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A Comparison Review of Indoor Positioning Techniques

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Abstract

The advances in positioning based technologies and the expanding significance of indoor positioning led to a growing business interest in location-based services. Today, most application requirements are real-time tracking of physical possessions inside structures precisely. The demand for indoor localization services has turned into a key essential in some markets. Moreover, indoor positioning technologies address the inadequacy of global positioning system inside a closed environment. This paper aims to provide the reader with a comparison review of different parameter that affects indoor localization. The comparison review is based on three techniques known as Angle of arrival (AoA), Time of arrival (ToA) and Fingerprinting techniques to deliver a better understanding of state-of-the-art of these techniques and inspire new research endeavours in this promising field. For this purpose, three localization positions and location estimation schemes are reviewed with a conclusion and future trends.

Keywords: AoA; ToA; Fingerprintin.

1. Introduction

Location based services (LBSs) [11] are permissive significant technology and turning into a key some portion of life. In this age, especially in wireless networks communication, LBS extensively exist from the short-run communication to the long-run telecommunication networks. LBS allude to the services that rely on a user's location to provide services in different categories including tracking and navigation in healthcare. However, its need is increasing due to increase of mobile device market.

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The heart of the LBSs is localization technologies to discover the movement activity of the mobile user [13].

After detection, we pass these statistics to the mobile client on the move at the right time and the right location. Along these lines, the localization technologies impact the performance, privacy and reliability of LBSs [7].

The important components of LBS are application software, network communication, a positioning device, and the client. There are some approaches to determine the location of a mobile user outdoors and indoors. The most well known outdoor technology is global positioning system (GPS) [6,12]. Location discovery rely to a procedure of acquiring area information of a mobile user with regarding an arrangement of reference positions inside of a predefined space. In the literature, numerous terms are utilized for area discovering like position location, location sensing, geolocation or localization. Position location is a system organized in such an approach to discover the object location. This paper provides the reader with AoA, ToA, and fingerprinting based indoor localization techniques and systems for indoor localization. The authors trust that this paper will advantage researchers working in this field, clients, and designer as far as utilizing these techniques and will offer them some assistance to identify potential weakness and future application items in this developing area.

2. Comparison metric

2.1. Accuracy

Accuracy of a system is the critical client prerequisite of localization systems. Accuracy can be accounted as for as an error separation between the evaluated location and the real mobile device. Some of the time, accuracy is likewise called the region of instability; that is, the good the accuracy is the good the system to be.

2.2. Adaptiveness

Environmental impact changes might influence the performance of localization system. A framework that can adjust to natural changes can give preferred confinement accuracy over frameworks that can't adjust. A versatile framework can likewise avoid the requirement for repetitive adjustment.

2.3. Cost

The cost picked up from a localization system can emerge from the expense of additional infrastructure, Extra bandwidth, lifetime, energy, weight and nature of positioning technology. The expense might incorporate establishment and review time along the exploitation period. If a location system can take the advantage of reuse communication infrastructure, some part of infrastructure, bandwidth, and equipment can be saved. The complexity of the processing signal and algorithms used to calculate the position is another issue that should be adjusted with the execution of the location system. Tradeoffs between the accuracy and system complexity influence the general expense of the system.

2.4. Number of beacons/Base station

Number of beacons stations is the key for the performance of indoor localization. The minimum number of beacons stations to achieve required performance goal has been considered in the comparison. If the positioning system can use fewer beacons to obtain the necessary accuracy the cost will be low.

3. Location Detection technique and Algorithm

3.1. Angle of Arrival

The Angle of arrival (AoA) method, once in a while called direction of arrival (DoA), positions the mobile station by resolving the angle of incidence at which signals land at the reception sensor [10]. Geometric relationships then can be used to estimate the location from intersection of two lines of bearing formed by radial line to each receiving sensor as illustrated in Figure 1. In a two dimensional plane, at least two reception sensors are required for location estimation with enhanced accuracy originating from not less than three or additionally accepting sensors which termed as triangulation [1].

