Review of Indoor Localization Based Services (ILBS) and its Applications

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Abstract

The energy consumption of every home is rising at alarming level, leading to increased carbon footprint per person. To generate more electricity, more and more fossil fuels are burned causing bigger problems like climate change and other catastrophic environmental damages. At the same time, wearable and mobile devices are more common among the people than ever. With advancements in wireless technologies and computational power, many new technological breakthroughs have taken place over the last decade. The Indoor localization-based service is one of them. In this paper, various applications across several fields are explored, while walking through the available technologies of Indoor positioning systems(IPS), the architecture, and algorithms. The evaluation metrics of Indoor Positioning is also discussed briefly.

Keywords: *Indoor Positionings system (IPS), Indoor localization Based Services, Machine Learning*

1. Introduction

Indoor Positioning Systems or IPS is a groundbreaking technology that enables a multitude of new user experiences through a branch of services called Indoor Localization based services (ILBS). In general, Indoor Positioning Systems function as GPS for indoors where GPS signals cannot be relied upon. Mostly, IPS is used for locating objects, humans, and animals inside a closed environment in which line of sight communication with open sky is not possible. Places like shopping malls, office complexes, hospitals and airports have leveraged the abilities of IPS to some extent to provide users with better experience. Places like underground mines have also used such a system to improve safety and efficiency.

Indoor Positioning Systems come in many forms. It may use radio waves, light waves, magnetic fields, sound, or vision to find the position of an item inside a closed environment. The choice of the technology to be used solely depends on the

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application and environment intended. Currently multiple technologies are combined to improve accuracy and reduce latency.
In this paper, the reasons why GPS cannot be used in an indoor environment are discussed, and then working overview of IP, available technologies and possible applications are discussed in the successive sections.

2. Limitations of Global Position Systems

The global positioning system, or more commonly known as GPS, has been used as a primary navigation tool for many years now. Originally developed for military purposes, GPS has existed since 1995. It was made available to the public in the year 2000. However, GPS is not the only navigation satellite orbiting the earth. Combination of United States' Global Positioning System (GPS) and Russia's GLONASS make up the Global navigation satellite systems or GNSS [1].

A GPS receiver works by receiving line of sight (LOS) signals from at least 3 or 4 GPS satellites at a time to determine the position. The signals are radio waves. GPS receivers require at least 3 satellites to determine latitude and longitude and 4 for determining the altitude. The receiver determines the location by a process called Trilateration. Trilateration is the process of determining your position based on inter- section of spheres [2].

The accuracy of GPS navigation is accurate to a few meters and can be very well relied upon for normal navigation. However, due to the nature of radio signals used in this technology, GPS requires a clear open-to-sky condition to work as expected. GPS loses its accuracy drastically if its overcast, or if the path is covered with dense trees. GPS will not work under buildings and underground environments as it is impossible to establish a line-of-sight communication with the satellites. GPS can also be not relied upon for fast moving objects like super jets and missiles due to its latency [3].

Therefore, to enable navigation in places where GPS cannot be used, IPS comes into play.

3. Architecture of Indoor Positioning Systems

The indoor positioning or localization architecture has been discussed by many research publications. One of those by Gressmann [5] will be discussed here. According to the author there must be two preconditions crucial for Indoor Location Based Services (ILBS), namely, an indoor positioning method for approximating the position with necessary accuracy and a wireless communication for transferring data. The paper discusses about two scenarios of positioning, self-positioning, and distributed positioning. Self-positioning involves the device determining its location obtaining the data from the base-station as shown in Figure 1. This setup works simi- lar to GPS. To provide various services, the location data can be sent to several entities. Distributed positioning, shown Figure 2, occurs if the device is unable to find its own position. This setup is ideal for low cost, low power devices which may not have power or capability of positioning hardware in it.

