IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⁜ Vol. 10, Issue 2, February 2022

DOI: 10.17148/IJIREEICE.2022.10233

Fingerprinting Techniques for Indoor Localization: A Survey

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Abstract: Location of a user or a device is of extreme importance. In case of outdoor environments, Global Positioning System (GPS) signal is widely used to determine the position of a user. However, in case of indoor environments, GPS technology fails to carryout. Hence, there is a need to develop an alternative technique for indoor localization. For indoor localization, several techniques are employed, among these techniques, fingerprinting provides several favourable features for indoor environments. This paper carries out the literature survey of fingerprinting techniques used for indoor localization. The fingerprinting is one of the most popular methods of localization because of its high accuracy compare to other methods.

Keywords: Global Positioning System (GPS); Indoor Localization; Fingerprinting

1. INTRODUCTION

Location of a user or a device is of extreme importance. In case of outdoor technology, GPS signal is widely used to determine the position of a user. However, in case of indoor environments, GPS technology fails to fulfil. GPS signal is weak to travel in turns and the location found out is not precise. Hence, there is need to develop an alternative technique, for indoor localization. Over the years various technology, like Bluetooth, Wi-Fi, Zigbee etc., are research to find the best possible technology suited for indoor localization.

Fingerprinting is the most popular method of localization because of its high accuracy compared to other methods. It does not require line-of-sight measurements of access points (APs), has low complexity and gains high applicability in the complex indoor environment. Indoor fingerprint positioning technology mainly uses signal fingerprint and uses the Received Signal Strength (RSS) of every location (as fingerprints are stored in the fingerprint database) to match the signal strength measured at user's location to achieve positioning. This review paper provides the fingerprinting techniques for indoor localization.

2. LITERATURE SURVEY

Literature Survey has been carried out in this section. This section outlines features of fingerprinting techniques for indoor localization.

In paper [1], author describes the fingerprinting techniques as a means of measurement of devices, instruments or person's location in indoor or closed buildings. First, a local map will be created based on the signal strengths received from the different locations of the building. Then location will be determined later by matching the signal level received at the time of measurement with the signal strength already recorded. The limit of this technique is the measurement of signal strengths in wireless systems which deteriorates with power. To improve this condition, multiple measurements from multiple nodes will be taken to match measurements with the recorded values. This paper focuses on measuring signal strength using the Bluetooth wireless system and improving its accuracy using different machine learning algorithms. This paper also compares the complexity and accuracy trade-off in the one-dimensional and two-dimensional environments with signal strengths measured from four set of anchor nodes. This paper also reviews the performance of machine learning techniques Random Forest, Support Vector Machine, k Nearest Neighbors and Artificial Neural Network. Also proves that Random Forest as best technique with accuracy of nearly 99%.

In paper [2], author describes the indoor localization technique in which the indoor environment will be split into different sets for better characterization and the position accuracy will be improved using the Bayesian Estimation. This system is also tested in Bluetooth wireless systems. In this paper location information will be added to the received signal strength

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to improve accuracy in positioning. Combining K-Means with Bayesian improves accuracy than the Bayesian Estimation alone in terms of indoor positioning.

In paper [3], author suggests that GPS can be used for outdoor localization, but it has limitation in indoor localization. Also, indoor localization is not adopted widely because it is complex and costly in terms of implementation. This paper suggests a methos of indoor localization using Wi-Fi technology, Wireless Local Area Network. This paper combines two Wi-Fi techniques for locating the user. First technique is the usual fingerprinting technique in which the received signal strength will be matched with the pre-recorded value. In second technique, distance-based trilateration will be used in which three access points will be used to derive the user's location. Combining both techniques improves indoor localization accuracy in deploying Location Based Services (LBS).

In paper [4], author describes the importance of indoor localization technique in the recent years and the application of various wireless technologies and techniques to improve its accuracy. Detailed survey of the indoor localization techniques such as Received Signal Strength (RSS), Time of Flight (ToF), Angle of Arrival (AoA) and Return Time of Flight (RToF) has been proposed. Also, the different wireless technologies used for indoor localization such as Wi-Fi, Bluetooth beacons, ZigBee, RFID systems have been compared. Different techniques have been compared in terms of energy efficiency, accuracy, latency, cost and range. Not only comparison of the localization techniques but also its description and working details are described in the paper.

