A SURVEY OF INDOOR POSITIONING SYSTEM BASED ON DIFFERENT HARDWARE TECHNOLOGY

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Abstract: Indoor positioning has its roots in the limitations of GPS. As far as its scope is concerned, it plays a vital role in increasing the positioning accuracy when the radius of targeted location is decreased. There are more than one ways to achieve this goal. If the use of hardware technology is subjected, RFID, Wi-Fi networks, Bluetooth, Ultra Wide Band etc. are the means to achieve IPS. If the positioning techniques are addressed, Time of Arrival (TOA), Time Difference of Arrival (TDOA), Angle of Arrival (AOA), Received Signal Strength Indicator (RSSI) and Triangulation, Trilateration, Scene Analysis etc. are at our disposal. Also addition of Machine Learning algorithms like KNN, improve its estimation process and reduce the errors. In this survey we will study applications of IPS based on different technologies. We will be focusing on four technologies only, those are Wi-Fi, Bluetooth, RFID and UWB.

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KEYWORDS: Indoor positioning, Wi-Fi, Bluetooth, RFID, UWB, Time of Arrival (TOA), Time Difference of Arrival (TDOA), Angle of Arrival (AOA), Received Signal Strength Indicator (RSSI) and Triangulation, Trilateration, Scene Analysis.

I. INTRODUCTION

Indoor positioning system is one of the emerging trends as far as huge corporate or academic architectures are concerned. A very prominent example of this is Yahoo Japan. Yahoo's offices have a promising scale and IPS helps it. Even though the idea of IPS sounds very simple to hear, it needs a deep understanding of the hardware technology which we are planning on using. All different hardware technologies have different attributes based on which their working differs.

We have studied a number of papers based on the above mentioned four technologies and each one has its own advantages and disadvantages. Different technologies can be deployed based on the work area, financial capabilities, client expectations, user preference etc. We will study all four of those technologies one by one as we move ahead.

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II. LITERATURE SURVEY

Rejina Wei et. Al in the paper High Precision UWB-IR Indoor Positioning System for IoT Applications has proposed the design and implementation of ultrawide band indoor positioning system using impulse radio methodology. Location is estimated using differential time difference of arrival technique.To overcome the limitation of constrained operational hours from UWB transceivers, the mobile tags in the proposed system operate as UWB transmitters and the command and control is handled via UHF data links. The fixed anchor nodes of a positioning system provide more flexibility in terms of power consumption and physical size requirements. In the proposed system, Beagle Bone Black (BBB) embedded platform is used by each anchor node. The architecture of the proposed system consists of a wireless network of fixed anchor nodes and mobile target nodes whose location needs to be estimated. The master anchor node initiates the process by broadcasting a beacon via UHF link to mobile tags. The mobile tag receives the beacon and sends the acknowledgement along with its ID to anchor nodes. Subsequently, it generates and transmits UWB pulses for position estimation. The anchor nodes acquire the UWB signals from the mobile tag as well as the reference tag and compute the signal TOA data. The reference tag is a device whose location is already known. The TOA data is then transferred to the central server using WiFi links. The central server runs MATLAB to estimate the location of mobile tags using TDOA values computed from the received TOA data.A wireless local area network (WLAN) is created in which all the anchor nodes are the hosts in the network and the central server acts as a Dynamic Host Configuration Protocol (DHCP) server which assigns dynamic IP address to the anchor nodes. The anchor nodes constantly poll the Network Time Protocol (NTP) server for time information via User Datagram Protocol (UDP) packet, and adjust their clocks based on the received timing information. This enables the anchor nodes to timestamp each TOA value from the mobile tag at different time slots. This technique also provides the facility to time synchronize the anchor nodes within the WLAN for achieving millisecond-level time accuracy.

The advantages of this paper are power consumption reduced, command and control is handled via UHF data links and good computational speed, low power consumption, reasonable hardware cost and reduced development time for the system. The disadvantages here are accuracy beyond mm cannot be gained and tests are performed only in a single environment.