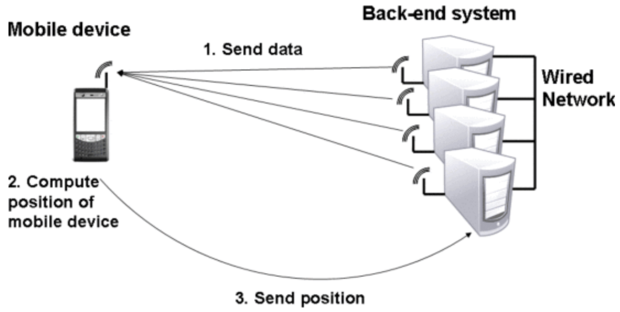

Figure. 1. Self-Positioning Systems [5]

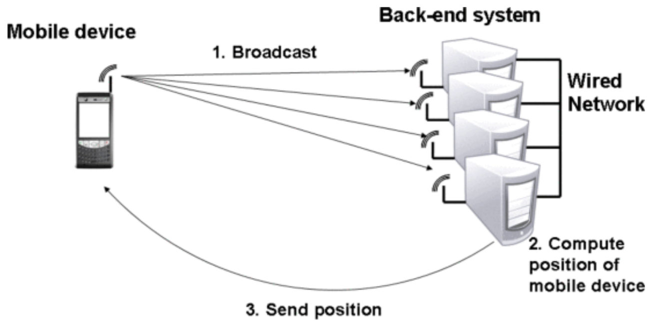

Figure. 2. Distributed Positioning Systems [5]

There are 8 layers in the architecture of Indoor localization-based service. Figure 3 represents the 8 layers.

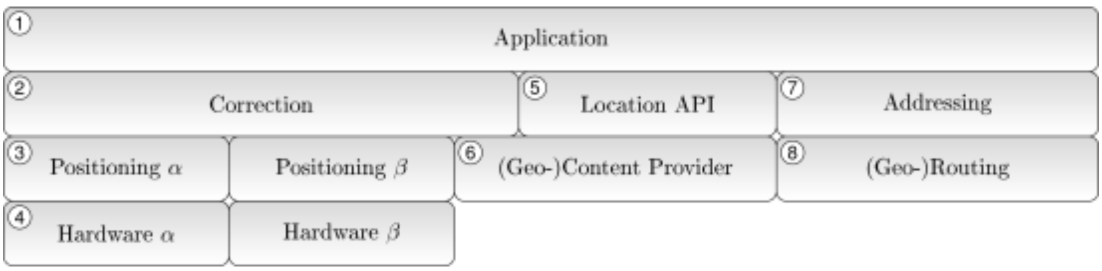

Figure 3 Layered Architecture of ILBS [12]

The bottom most layer is the hardware layer, which includes the devices that are required for positioning. Such devices could be any wireless devices and using Bluetooth, ZigBee or Wi-Fi.

Above the hardware layer comes the positioning layer. This layer provides the position of the device that is connected to the hardware layer using values like RSSI. Another layer, called Content Provider, also sits in the same level and is responsible for providing data and functionality to access the position data. Routing layer also resides in the same level, and it establishes reliable communication between devices.

The correction layer sits on top of the positioning layer, content provider layer and the routing layer. This layer is responsible for error correction in the positioning data provided by the previous layer. In this level, the Location AP layer is also present. It provides basic functionality which applications can use to provide location-based services. The Addressing layer, that is present in the same level, makes it possible for the communication to be routed or addressed, to ensure secure and reliable communication. The top-most layer is the Application layer that uses Location API to provide an application service for the user.

4. Various Types of Indoor Positioning Systems

There are several types of Indoor Positioning Technologies that were developed over the years for various use cases. Most techniques that use wireless technologies for positioning makes use of entities like RSSI (Received Signal Strength Indicator) TOA (Time of Arrival), and TDOA (Time Difference of Arrival)[[13]. In this section, some of the available technologies will be discussed briefly.

4.1 Infrared Based Systems

Infrared-based indoor positioning systems use infrared light to discover signals within a construction. IR receivers are fitted in every room, and when the IR tag pulses, it is read by the IR receiver device. Since the technology uses light instead of radio waves, Infrared is a near foolproof way to guarantee room-level accuracy as light cannot go through walls. There are several positioning systems that use IR technology. A few examples are discussed below.

Active badge is one of the earliest forms of indoor positioning system. In this system, a small device transmits a unique IR signal every 10 seconds to an IR receiver that is present in every location needed to be positioned. The receiver receives the signal and processes it to determine the exact position of the system [6].

