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VISITOR LOCALISATION USING ULTRAWIDE BAND

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Abstract – *In this age of growing technology tracking has become one of the vital requirements for many use cases, its application spectrum varies from military use to normal day to day tracking of our location. Localization can be classified into two categories depending on the environment*

i.e. Outdoor Localization and Indoor Localization. GPS is the standard technique for Outdoor Localization, but it does not work well in indoor environment due to its signal being blocked by walls and ceilings. To acquire accurate localization in indoor environment, many techniques have been developed by using Bluetooth Low Energy (BLE), Wi-Fi and Ultra-Wide Band (UWB).

Ultra-Wide Band unlike others uses sub-nanosecond radio pulse to transmit data in a wide range of bandwidth (generally greater than 500 MHz) which offers uninterrupted transmission as its signals are regarded as noise to other wireless technologies. It has very low power consumption and due to its unique short impulse transmission it delivers much more precise location without being affected by multi-path problem.

***Key Words*: Ultra-Wide Band (UWB), Bluetooth Low Energy (BLE), GPS, Indoor Localization, tracking**

1. INTRODUCTION

Localization has gain momentum in past few years. Tracking locations of entities has become crucial. There are two categories of localization viz. Indoor localization and Outdoor Localization. For Outdoor Localization GPS is very efficient. But GPS has limitations that it cannot penetrate through the walls of buildings. Hence GPS is ineffective for indoor positioning. So we need to use some other techniques for indoor positioning. There are wide varieties of technologies available, which could be used for indoor positioning. Some of them are Bluetooth Low Energy (BLE), Ultra Wide Band (UWB), Radio-frequency identification (RFID), Cellular, Wi-Fi, etc. Out of these UWB and BLE are the most commonly used technologies. UWB technology is ideal for indoor positioning because it offers high reliability and accuracy. It can also penetrate through the walls, overcoming the disadvantage of GSM. Also, it is unlicensed in majority of countries. If UWB is implemented carefully, it will not interfere with other electronic devices in its surroundings.

Furthermore it is possible to integrate UWB with GPS, wireless local area networks (WLANs), and Wi-Fi.

2. TECHNOLOGIES FOR INDOOR LOCALIZATION

There are several wireless technologies available for indoor localization. These technologies are categorized into 3 major types-

2.1 LONG DISTANCE WIRELESS TECHNOLOGIES

FM (Frequency Modulation) is ubiquitous for regional radio broadcasts with a radio spectrum ranging between 87.5 to 108.0 MHz. In FM, radio frequency interference is less due to large signal-to- noise ratio (SNR). Since the universality of FM, there is no compelling reason to fabricate additional reference point framework utilizing FM for indoor confinement. FM works better for larger area because it has large wave length.

GSM (Global System for Mobile Communication) and **CDMA** (Code Division Multiple Access) are two dominant technologies. The CDMA depends on spread spectrum innovation which makes the ideal utilization of accessible transfer speed. It enables every client to transmit over the whole recurrence range constantly. Whereas, GSM operates on the wedge spectrum called a carrier. This carrier is divided into a number of time slots and each user is assigned a different time slot so that until the ongoing call is finished, no other subscriber can have access to this.

2.2 MIDDLE DISTANCE WIRELESS TECHNOLOGIES

Wi-Fi positioning system (WPS) is a geo-location system that utilizes the attributes of adjacent Wi-Fi hotspots and different remote passageways to find where a gadget is found. It is utilized where satellite route, for example, GPS is deficient because of different causes including multipath and flag blockage inside, or where gaining a satellite fix would take excessively long.

ZigBee is a communication protocol. We can create wireless personal area networks (WPANS) using small,

low-power digital radios. It is used for transmitting small data packets and controlling and monitoring applications over short distances (10-100 meters), but it is a mesh network protocol. It can also be configured into star and tree. It supports different network configurations for master to master or master to slave communications. We can also extend the network using routers, which allows many nodes to interconnect with each other for building a wider area network. It consumes less power and is less expensive and simpler than Bluetooth and Wifi.

2.3 SHORT DISTANCE WIRELESS TECHNOLOGIES

Bluetooth is a wireless technology standard that describes how cell phones, computers and other devices can easily communicate with each other utilizing a short-range remote association. It entails a low-cost transceiver chip. Bluetooth make use of 2.4 GHz and 5 GHz bands. The maximum range of Bluetooth is 10 meters. Information can be exchanged at a rate of 1 megabit per second -- up to 2 Mbps in the second era of the technology.

