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An Approach for Efficient Object Tracking for Indoor Localization

Pooja Amdhare[1] Archana Raut[2]
[1,2]Department of Computer Science & Engineering
[1,2]G. H Raisoni College of College of Engineering, Nagpur, India

Abstract— Positioning systems plays an important role in finding location information. Location based services are increasing very rapidly and hence the demand for efficient positioning system is also increasing day by day. For positioning Global Positioning System (GPS) is mostly used all over the world but it's very power consuming and it not very effective in built-up indoor environments. So positioning techniques like Global System for Mobile Communications (GSM) and Wi-Fi based on wireless sensor networks are used. We implemented the localization system using Received Signal Strength (RSS) for Location Defining Phase, by collecting the different values of the Defined Area which is used for the localization. It includes Basic Artificial Neural Network (ANN) Mapping Algorithm to transform the RSS Integration to the Mapping of Longitude and Latitude of the Database. Location Estimation Phase uses the supervised dataset for Determining the current Location of the device. The system overcomes drawbacks of GPS and reduce transmission load, computational overhead, computational iteration and efficiently localize the device.

Key words: Global Positioning System (GPS), Global System for Mobile Communications (GSM), Wi-Fi, Artificial Neural Network (ANN), Received Signal Strength (RSS)

I. Introduction

Location Information plays a crucial role in many applications and services. In Wireless environment detemining location is a challenging and important task in many Localization applications. Positioning accuracy of the devices in indoor as well as outdoors require fine accuracy. The Global Positioning system covers the entire globe and provides accuracy in open environments provided that the receiver is in the visible range of the four satellites that are covering the earth surface. Due to signal blockage in GPS for indoor environment IEEE 802.11 WLAN (Wi-Fi) is an attractive solution for indoor positioning environments [1,4,5]. Entertainment, Military and various other utility services have given a boost to the location based services (LBS) . GPS devices works well in outdoors and Wi-Fi devices outperforms well in indoor environments by eliminating the inefficiencies of GPS system like the unacceptable energy cost and the signal inability to penetrate into the indoor environment [2]. Patients monitoring, rescue operations and security based applications focuses on indoor positioning thus indoor localization is a key issue in the present era[1].

In Wi-Fi Systems the time to establish connection is 1 second, time to send request packet is 1second, time to process location algorithm is 3seconds, time to receive response is 1 seconds and time requires to end connection is 1second respectively while in GPS system time to establish connection is 6 seconds, time to send request packet is 6 seconds , time to process location algorithm is 0.5 second ,time to receive response is 6 seconds and time to end connection is 6 second. We can see the difference between the processing time of both the system and it is clearly visible that the overall processing time of Wi-Fi system is far better than that of GPS system Time Comparison of Wi-Fi and GPS system shows that. in GSM system time as well as transmission load increases by multiplier (0.2) with addition of new device which is very less compared to GPS system where time and transmission load becomes double with addition of every new device. GSM is more preferable with respect to time as it process most of the tasks in less duration compared to GPS.

Many wireless methods like Wi-Fi, radio-frequency based identification(RFID), Bluetooth and Ultrawide Band (UWB) primarily focuses on localization and based on triangulation and fingerprinting methods [3]. Triangulation requires heavy hardware installation whereas fingerprinting methods rely on already existing infrastructure which makes it more preferable. One of the widely used fingerprinting based technique is Received signal strength due to its cost effectiveness and the datasets required for taking RSS measurement are easily collected from the area under experimentation.

The triangulation method requires at least three fixed points to locate the position. This method calculates the distance from station to device and the distance is then used as radius from the station. In fingerprinting approach RSSI measurement are recorded along with GPS measurement which are used to locate the device [3,6,7].

The Paper focuses on the various implemented techniques and their uses and limitations in localization approach, the architecture of the localization system for location based services and facilities which uses wireless networks like Wi-Fi, RSSI readings and ANN algorithm based on supervised learning. The rest of the paper covers the briefness of Training and estimation phase, Experimental results and discussion and the Performance analysis of the system.

II. Related Work

Large amount of work have been done for localizing objects in indoor environment and is primarily focused on following techniques:

1) Time-based
2) Angle-based
3) Signal Strength(Power-Based)

Time based techniques focuses on RF signal time of flight(TOF) to estimate the range. They require line of sight (LOS) [9], between transmitter and receiver hence are not preferred for indoor environments. Angle -based approach is also not suitable to indoor since it rely on estimating the angle of arrival of RF signals[1].Power based techniques like received signal strength is widely used in indoor due to its low processing power and energy consumption.

A cross layer approach (FILA) comprised of two models, CSI based propagation model and CSI based fingerprinting. It is implemented on 802.11 NICs which shows a significant location accuracy than traditional RSSI approach, however the spatial diversity is not taken under consideration [2].

In BWC a feature type is defined for a components stored in a record that are homogeneous in nature. The record contains two different feature types, a location feature type and Radio Access Technology. It is noteworthy that it does not require any additional processing while recording the datasets of the initial database. All the components that are homogeneous are assigned equal weight factors [4].