Firefly is a system that was designed by Cybernet System Corporation. The system offers high accuracy using IR tracking technology. The Firefly system animates the intricate motion of an object by detecting small tags mounted on the body that emit IR. The information generated by the system is used to track the motion of an object [7].

The next system was designed by Northern Digital Inc. to be used in congested environment. The OPTOTRAK system used a set of three cameras as a linear array to track markers placed on an object. The markers that were mounted on the object emit- ted IR light for the camera to detect and estimate the position with an accuracy to up to 0.1mm [8].

Infrared Indoor Scour Local Positioning System is another IR based positioning system that uses cheap immobile stereo-cameras to receive IR signals from a tag mounted on an object. The angle of arrival is measured and by using triangulation technique the location was calculated [9]. IR based systems are proven to be highly accurate when every parameter is made sure to be compatible. The advantages include their small size factor, simpler design, and lower costs. However, they have a huge interference from fluorescent lamps and sunlight, making them unsuitable for general use. Also, they require line of sight for proper functioning.

4.2 Ultrasound Positioning System

For indoor positioning, ultrasound signals can also be used. Animals like Bats use Ultrasonic waves to navigate and position their preys. The ultrasonic based positioning system is an effective low-cost solution for IPS. However, the accuracy of such a system is lower than IR and the range is very minimal. Also, the bandwidth of the signal is too low for any information exchange. In this section, a few examples of systems that use Ultrasonic waves to position will be discussed.

Active Bat is an indoor positioning system developed by AT&T Cambridge. It delivers 3-D position and orientation information for the tracked objects. A tag present on an object periodically broadcasts a short pulse of ultrasonic wave. It is then received by a matrix of receivers mounted on the ceiling at known positions. Like sonar, the time of arrival is used to find the distances between the tag and the receivers [10].

Cricket is an ultrasonic based positioning system that was made to enhance user privacy, performance and to lower the cost. It uses time of arrival to find the distance and thereby the target. Ultrasound emitters were attached to the walls or ceilings at known positions and a receiver was mounted on each object. In addition to ultrasound, this system also used RF signals to synchronize as a fault tolerance mechanism [11].

Sonitor is an ultrasound based indoor positioning system in which tags were mounted on people or the object to be tracked by detectors fixed at known positions. The tag emits ultrasound signals with unique ID. The detector receives it and forwards the data to the centralized unit for position calculation.

4.3 Magnetic Positioning System

Positioning using magnetic signals is an old and classic way. The magnetic positioning system provides high accuracy and do not suffer from the line-of-sight problems. In this section, an example of magnetic positioning system will be discussed.

MotionStar Wireless was a tracking system that uses pulses of DC magnetic fields to locate sensors. The MotionStar wireless system enables accurate body motion tracking by computing several sensors mounted on the different parts of a body. This system tracks multiple sensors simultaneously in real-time to determine the exact points in motion. It consists of a transmitter and controller, a base station, mounted sensors and RF transmitters.

Magnetic positioning offers greater accuracy and is a simpler system, but the range of detection is very minimal. To increase the range, higher strength of magnetic fields is needed, which could cause various adverse effects including health hazards.

4.4 Vision-Based Positioning System

Vision-based positioning is an indoor positioning technique that enables ILBS in a complex indoor environment. Moreover, this system does not require any tag or sensors on the object to be tracked. In this section, an example of vision-based positioning system is discussed.

The Easy Living positioning system was coined by the Microsoft research group. Vision-based location technique either captures the motion of the body with data from one perspective or multiple perspectives. The Easy Living system uses the multiple perspective vision-based tracking technique by using the combined data of color and depth from two cameras to determine the accurate location [12].

The vision-based system could provide good accuracy and can be developed using a low-cost camera. However, high computational power, privacy concerns and effects of external factors make it a difficult choice for indoor positioning.

4.5 Audible Sound Positioning System

Audible sound was identified to be a possible indoor positioning technology as every mobile device has the ability of producing audible sounds. Researchers found that these devices can be used to develop a sound-based positioning system. In this section, one such system is discussed.