In particular, Paolo Dabove et. Al in his paper Indoor positioning using Ultra-Wide Band (UWB) technologies: positioning accuracies and sensors' performances is focused on testing and evaluating the performances of a commercial solution called Pozyx, an UWB network solution which exploits also other sensors measurements like inertial chipsets, magnetometers and altimeter. The tests were conducted in 3 different environments and the accuracy was found as high as few millimetres. In this paper, an Ultra wideband (UWB) indoor positioning commercial system is presented which exploits two-way time of flight (TWTF) to compute range measurements. These measurements are used in multi-lateration method to compute the position of a transreceiver (TAG). The average 3D accuracy obtained from the test is 100 ± 25mm. Also the ranging measurements has been analysed as the raw data from which the Pozyx inner algorithm starts to compute the positions.Pozyx® accurate positioning is a UWB-based hardware solution able to provide position and motion information. It has been demonstrated that the range accuracy is about 320 ± 30mm. After these first tests, the system has also been tested in a harsh environment in a narrow corridor where a horizontal accuracy of about 87.4 mm is obtained with a maximum ranging error of ±225 mm. The system and algorithms tested in this report gave almost similar performances in both environments. The system consist in a network of radiofrequency E/R modules with a very low power consumption. The bandwidth f 500MHz used by this system permit to send a pulse of 0.16ns wide, permitting accurate range measurements with an accuracy of about 30 cm. The network is composed by one tag, that transmit the package of data, and a series of anchors with well known position. Another tag can be added to this configuration in order to set a master-rover configuration for the emitter module. These system transmit with a power spectrum density below -41.3dBm/MHz a train of pulse that accumulated permit to the signal received to rise above the noise level. The maximum update rate for a single tag is currently as high as 80Hz (locally) or around 40Hz (remotely). With more tags the remote update rate must be divided by the total number of tags. Pozyx® tags are also equipped with an accelerometer, gyroscope and magnetometer. With these sensors it is possible to obtain the orientation of the device.Pozyx offers 9-axis sensor fusion (3 axes for every sensor) to get the best possible measurements. These tags can be connected to any computational external device, like Raspberry Pi and Arduino boards, permitting to interact with the microcontroller unit (MCU).

The advantages here are high accurate positioning, low power consumption, high level of multipath resolution and high data rate. Though raw data ceasing is tedious.

Abdul Alif Wafi Ab Razak et.Al in the paper Active RFID-based Indoor Positioning System (IPS) for Industrial Environment proposes an active RFID-based indoor positioning system (IPS) for an industrial environment.The work mostly focuses on Time of Arrival (ToA) and Received Signal Strength Indicator (RSSI) technique. Each technique has their own deficiency.Study is done such as relate both methods to overcome that deficiency. Ultra-High Frequency (UHF) RFID are used in this development of IPS. Based on a developed system, the tags are measured by three of an antenna that located in a different edge. The data get from antennas are send to the data collector by using 433 MHz wireless connection. Then all the data get are stored in the server and calculated to get the location of the tag.

Here advantage is that due to reference tags the accuracy of locating an object has been improved.While disadvantages are tag collision in the case when multiple tags are energized by the reader simultaneously.

Peng XU et. Al in the paper Research on Indoor Location Algorithm using RFID introduces the concept of virtual reference tags to generate a more accurate estimate, and makes each virtual tag own a more appropriate threshold using MVIRE method. Indoor location system based on RFID is consists of reader and tag. The number of the reader is four, and the readers are located in the four corners of the positioning area. The tags contain reference tags and target tags. Target tags are used to mark the target, the number of target tags depend on the number of the target. Reference tags are distributed in various parts of the location area. Firstly, we measure the RSSI of each tag. Then we calculate the Euclidean distance of each reference tag with the target tag based on RSSI. After that, we define a threshold T ,choosing some coordinate points which the euclidean distance based on RSSI is less than the threshold T ,and the number of the coordinate points is k. We call those coordinate points adjacent virtual tag. After getting the k adjacent virtual tag, through weight-average ways, we can get the location of target tags. The weight depends on the euclidean distance, the smaller the distance, the greater the weight. MVIRE method make the RSSI of virtual reference tags more reliable, because we get the RSSI by two directions ,not just one directions. The MVIRE method makes each virtual tag own a more appropriate threshold in order to improve the positioning accuracy.

The advantages here are recognition distance is more,multi-object recognition and also the speed of recognition is good.However positioning accuracy in not that correct.

Jongtaek Oha et.Al in the paper Adaptive K-nearest neighbour algorithm for Wi-Fi fingerprint positioning proposes various IPS making use of fingerprinting technique for positioning. Even though it is convenient and easy to execute it has a certain amount of error introduced for various reasons. So to avoid this KNN algorithm can be used. But a fixed value of K cannot promise a perfect output .So, based on the error factors for each Test Point when compared to its closest Reference Point, the value of K is set.