UWB (Ultra Wide Band) is a wireless technology that can transmit information at rates between 40 to 60 megabits per second and in the long run up to 1 gigabit per second. UWB transmits ultra-low power radio signs with short electrical heartbeats, frequently in the picosecond (1/1000th of a nanosecond) go, over all frequencies without a moment's delay. Due to its low power necessities, UWB is extremely hard to identify and hence hard to direct. Since it traverses the whole recurrence range (authorized and unlicensed), it very well may be utilized inside and underground, in contrast to GPS.

RFID (Radio-Frequency Identification) system is made up of two parts: a tag or label and a reader. RFID tags or labels are embedded with a transmitter and a receiver. The RFID segment on the labels has two sections: a microchip that stores and procedures data, and an antenna to get and transmit a signal. The tag contains the particular sequential number for one explicit item.

RFID	BLE	UWB
Passive RFID Tags	BLE Tags	UWB Tags
Identification	Identification, Positioning, Sensor	Identification, Positioning, Sensor
Coverage: 3-5 m per reader	Coverage: 5-50 m per reader	Coverage: 20-100m per station
Very immune to interference	Unstable with layout changes and radio interferences	Exact location in real time with accuracy of 0.3 m
No battery	Battery: From 2-5 years	Battery: Upto 2years
Expensive to install	Plug and play readers	Plug and play readers
Not compatible with smartphones	Compatible with smartphones	Compatible with smartphones

3. MATHEMATICAL TECHNIQUES FOR INDOOR LOCALIZATION

Triangulation:

Triangulation uses geometric knowledge to obtain the location of user. The location of user can be determined by either the distance to the fixed known measurement points, or the received signal angle.

Figure 1 shows how to get the location of user through distance and angle information. Suppose we have base A, B and C, three fixed wireless beacon stations in known positions. In (a), if the distance of the user point to all three base stations is known, the location of user point can be expressed as the intersection of three circles.[11]

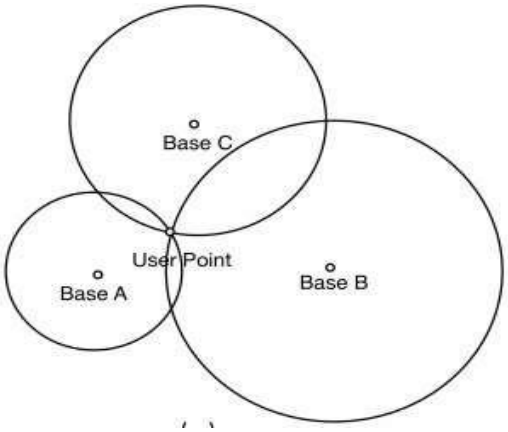


Fig.1

In triangulation location of the user can be find out by two methods:

1) Angle Based Triangulation

AOA (Angle-of-arrive) is a method to get the angle of received signal from known stations to get the location of user position. The angle of signal can be easily retrieved if the user device and beacon stations uses directional antenna technology.[11]

2) Time Based Triangulation

Time based triangulation is one of the method that use distance for triangulation. The assumption under time based triangulation is that the time used from beacon to user point can be used to infer the distance between the two points. Since the travel speed of wireless signal is known, it approximately equals the speed of light in the air. For time based triangulation there are two types of methods: ToA (Time of Arrive) and TDoA (Time Difference of Arrive). [11]

Time-based Methods

Time of Arrival (ToA): It is the simplest and most common ranging technique and is used in GPS. This method is based on knowing the exact time that a signal was sent from the target, the exact time the signal arrives at a reference point, and the speed at which the signal travels (usually the speed of light). Once these are known, the distance from the reference point can be calculated using the simple equation[2]-

d = c ∗ (ta-ts)

where, c = the speed of light, ta = time of arrival

ts = time of sent.

There are two Time of Arrival techniques-

One-way ToA: One-way propagation of signal requires highly accurate synchronization of sender and receiver clocks.

3) Distance = (t2-t1)*v

Two-way ToA: Round-trip time of signal is measured at sender device. Third message if receiver wants to know the distance.