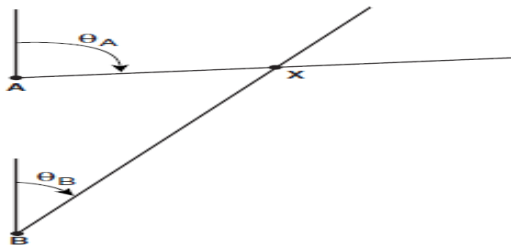

Figure1: Representation of probable location of mobile station X AoA technique

AoA-based strategies have their confinements. AoA requires extra antennas with the ability to compute the angles which expand the expense of the AoA framework usage. In indoor situations, AoA-based technique is influenced by multipath and non line of sight (NLOS) signal propagation, alongside reflections from other objects, which is the situation of indoor environment. Because of these variables, it can significantly alter the direction of signal arrival and thus limit the accuracy of an indoor AoA-based localization system [9].

3.2 Time of Arrival

Time of arrival (ToA) systems is based on the exact measurement of the arrival time of a signal transmitted from a portable device to several accepting sensors. Because signals travel with a known velocity (approximately the speed of light (c) or ~3 × 108 meters per second), the distance between the mobile device and each receiving sensor can be determined from the elapsed propagation time of the signal travelling between them [3]. The ToA technique requires extremely exact knowledge of the transmission start time(s), and must ensure that all receiving sensors as well as the portable device are precisely synchronized with an exact time source [5], [15]. From knowledge of both propagation speed and estimated time (t), it is conceivable to compute the distance (D) between the mobile device and the receiving station as it shown in equation 1.

$$D = c \times t \qquad (1)$$

One of the inconveniences of ToA method is the prerequisite for exact time synchronization of all the considerable number of devices. For time delay estimation, an extra server will be required which will increase the expense of the system. Alongside this, expanded delay can likewise be spread by a denser situation, as far as more individuals.

The measure of time required for transmitting a message from station X to land at accepting sensors A, B, and C is definitely estimated as tA, tB, and tC. Given a known propagation speed (stated as c), the portable device distance from each of these three getting sensors can then be computed as DA, DB, and Dc, respectively. Each computed distance value is utilized to develop a round plot around the particular accepting sensor. From the individual viewpoint of every receiver, station X is accepted to exist in some place along this plot. The crossing point of the three round plots determines the location of station X as illustrated in Figure 2.

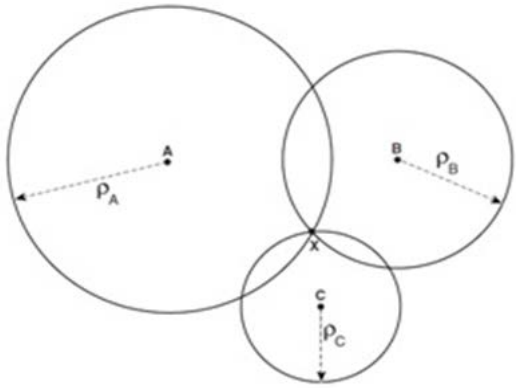

Figure2: The intersection of the three circular plots resolves the location of station X ToA technique

4. WiFi-Based Indoor Localization

One of the merits of utilizing WiFi positioning systems is to find the position of approximately every WiFi well matched device without introducing additional software or altering the hardware. Alongside this, in WLAN, viewable pathway is not required. Because of this point of preference, WiFi localization systems have turned into the most well known method for indoor positioning [9]. Most localization systems in view of WLAN are existing as business products as model in light of estimations on the received signal strength (RSS). WiFi based localization system have several point of interest [12].

Firstly as far as cost effect, WLAN bases usage of position calculations does not require any extra equipment as network interface cards measure signal quality values from all beacons in range of the receiver. Along these lines, signals required for positioning can be attained specifically from NICs accessible on most mobile device. Because of the pervasiveness of WLANs, this method of situating gives an especially financially answer for offering LBS in business and private indoor situations [8]. Also, WLAN situating frameworks offer versatility in two regards: in the first place, no exorbitant necessity of base and equipment and second the quantity of cell phones subscribing to situating services. Adjacent to this, there are likewise sure WLAN limitations: signal constriction of the static environment caused by different objects.

4.1. Fingerprinting Based Indoor Localization

Most indoor positioning techniques accepted fingerprint matching as the fundamental plan of position determination. The primary subject is to gather elements of the scene (unique mark) from the encompassing signature at each location in the interested area and afterward construct a unique mark database. The position of an object is then dictated by coordinating online estimation with the offline database [9].