Beep was a cheap positioning solution that used audible sound technology for positioning. A mobile device was used to emit audible beeps, while several acoustic sensors were placed in known positions to receive them. TOA is calculated to determine the distance. Triangulation location technique was used in Beep to determine the accurate location [13].

Audible solution might be simple on paper, but it had several limitations making it a difficult choice for indoor positioning. The continuous audible sound could be an annoyance and other sounds produced in room can potentially interfere.

4.6 Wi-Fi Based Indoor Positioning

In most research related to Indoor positioning; Wi-Fi has been used in the algorithm to determine the location of a device. The reason behind this is the ubiquity of Wi-Fi in today's world. Wi-Fi exits everywhere, and there is no need of any special setup, especially in an office environment.

One of the approaches stated by [23] uses WLAN in a multi-floor environment to identify accurate position. They propose a new Adaptive Indoor Positioning System model called DIPS as shown in Figure 2.4 which is based on a dynamic radio map generator, RSS certainty technique and peoples' presence effect integration for dynamic and multi-floor environments. This particular technique has achieved 98% accuracy with an error of 1.2m. The technique also doesn't require any extra devices. Another technique used in [24] also uses WLAN for positioning. It is a simple setup that uses RSSI between terminals to avoid site calibration. The setup is robust and can recognize position accurately in 4.8sec.

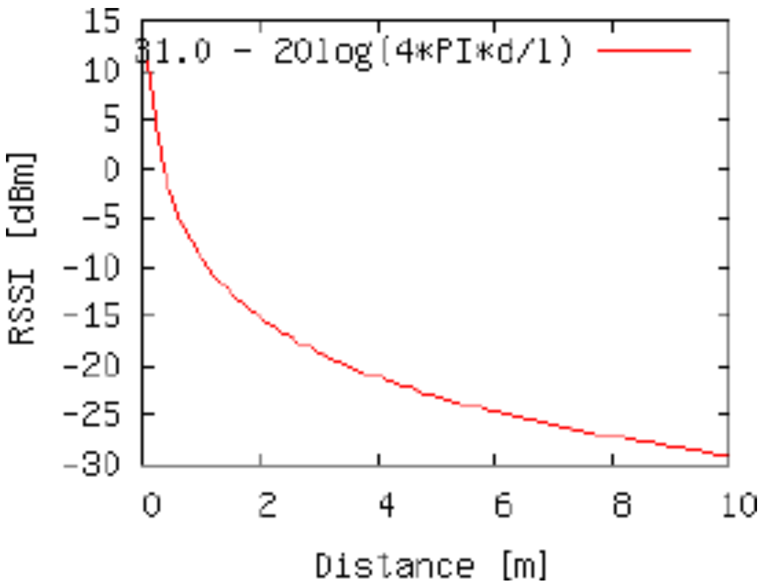

Figure 4: Relation between RSSI and distance[

The mechanism determines distance based on RSSI values using the following equation. A sample plot is given in Figure 4.

$$P_r(d) = P_0 - 20\log_{10}(\frac{4\pi d}{\lambda})\ [dBm],\ P_0=31.0[dBm]\ \text{(empirical constant)}$$

In the idea proposed in [25], the positioning is achieved by sending a set of predefined messages to the nodes. ToA measurements are done to get the accurate position of the node.

In another technique stated in [26], multiple nodes are positioned using RSSI values stored in a database and mapping it with a reference radio map. The radio map comprises a set of samples taken at specific location on a layout called fingerprints. In this technique, MAC addresses of each detected APs are also used. Again, the system works on two phases, online and offline phase. In the idea suggested in[27], compressive scanning is used for positioning. Using compressive sensing the best match of detected RSSI values and prestored values is found to accurately find the cluster a node is present. Figure 5 gives the overview of the entire system.

