distances between receiver and emitters. Nevertheless, this technology has several drawbacks: lack of standardization that results in no smartphone available and high cost.

Fingerprinting positioning technologies use signal measurements across buildings to compute one's position. It is based on the assumption that for every position there is an almost unique signal that can be recorded. Then, it becomes possible to compare received signals with existing records to figure out current position. However, fingerprinting does have a flip side. First, it only works when in motion, and second, it requires stable signals over time. This technique can either be used alone or to improve the accuracy of other positioning technologies (usually those based on trilateration). Moreover, it is possible to simultaneously combine fingerprinting from multiple sources to increase accuracy. Here's a list of technologies that can take advantage of fingerprinting:

Bluetooth Low Energy (BLE) fingerprinting works very well because it can be performed on the client-side and because BLE signals prove to be stable over time.

Wi-Fi fingerprinting works as well as BLE except it can't be used on iOS devices due to Apple's limitations. Which is why it is only used for Android smartphones and specific tracking devices used by intelligence and law enforcement agencies to bypass GPS jammers.

Magnetic field fingerprinting uses unique variations of the earth magnetic field caused by steel parts inside building structures. It appears to work quite well but it proves unstable over time due to multiple factors (earth field variations, equipment moving, etc.).

Photo fingerprinting is based on the image analysis of the building interior. It works well when there are significant differences between floors including furniture. It does not prove stable over time except when fingerprinting comes from high resolution permanent cameras able to frequently refresh records.

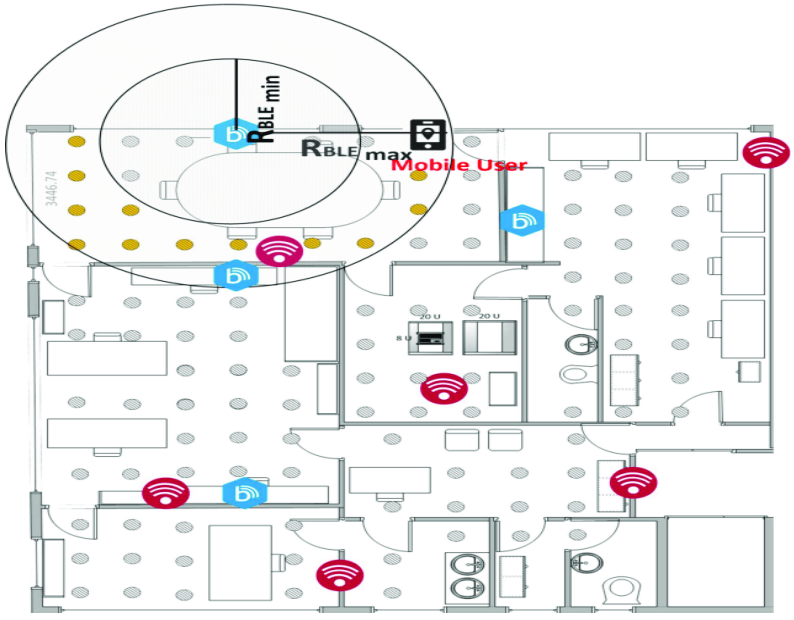

Fig.6 Combined BLE and Wi-Fi Fingerprints based IPS

Motion positioning inside and outside buildings works on the same principles but with different technologies. Since it is not possible to use traditional IMUs, smartphone sensors are used to detect and quantify movements. Here is a list of sensors you can find in most smartphones: compass, accelerometers, barometers, pedometers. Algorithms such as Kalman filters process data that come from those sensors to compute relative movement. The issue with those techniques is poor accuracy resulting from small size sensors and cumulative errors. It goes without saying that the level of accuracy is far lower this way than it would be with IMUs. As for fingerprinting, motion positioning is best used to increase trilateration positioning rather than as a stand-alone technology.

Fig. 7 Cognitive sensors and IoT.

Indoor positioning is a very complex matter that can't be solved with a unique technology the way GPS does outdoors. The best providers rely on an approach called **Sensor Fusion** that is based on the use of a combination of technologies to provide the best possible accuracy. Most of the time they use Trilateration to obtain an absolute position, sometimes coupled with Fingerprinting to increase accuracy. Then, they use Motion positioning to move the blue dot until they have enough radio signal variation to compute another absolute position. This way, they can spare smartphone batteries since aggressively scanning radio signals (whether BLE or Wi-Fi) comes with a high energy cost. Proximity positioning is both a low-cost and a low-tech way of getting a position.

Finally, the current trend in indoor positioning is to reuse existing infrastructures instead of deploying new ones which limits overall costs. For instance, Wi-Fi access points can be used both to provide Internet Access and Indoor Positioning especially since most of them now have BLE chipsets within. It goes the same with Li-Fi lamps that can embed BLE chipsets and various sensors alike [3].