This technique does not require specialized equipment in either the portable device or the less than desirable end nor is no time synchronization fundamental between the stations. It might be implemented absolutely in software which can decrease complexity and cost fundamentally contrasted with angulations or simply time-based lateration frameworks [1].

The position fingerprinting likewise called a fingerprinting technique comprises of two phases [4]. The first phase is known as calibration phase, training phase or offline phase, and the second phase is known as online phase or positioning phase. In the training phase, maps for fingerprinting are set up either exactly in estimation operations or analytically.

In the training phase, a construction of radio maps for site study where the localization should work should be recorded. Essentially, radio guide is a database of spots at predefined reference points combined with different radio signal attributes, for instance, signal angles, RSS or propagation time known as signal fingerprints. Orderly, for each unique mark, there must be an estimation that incorporates the data about all stations and their measured RSS. At the point when the restriction framework is operational, online stage, the mobile receiving sensor measures signal properties at obscure spot. At that point, the current measured signal qualities are contrasted for the best match with the database. The real disadvantage of the fingerprinting technique is the laborious and tedious process in calibration phase. Besides, including new signal stations would challenge the simplicity of setup in fingerprinting. Next to this, the fundamental test to the procedures in light of area fingerprinting is affectability to environment changes, for example, object moving into the building.

Fingerprinting-based localization algorithms are methods that create reliance between area data and area unique finger impression premise with a specific end goal to decide a position or area from tests of RSS signals. Fingerprinting localization algorithms can be ordered into three fundamental gatherings; probabilistic algorithm, deterministic algorithm and else algorithm that go outside past deterministic and probabilistic.

5. Related work

Existing works of [14,16] on their study used different number parametric to report the comparison of indoor positioning technique. Though their investigation has shown that, the cost is important parameter that has significance impact in localization, [14,16] failed to explain what really causes different techniques to have different cost. [14,16] also used the different parameters to draw their conclusion. Although [14,16] failed to illustrate the minimal number of beacons required in each technique which is important information to be known. However, [14,16] the facts of the number of beacons were not reported. On the contrary, the study in [17] demonstrated that the number beacons is very important parameter in localization but is not shown.

6. Result and discussion

In this section we compare three positioning techniques. The comparison is shown with respect to the parametric of giving the best indoor localization systems which are discussed in section 2. Table 1 shows a comparison among the positioning techniques. Information in this table collected from different sources as reviewed from each technique. We notice that, the Fingerprinting which is based on unique mark provides extra promising advantages compared to other techniques. On the other hand, fingerprinting based indoor positioning technique provide an excellent accuracy compared with alternate systems. This might the results of nonexistence of multipath, synchronization problem as well as low cost requirements. One can notice that the cost of fingerprinting is low because it does not need much infrastructure deployment due to reuse of the existing beacons to perform localization.

All through our study we discovered many contributions in the indoor positioning technique. Most of the conceivable enhancement that might be recommended is already proposed in the field and there is a very narrow space for new ideas to be proposed. Our discussion shows that fingerprint indoor positioning still shown the promising accuracy. Several errors faced the indoor positioning systems based on various wireless technologies accounted. However, researchers proposed many different solutions to overcome these errors and many new algorithms proposed. Therefore, we believe that the fingerprinting indoor positioning technique is the expected one.

Table 1: Comparisons of indoor position methods

Method	Measurement type	Indoor accuracy	Affected by multipath	Minimum number of beacon required	Cost	Need of Time synchronization
Direction (AoA)	Angle of arrival	Medium	Yes	Three	High	No
Time (ToA)	Time of arrival	High	Yes	Three	High	Yes
Fingerprinting	Received signal strength	High	No	Three	Medium	No

7. Conclusion

This paper reviews three wireless indoor localization techniques. Three techniques for wireless indoor positioning and navigation are discussed, and several drawbacks and benefits among them are observed. Regardless of the drawbacks of those techniques to handle the indoor positioning, fingerprinting technique shown to have more benefits in indoor localization compared to ToA and AoA. Fingerprinting method has shown benefits in term of costs, multipath, accuracy and time synchronization. Therefore more effort to overcome the drawbacks of fingerprinting method is important for indoor localization solution.

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