In paper [5], author proposes a compartmental method for real-time tracking in wireless networks. Compartmental model uses fusion data from the multiple sensors. In the multiple sensor model, data will be derived using the sum of exponentials model in which model using acoustic, visible light and radio signals will be derived. Individual sensor data will be selected based on the bandwidth utilization criteria. In this model, high accuracies will be obtained in tracking because of the use of Prony estimator computation. The other advantages of this model include asymptotic distribution of estimator and lower computational complexity. Results obtained from compartmental model indicate improvement in tracking compared to state-of-the-art methods.

In paper [6], author proposes a method of improving the traditional old fingerprinting technique by combining it with WCL, Weighted Centroid Localization technique. This method reduces the number of reference points considered thus reducing the time required for reading the radio signals which in turn reduces the time consumed by the whole process. There are two steps in this proposed method. First, fingerprinting and WCL from reference point which is lightly populated will be considered. Next, WCL will be run again using the location obtained from the previous step. This method reduces the number of fingerprint Reference Points by 40% compared to traditional fingerprinting technique with similar location estimation error.

In paper [7], author emphasizes on the importance of development of wireless technologies for improvement of indoor localization. Indoor localization techniques can be used to overcome the limitation of using GPS for indoor localization. It indicates the process of localization as a combination of receiving signal, measuring its strength and to calculate position based on that. This paper also discusses localization techniques in different categories as time-based techniques, angle-based techniques and methos based on Received Signal Strength. The method of calculating positions using these methods based on the measured signal parameters have also been discussed. These methods include trilateration, Triangulation and MLE (Maximum Likelihood Estimation).

In paper [8], author describes an Indoor Positioning System that combines WLAN fingerprinting and Image Processing technique. First part in this system is image processing is used for locating the position and the WLAN fingerprinting is used for supporting to improve the performance of the system. In next part, WLAN fingerprinting is used for position estimation and support will be provided by image processing for improving system performance. Image processing will be used for construction of building map whereas WLAN fingerprinting will be used for location estimation. This methos will have two databases, RSSI database and Image database. Later combining both techniques Indoor Positioning System will be formed for location estimation.

In design guide [9], discusses about the Cisco RF fingerprinting technique for designing an Indoor Localization System. This design guide from Cisco provides guidance for designing the Location Based Services Solutions. These systems can help in position tracking for Wi-Fi 802.11 RFID Tags or standard WLAN clients. These systems include RFID tags which are capable of authenticating and associating with the WLAN infrastructure. This design guide also discusses the best deployment practices for these WLAN based Location Service Systems. Also discusses about the Traffic and RFID Tags considerations for designing these systems.

In article [10], author discusses the recent advances in the Wireless Indoor positioning systems and the localization techniques. Nowadays demand has been increased for indoor localization because of the increase in demand for the real-time tracking of personal belongings inside buildings. Different performance metrics like accuracy, responsiveness, coverage, adaptiveness, Cost and Complexity for measuring the effectiveness of the indoor positioning system has been discussed. Different location detection techniques like direction-based techniques and distance-based techniques have been discussed. Also, different wireless technologies used for indoor localization like WLAN, Wi-Fi, RFID, Bluetooth, ZigBee have been discussed and compared in terms of their usage for Indoor localization Systems.

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In paper [11], author describes about the new indoor positioning method which is based on Wi-Fi fingerprints that is RSSI measurements from one or more Wi-Fi access points. In this there are two modes- offline mode and online mode. In offline mode, all fingerprints are collected at known positions in buildings, which is stored as database. This database of locations and the collected fingerprints is known as radio map. During the online mode, the present Wi-Fi fingerprint probability distributions are compared with those stored in radio map. In this paper, the signal strength probability distribution of each detected access point (AP) is estimated in both offline and online phases, in order to find the nearest offline locations in indoor positioning system with improved accuracy of fingerprint.
In paper [12], author describes the fast-fingerprinting method by using indoor path-loss model instead of using reference points with complex measurement devices. The proposed method in this paper is to provide utilized fingerprint RSS values, instead of the measured ones. These values are achieved by using path-loss model for indoor environments. A simulated data using a path-loss model and a measured dataset collected by smart phones are employed, analysed and compared. K Nearest Neighbor (KNN) and K Weighted Nearest Neighbor (KWNN) are the two most common deterministic algorithms in location fingerprinting technique which are implemented in this paper to localize users in an indoor environment.

CONCLUSION

Fingerprinting techniques is one of the best methods for indoor localization. It provides high accuracy and best results compare to other methods. This paper surveys the recent advances in fingerprint localization techniques and system which are implemented in indoor positioning systems.

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