4) Distance = (t4 – t 1) – (t3 – t2) 2 * v

Time Difference of Arrival (TDoA): TDoA does not require the time that the signal was sent from the target, only the time the signal was received and the speed that the signal travels. Once the signal is received at two reference points, the difference in arrival time can be used to calculate the difference in distances between the target and the two reference points [2]. This difference can be calculated using the equation-

$\Delta d = c * (\Delta t)$

Where, c = speed of light

Δt = the difference in arrival times at each reference point.

In two dimensions, this leads to the following equation-

$$\Delta d = \sqrt{(x_2 - x)^2 - (y_2 - y)^2} - \sqrt{(x_1 - x)^2 - (y_1 - y)^2}$$

where, (x1, y1), (x2, y2) = known positions of the beacons.

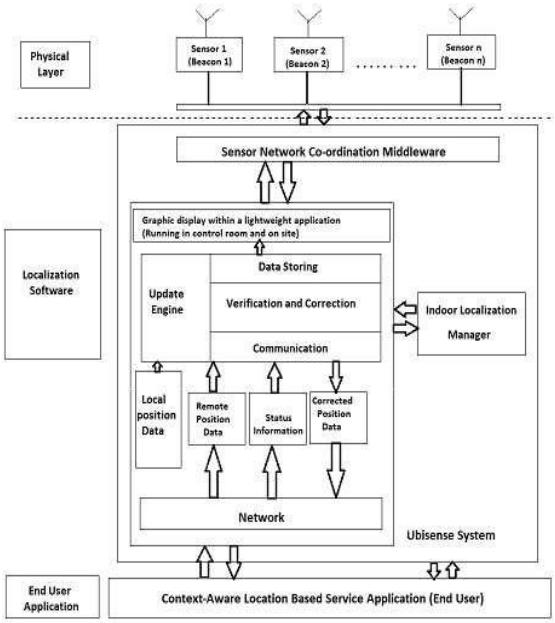
4. ARCHITECTURE

There are three major layers -

1. **Physical Layer** – This layer comprises of the database/data storage system and data access layer.

2. **Logical/Application Layer** – At this layer reside the application server and the programs that access the database. For a user, this application layer presents an abstracted view of the database. End-users are unaware of any existence of the database beyond the application.

3. **User (Presentation) Layer** – End-users operate on this layer and at this layer, multiple views of the database can be provided by the application. All views are generated by applications that reside in the application tier.



5. INDOOR LOCALIZATION METHODOLOGY IN FINGERPRINTING

Firstly, suggested fingerprinting technique divides cells based on fingerprinting technique and determines the cell user is located. At this moment, K-NN algorithm and moving average filter are used to increase accuracy. RSSI data from K-NN algorithm are gathered and the most similar cell is outputted by comparing those clustered RSSI data and user's actual location.[12]

5.1 Fingerprinting algorithm configuration for higher accuracy

In fingerprinting, each cell gets an ID when positioning sectors are divided in order to form database during Training process. [12]

Among the measured RSSI data of each cell, representative RSSI data is set and saved in database.

After establishing fingerprinting database through Training process, Bluetooth RSSI data is measured by Bluetooth signal receiving device. Received beacon's ID and RSSI data get checked up before outputting the

positioning result using matching algorithm. Matching algorithm used throughout this paper consist of KNN algorithm and moving Average filter. K-NN algorithm begins by arranging RSSI data of received beacon's ID in ascending order. The top three RSSI data of beacon's ID gets calculated by weighted value given. Any error of cell with the highest score can be detected using moving average filter. In other words, if the data of selected cell is within error range, the original weighted value is used and in other case, moving average is used to calculate the final value. [12]

6. SCOPE

a) Providing indoor navigation systems for blind and visually impaired people.

b) Aiding tourists in museums.

c) Finding an emergency exit in a smoky environment.

d) Navigation in large mall or complex yet unfamiliar place for users, for e.g., it could help users find the best way to their desired store or nearby facilities like restroom, or diaper changing stations.

e) Robot navigating system in indoor environment. The location information can tell them where they are and guide them through the building..

CONCLUSIONS

Positioning is one of the most important and challenging phases in navigation systems where different technologies have been developed to improve performance. In recent years, indoor positioning has emerged as a critical function in many end-user applications; including military, civilian, disaster relief and peacekeeping missions. Several factors can contribute to the enhancement of positioning performance. For example, a prior knowledge on the environment can improve the positioning performance while cooperation among the nodes may enhance the performance if carefully exploited.

This project will prove to be a helpful tool for indoor localization of visitors in the campus area. It will serve asa road map inside the campus to them.

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