Access points are used to build the WLAN-based indoor positioning system. Instead of collecting small subsets of access points the elements are replaced by principal components in order to ensure accuracy. Actual RSS samples are collected for the operation of entire model though there are limitations of linear transformation and it also exclude noises. There are possibilities to investigate nonlinear approaches like Isomap [8].

LOS radio map matching primarily focuses on the knowledge of phase information. The operating frequencies of the router are different and may vary from place to place resulting in different RSS values. The phase information of the signal is obtained with the help of different operating frequencies. As a result the LOS signals are filtered out from multipath signals, merely changing the channel of the radio signal provided with the phase information [9].

RSSI algorithm based on Interval analysis takes into account the complicated factors on RSS data and provide a robust and effective technique but the weakness of the method is that the overall computation cost of the process is increased [10].

A method using Monte Carlo importance sampling is for TDOA based source localization significantly decreases the computational cost but is only limited to LOS environments and is not suitable for non-line of sight of sight(NLOS) environments[11].

By using polynomial modeling on relationship between RSSI and distance more number of RSSI points are located on the anchor trajectory and the technique achieves higher accuracy but an intelligent approach for comparison is not presented [13]. Localization of objects using Cross-Correlation of shadow fading noise focus on copula function and provide localization accuracy but the computational overhead is very exhaustive[13].

Extensive efforts to deploy the RSS localization system are minimized with limited calibration radio-map construction. Datasets known as simulated radio propagation map and the environment's plan coordinate are tested to localize the indoor entities [14].

III. PROBLEM DEFINITION

The existing GPS System shows poor performance in crowded and built up areas and also suffers from signal blockage for indoor environments hence Wi-Fi system is used to eradicate this problem and the computational overhead was also a problem that needs to be focused in indoor mapping schemes. None of the indoor techniques focus on intelligent mapping of the recorded samples for localizing the object. The use of artificial intelligence with RSS and Wi-Fi will intelligently localize the device using supervised learning algorithm.

IV. ARCHITECTURE OF SYSTEM

The system architecture of the proposed system is shown in fig.1.

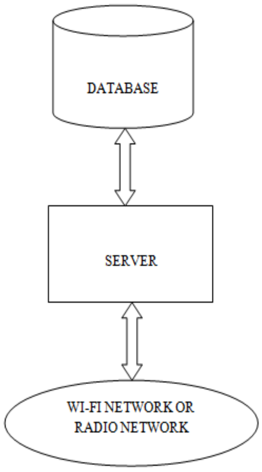

Fig. 1: System Architecture

For network connectivity Wi-Fi Router is used. This allows the application to fetch the data from the devices that needs to be located and send the fetched data to the server where the algorithm perform the computing and processing action .The server also handle all the operations between database and device present in the Wi-Fi network and provide the location trace in terms of latitude and longitude.

Localization is widely used in location based services for security and tracking purpose. An innovative artificial neural network mapping approach that uses supervised learning to trace the indoor localization is used. Also, the computational overhead of each iteration or calculation is reduced improving the speed and saving the time for tracing the location. Artificial Neural Network intelligently transforms the collected RSS samples into the mapping of longitude and latitude with supervised learning. In supervised learning, teacher is already present. Here the already collected sample values will act as teacher. Hence output is found on the basis of example pairs that matches with the stored pattern.

Fig 2.Shows the workflow of the proposed plan:

It starts with constructing a map of the area under experimentation in indoor environment, it includes manual construction of map coordinates.

1) The map is traced by recording the signal strength or radio values at each coordinate and radio values at different interval of time and distance are collected and stored into database.
2) The located co-ordinates forms class as the map tracing phase is repeated and same number of co-ordinates are again stored in the database with their radio values to make the system more robust and to improve location accuracy.
3) Map tracing also provide Wi-Fi router details like SSID(Signal Strength Identification),MAC address of all the available router in that environment.MAC adresses is unique address and it help in distinguishing various routers with same SSID.
4) All the router details and obtained RSS samples are compared using KNN algorithm and location is traced by comparing the radio values.

5) Finally the map matching is done with the help of ANN algorithm and its performance is compared and which gives the location trace in terms of latitude and longitude.

The efficiency is improved with the neural network as it use supervised learning algorithm and reduces the number of computational steps performed by using knowledge of the stored samples .Localization is widely used in location based services for security and tracking purpose. An innovative artificial neural network mapping approach that uses supervised learning to trace the indoor localization is used. Also, the computational overhead of each iteration or calculation is reduced improving the speed and saving the execution time for tracing the location.