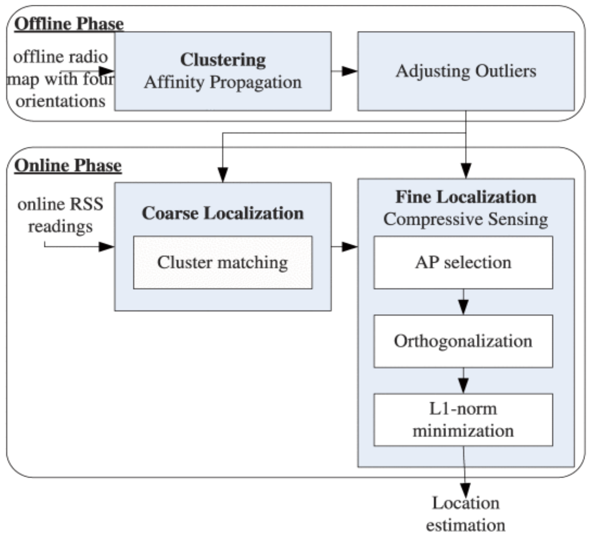

Figure 5: Block diagram of Compressive Scanning Positioning System [27]

4.7 WSN Based Indoor Positioning

Wi-Fi may be ubiquitous and highly proven to be considered for indoor positioning. However, there are certain cases like in that of low-power, small sized minimal devices, where Wi-Fi connectivity is not possible. In such cases an alternative must be found. Here's where WSN technologies, like Bluetooth (both conventional and Bluetooth Low Energy) and ZigBee, come into the play.

Wireless sensor nodes (WSN) are installed in an environment for various purposes. Utilizing them is very easy and they are highly flexible as there is no need for any infrastructure setup. Again, their positioning algorithms mostly work based on received signal strength indicator (RSSI). RSSI is chosen as it is regarded to be low cost and low power, even though it has many limitations.

Similar to Wi-Fi based solutions, WSN has also attracted a myriad of research. The solutions are not just limited to Bluetooth and Zigbee, even RFID and Radar are used to determine the location.

Bluetooth is also widely used for indoor positioning like how [28] has used piconet to enable mobile devices to share location data with each other in ad-hoc mode using the Bluetooth technology in conjunction with 3G. [29] proposed a system to track

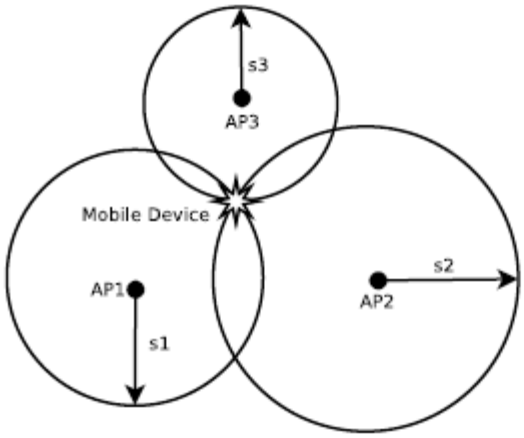

Figure 6: Triangulation in Rodriguez's Model

mobile users inside a corporate building using Bluetooth. The system comprises of several access points (AP) where each AP performs two main tasks. The system discovers the entry of the into the coverage area Bluetooth and transfer data to and from the users connected to the piconet. In the system proposed by [17], signal energy from a Bluetooth access point is measured by the mobile device transmitted to a centralized server calculating its location. An RSS map, as given in Figure 6 was built for the environment to create a scene for the positioning. This method is of low cost and easy to implement. The error is also less than 2m.

4.8 RFID Based Indoor Positioning

RFID has been a tool used in businesses and consumer market for a while now for various purposes like identification, authentication and tracking. It usually involves an RFID tag and an RFID reader. The tags contain key information and a unique ID to differentiate itself from other similar tags. RFIDs can be classified as Passive RFIDs, which operate mainly at four frequency bands: LF (125 kHz), HF (13.56 MHz), UHF (433, 868–915 MHz), and microwave frequency (2.45 GHz, 5.8 GHz) and Active RFIDs that operate at higher frequencies. Passive RFIDs do not require any power source within the Tag; however, active RFIDs equip a cell or a battery and have a higher range of communication. Research [14] designed a product called SpotON, which uses multiple base stations to read an RFID tag to determine the location. It works based on the signal strength variation depending on the distance from the base station. Using this information, the location is calculated. In another research, a system called LANDMARC was developed [15]. It makes use of power levels of various tags detected to triangulate the location. It uses three types of tags, Reference Tag, Tracking Tag and RF Readers. It was mentioned that placement of the tags is essential in this setup. RFIDs are low cost, low powered solution for Indoor positioning. They are, however, weak in terms of signal strength and thus require large number of sensors.