Here the advantage is that while working with KNN, for some cases the error was non-existent even for K=1 without adding any additional infrastructure.However limitation is that a few cases still showcased errors as large as 2.5m.

S.M.Siratim Mustaquim et.Al in the paper An Indoor Positioning System Model Using Wi-Fi Network has approached to create a IPS based on minimalistic approach. Their approach is to have a light and dynamic application. Though this paper has not addressed any of the error factors in this process but they have a given an in depth knowledge of all the important terminologies in the IPS domain like RSSI, Trilateration, triangulation, fingerprinting, TOA, AOA, FSPL and Euclidean equation. Use of mathematical equations and applying time based techniques to acquire RSS and compare it with fingerprint data.

The merits here include less computing power,easier to understand and implement.While the demerits are cannot function properly when interference is introduced.Also errors are introduced in Windows and Android based FSPL technique.

Yaxiong Xie et. Al in the paper Precise Power Delay Profiling with Commodity Wi-Fi has proposed a unique and innovative way to decrease the error factor in the IPS data. When we consider Wi-Fi hardware as a way of achieving well functioning IPS with a budget we need to consider the humungous error factor in CSI data. The authors of this paper have created their own new software named CUPID and splicer. CUPID and CUPID-Splicer here reduces error in each component of the CSI like, phase, amplitude etc. And then combine it to produce high quality power delay.

The proposed method here can overcome all kinds of interferences and superimpositions which gives it an advantage over others. However it needs high processing space as two software play an important part in splicing.

Suk-Hoon Jung et. Al in the paper Methods and Tools to Construct a Global Indoor Positioning System have proposed their ideas way ahead in the future and has a huge scope. These people are trying to create a global level IPS system. And to achieve this they have chosen Wi-Fi as their technology as it is the only IPS supported technology that easily available on a global level. They have created a tool name KIALOS (KAIST ILS) to satisfy this purpose. Access points are set up across the area and radio maps are generated by using tools of KAILOS (KAIST ILS) like KAI Maps, KAI Pos and KAI Navi.

Here the advantage is software works and gathers data from users to create a Global level IPS.The disadvantages are privacy risks and learning based methods needs a large data set and hence large processing time and power.

Jun-Ho Huh et. Al in the paper An Indoor Location-Based Control System Using Bluetooth Beacons for IoT Systems has suggested the use of BLE in the process of IPS. To deploy IPS they divide the area in multiple hexagons. The beacons are deployed at the corners and the centre of the hexagon. To measure the distance here RSSI is used. To deal with loss of energy w.r.t. distance path-loss model is used. They have used an HM-10 module and a Arduino UNO with techniques like Spatial Partitioning using Trilateration.

The pros of the proposed system are performing trilateration can provide highly accurate result.However every indoor area is divided into multiple hexagonal divisions and every hexagonal division has 7 beacons, thus increasing the number of beacons immensely.

Dongyao Chen et. Al in the paper Locating and Tracking BLE Beacons with Smartphones have created a smartphne application called LocBLE which interacts with nearby BLE beacons. They have given their system architecture where they have mentioned all the three layers in their system. They have dedicated layers to data collection, location estimation and caliberationtheir aim at good accuracy is achieved by mitigating RSS signal fluctuation.

The advantages are pseudo Standards help in identifying the advertising packet from any other Bluetooth packet. While the disadvantages are the embedded payload must be formatted so as to follow the pre-defined Pseudo-standard that the beacon uses

III. Discussion

The above literature survey has led to conclude that each of the technology has its own dominated work situation where only that technology can provide accurate and trustworthy output. Based on different attributes the technologies can be differentiated as follows:

Parameters	RFID	UWB	Wi-Fi	Bluetooth
Range	1m	Upto 150m	Upto 20m	Upto 7m
Financial feasibility	Less expensive	More expensive	Less expensive	More expensive
Accuracy	Within 10cm	30cm	Upto 45 meters	2-5 meters
Battery life	No battery	Up to 2 weeks	No battery	Upto 48 hours
Hardware feasibility	Easy to set up	Complicated to set up	Easy to set up	Easy to set up

IV. Conclusion

To choose hardware between the above 4 to deploy any project is not an easy task. We firstly have to understand the needs of the client, the area of the location for which the system is to be deployed and the financial feasibility of the client, and through what device the system is to be deployed. Based on this data the choice of hardware becomes crystal clear. Each of the above hardware has its own plus points. It’s up to the programmer to decide the technology according to gathered data and use it to create an IPS as accurate as possible.

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