Severalworks has shown that RF Fingerprinting provide more accurate results than trilateration algorithm especially in indoor environments, and that infrastructures with a combination of WLAN and Bluetooth technologies result in lower average error if compared to infrastructures that adopt only WLAN. [4]

Figure 8 shows Cross sectional image of a building floor with IPS installed, easily can install and monitor the system.first want fix the position of skeleton and define the floor with different level.

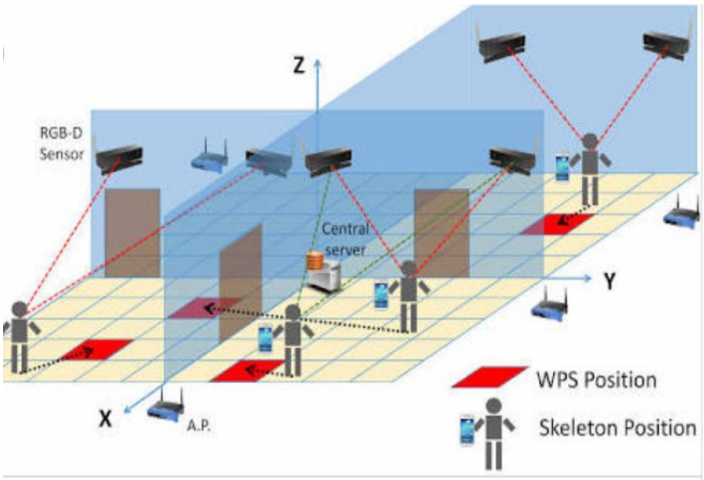

Fig.8 Cross sectional image of a building floor with IPS installed

III.CHALLENGES FACED DURING INSTALLATION OF IPS

1. Access to Wi-Fi.
2. Everyone might not possess a smartphone.
3. Involves complex mathematical algorithms.
4. Security threat.
5. Incorporation of the system is expensive.

IV. RF BASED INDOOR POSITONING USING RSSI FINGERPRINTS

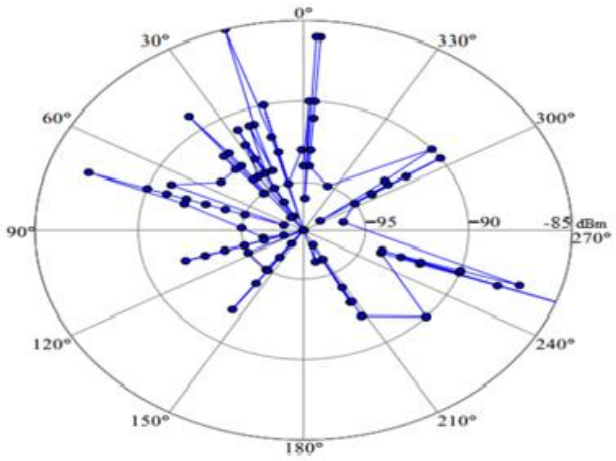

Fig.9 RSSI-based Indoor Localization Using RSSI-with-Angle-based Localization Estimation Algorithm

Figure 9 shows the RSSI-based Indoor Localization Using RSSI-with-Angle-based Localization Estimation Algorithm,Several technologies used for indoor positioning – such as Radio Frequency (RF), Visible Light Communication (VLC), magnetic fields, etc.The main components of RF Indoor positioning systems are the beacons and a mobile phone. The proliferation of these devices in modern times makes RF- based indoor positioning very attractive. A key application scenario is shopping in a large retail store or shopping mall. The customer wants to know their location inside the shop as they try to locate items already pointed out in the map of the store on an application on their mobile phones. Also the data of customer's locations and movement of people in the shop could be usedfor gaining insight into customer's needs or even assist targeted advertisement.Methods of RF Indoor Positioning often use time of arrival,angle of arrival or the Received Signal Strength Indication(RSSI) of the beacons received by the mobile phone. The use of time of arrival faces synchronization issues as wellas multipath. This worsens its accuracy and reliability. Using the angle of arrival, determining the angle of arrival of an RF signal requires using multiple antennas. Although this technique yields a high accuracy up to 40 cm on average, they would require special devices - mobile phones that use multiple antennas. RF indoor positioning methods based on RSSI include: trilateration (which as a poor accuracy), Particle filtering (which is good), Kalman filtering (which is also good), and the RSSI Fingerprinting method.[6]

V. CONCLUSION

GPS has no applications indoor. To overcome this crises IPS came to picture. This system works on many algorithms and sensors like trilateration, VLC etc. However RSSI (Relative received Signal Strength Indication) and fingerprint sensors show more accurate result.

By including these technologies and algorithms in the indoor positioning system, required information is more accurate and user friendly. This system help to again access the locations in huge building such as hospitals, airports, shopping malls, museums, etc easily. This is a huge step towards a smart world.

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Bibliographical Note's

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