4.9 Cellular Based Indoor Positioning

GSM and other cellular mobile signals can be used for positioning as well. This type of positioning is possible in urban setup where there are a lot of signal base stations around a place. The accuracy of such a method would be much lesser due to attenuation factor of the cellular signals. One of the researches mentioned a GSM-based indoor localization system that makes accurate GSM-based indoor localization possible by using wide signal-strength fingerprints obtained from different base stations surrounding an area [16]. It was noted that there were many base stations that were detected but were too weak to be used. Cellular based Indoor Positioning is easy to setup, but the accuracy and reliability are very low.

5. Indoor Positioning Algorithms

Indoor positioning is not an easy task. There have been a number of technologies that were developed to enable IPS, as discussed in the previous section. In order to determine location of an item, complex algorithms are needed. In this paper, the discussion is confined only to algorithms that are related to IPS using Wireless Technologies like Wi-Fi and WSNs (Bluetooth/ZigBee) only.

Generally, there are four methods used in IPS, i.e., Triangulation, fingerprinting, vision, and proximity to determine the position.

In Triangulation, the geometric properties of a triangle are used to calculate the position using the properties of a wireless signal like RSSI, TOA, AOA and TDOA. By knowing the geographical coordinates of three reference positions on a 2D plane, the absolute position can be determined using length or direction of the item from the reference point. RSSI and TOA require a minimum of three reference points to triangulate, whereas only two are sufficient for AOA. Every technique comes with a trade-off and must be chosen according to the requirements [17].

Fingerprinting is another technique in which the area in which IPS is to be implemented is mapped in a database. It is often done in two phases: offline and online. In offline stage, RSSI values are measured from several access points of WLAN and recorded for every geographical coordinate. In online phase, the data is compared with the database using algorithms like K-Nearest Neighbors to determine the absolute location of the user [18].

If the requirements don't need a high accuracy for the location, then Proximity technique can be used. This is a technique that determines the location of an item in a known area. Several detectors are placed in an area and when a detector detects the item/user, it can determine the proximity of it. Such a technique is used in cases like determination of presence of an item or user in a room, regardless of the exact coordinate. The vision technique uses images from several positions to determine the location. It is a very complex and expensive technique.

Several other techniques are present for Indoor positioning based on Wi-Fi technology. All the techniques discussed are compared in Table 1.

Table 1: Indoor Positioning Algorithm

S.No	Paper Title	Authors	Technology/ Technique	Accuracy
1.	*Adaptive Indoor Positioning Model Based on WLAN-Fingerprinting for Dynamic and Multi-Floor Environments.*	Alshami, I. H., Ahmad, N. A., Sahibuddin, S., FirdausF.	RSS, WiFi, Dynamic radio map generation	1.2m, 98%
2.	*WiPS: Location and Motion Sensing Technique of IEEE 802.11 Devices*	T. Kitasuka, K. Hisazumi, T. Nakanishi, A. Fukuda	RSSI between mobile terminals and Access points	4.9 secs average detection time. 83%
3.	*WiFi-Based Indoor Positioning*	C. Yang, H. Shao	Time of arrival (ToA), predefined messages	1 meter
4.	*WIFI-Based Indoor Positioning System*	A. H. Lashkari, B. Parhizkar, M. N. A. Ngan	Radio maps, MAC Address and RSS	-
5.	*Received-Signal-Strength-Based Indoor Positioning Using Compressive Sensing*	C. Feng, W. S. A. Au, S. Valaee, Z. Tan	Compressive Scanning of RSS values, MAC Address	1.6 meter with 8 APs

There are advantages and disadvantages in each of the techniques mentioned above. Choice of what technique to be used solely depends on the requirements, cost and preference.

6. Machine Learning in Indoor Positioning

Machine learning plays a key role in indoor positioning. Most algorithms discussed in the previous sections use Machine learning. It usually consists of two phases called online and offline. Offline phase involves the training of the algorithms and online is where the positioning takes place. RSSI values are the most common fingerprints used in positioning. Other fingerprints like TOA, TDOA and AOA can also be used.

AdaBoost was used in one of the research projects for detecting position using Wi-Fi signals. As seen in Figure 7, the basic concept behind Adaboost is to set the weights of classifiers and training the data sample in each iteration such that it ensures the accurate predictions of unusual observations. The experiment in the research was conducted in 9528 sq. meter area. An android device was used to collect the data. Data were collected both indoors and outdoors and trained an AdaBoost learner with 27 weak learners. The result obtained was around 97% accuracy [19].

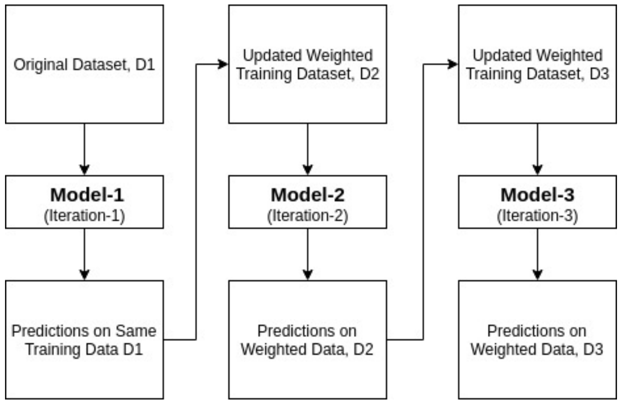

Figure 7: Flow of a simple Adaboost [19]

In another research, Naïve Bayes was used in a very similar setup as mentioned in [20]. The average delay in this research was 12 seconds however, the accuracy was 62% only. To improve the detection accuracy the number of samples were increased to 4000 from 1000 [20]. A Naive Bayes classifier is a probabilistic machine learning model that's used for classification task. The core of the classifier is based on the Bayes theorem. The equation gives probability of A to happen given B has already happened. It works when presence of one feature does not affect the other.

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Decision Tree is another commonly used Machine learning algorithm. Again, using RSSI values of radio signals, the position was identified. It was stated that the data required for Decision Tree classifier is much lesser than the other comparative algorithms [21]. It applies a straightforward idea to solve the classification problem. Decision Tree Classifier contains a series of carefully crafted questions about the attributes of the dataset. The answer of one node branches out as question of other spreading like a tree. The deeper the tree is, the better the model as long it doesn't reach saturation.

As seen in this section, there are many Machine learning classifiers suitable for indoor positioning using RSSI as fingerprint. The best algorithm for such cases is not clearly defined. All the machine learning algorithms are based scikit-learn Machine learning libraries. Project scikit-learn is a Machine Learning library in Python. It comprises of a collection of algorithms for some of the well-known machine learning jobs such as for Classification, Regression, Clustering, Dimensionality reduction and Model Selection.

7. Evaluation Criteria for Indoor Positioning Technologies

Since there is a plethora of Indoor Positioning technologies and techniques, there is a strong need of performance metrics to determine the best suitable technology or technique. One might argue that accuracy is sufficient, but to benchmark such a complex system, we need more parameters. In this section, a few bench-marking parameters are discussed.

Accuracy

Accuracy was the first and most important parameter to be prioritized in an Indoor Positioning System. To measure accuracy, mean distance error was considered by using the average Euclidean distance between the actual location and predicted location. Several factors can affect the accuracy of a system and in general, higher the ac- curacy, better the system. Based on the need of precision, technology of the system can be designed.

Cost

The cost of a complete IPS is contributed by several factors. Complexity of the environment, number of users, technology to be used and services provided are some other factors that add to the cost of the system. The most popular IPS currently uses WLAN technology, which uses existing WLAN infrastructure, thus costing relatively lower. Sensor based technology requires additional installation of devices specifically for Indoor positioning, which can be expensive. Other than initial costs, IPS needs regular maintenance for both its software and hardware, which adds to the cost. Again, based on the requirement and user preference, costs can vary.

Complexity

Hardware and Software used in the IPS can contribute towards the complexity of the overall system. As seen earlier, there are several algorithms for calculating the position. The algorithm and calculation technique used in the system determines the software complexity of the system. Factors like processing server, node devices, location of sensing devices and environment contribute towards hardware complexity. Even attributes like computational power required for the system can add directly to the complexity. It is often best to go for simpler system while ensuring maximum efficiency. For example, WLAN technology can make installation much faster as it uses existing WLAN infrastructure. Complexity can be measured based on the amount of human intervention required during setup and maintenance of the system.

Robustness

Indoor environments are complex areas for Wireless signals to travel. Wireless signals tend to attenuate significantly as they travel through walls, furniture and even humans. Robustness of a system can be considered as its ability to recover and work as expected even in the event of a complete signal loss. System with high fault tolerance should be able to provide an idea of the location with limited availability of information, even if it means to be less accurate. The system must also be intuitive and inform the user or administrator about errors and log the errors that occur.

Market availability

Many of the Indoor positioning technologies are yet to be commercialized as they are research-based technologies. If the goal is to develop the research further, research products can be considered, or using the available components, a system prototype can be developed. If the goal is to implement the system in real-time scenario, it is advisable to use product kits that are commercially available. Generally, such kits come with proprietary software, algorithms, and maintenance tools.

User Preference

Based on technology and technique, the shape, size, and complexity will vary significantly. User preference to use a particular system type is also considered when classifying IPS.

Scalability

Any system must be available or easily expandable when the scenario being implemented evolves or when the requirements increase. Consider a mall in which IPS is being implemented. If the mall undergoes an expansion or if the visitors increase significantly, the system should be scalable automatically or with minimal effort. It should be available to handle larger traffic and network congestion.

Limits and weaknesses

As discussed in several instances in this paper, each technology is designed for various situations. However, limitations and weaknesses must be considered while choosing a technology for IPS. For example, implementing Wireless signal-based technology in hospitals can have issues due to X-Ray rooms, or in factories with large metal structures, as it would block the signal as it travels. Another issue is within the framework of the system. Some systems are designed only for handling a small area with small number of users. Using it for extensive applications can result in inaccurate results.

8. Applications of Indoor Positioning Systems

Indoor positioning systems have several applications in many fields. The services offered using Indoor Positioning systems are called Indoor Localization Based Services or ILBS. Under this section, some of the applications of IPS will be discussed.

1. In a research project, IPS was used to assess the dynamics and control the Influenza spread by droplets in the air. The study was done in a school in the US. Several Wireless nodes were placed across the area to track the infected individuals and identify the patterns of the spreading of virus. The droplet and aerosol transmission were represented as weighted networks [22].
2. There are many patents on ILBS, one of them is a system to generate customer alerts based on the location of the customer inside the financial institution to im- prove its customer service without compromising the security. In another patent, a system to load customer information based on proximity of the customer in a queue, to speed up the process of customer service, was proposed.
3. Asset tracking is one of the key areas where Indoor Positioning is actively used. Companies like Amazon make use of such technologies to track their shipment in the warehouse to enable automation.
4. Immersive Experiences can be enabled using ILBS. Exhibitions and Museums can benefit from Indoor Positioning Technology to enhance their interaction with visitors. Electronic Guides can provide the visitors with immersive experience based on the location.
5. Malls can equip ILBS to enable easy navigation. People can make use of ILBS to find their way to stores or shops. Mall authorities can send location-based advertisements to the users and enhance the overall shopping experience. Data about user behavior can also be collected for marketing and business study purposes.
6. Parking Lots can be easily accessible using Indoor Positioning. Most parking lots are underground, where GPS signals cannot be used. Cars can be easily identified using Indoor Positioning Systems.

Apart from these, there are many other applications that can be benefited from Indoor Positioning. The requirement is, however, the accuracy and ease of use.

9. Conclusion

In this paper, the Indoor Positioning Technology was reviewed, and the application was discussed. The paper began talking about the limitations of the GPS and the reasons for the need of Indoor Positioning System. Then, the Indoor Positioning working was discussed, which was followed by the general architecture. The Machine learning algorithms used in ILBS were discussed. Later, several technologies used in Indoor Positioning were explained in detail. The evaluation criteria for opting an Indoor positioning system from several systems were also discussed and finally the applications of Indoor position systems were discussed. Indoor positioning is an exciting area of research. More study in this subject is always encouraged to enable Indoor positioning using existing infrastructure.

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