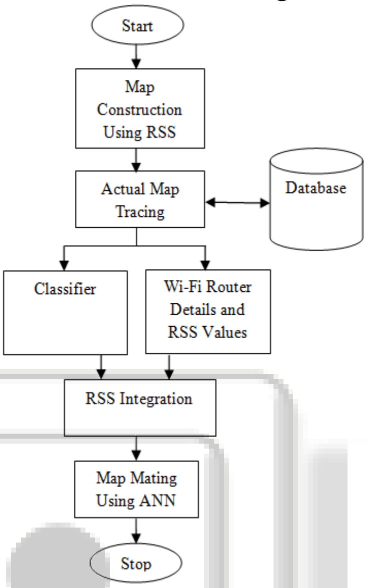

Fig. 2: Work-Flow Diagram

V. TRAINING AND ESTIMATION PHASE

The Lab shown in fig.3 taken under experimentation is observed carefully and divided into two axes X and Y respectively from a common origin point (0,0). Afterwards respective coordinates are taken along X and Y axes.

While storing the coordinates into the database the respective Wi-Fi strength of that particular position or co-ordinate is also stored into the database.


Fig. 3: Experimental Area

Manual construction of Radio map is the first and most important task in training phase. The area in which location is to be detected or the experimental area under consideration is divided in a grid like formation as shown in fig 4. The area is divided in X and Y axis respectively and further process is carried according to the divisions.

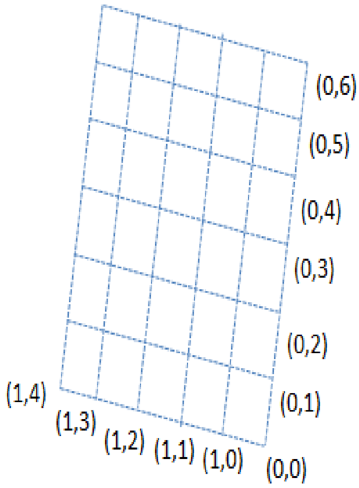

Fig. 4: Division of Co-ordinates

The training phase helps in creating a database of signal strengths of Wi-Fi routers along with their X and Y co-ordinates, MAC address, location date and time and Wi-Fi SSID. All this entities together form a database of trained samples. This information helps in retrieving the location information during the estimation phase.

Estimation Phase is dependent on the Trained data recorded during the training phase. Supervised learning algorithm is used to estimate the location. The ANN works using the three layers of neurons the input layer, the hidden layer or middle layer and the output layer as shown in fig 5. It works by comparing the supervised dataset recorded during training. Signal strengths are matched for all the available routers and the row with maximum matching is selected as output.

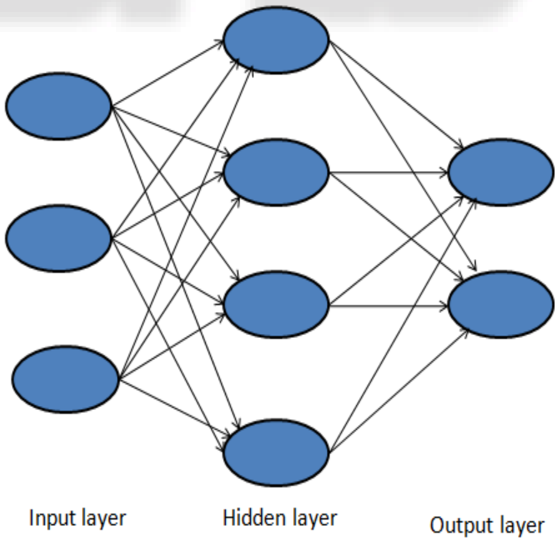

Fig. 5: ANN Structure

VI. RESULTS AND DISCUSSION

In training phase each co-ordinate is visited and radio values of Wi-Fi routers those are accessible at that particular co-ordinate are recorded in the database. Fig.6 is showing the list of Wi-Fi devices whose strengths are recorded successfully in database .The Wi-Fi strengths are obtained in percentage are converted to dbm. The strengths are accessed with the help of network interface cards available in the devices that needs to be located. The access is provided with the help of manage Wi-Fi library.

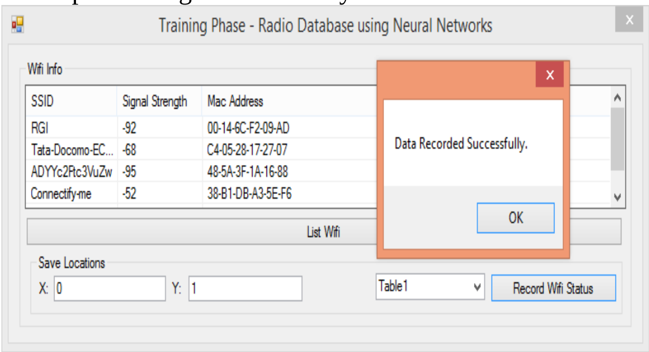

Fig. 6: Data Recording During Training Phase

To estimate the longitude and latitude a GPS co-ordinate is taken as reference and the respective longitude and latitude values are also stored in database. The ANN structure works in three layers as shown to retrieve the desired output row. It start with selecting the matched signal strength value of the all the available routers in the vicinity. The matching is done by selecting the value of signal strength of each available routers. If none of the signal strengths are matched an error correction factor is provided to resolve this and make a probable match. All the signals strengths of available routers are matched likewise and the row with the highest matching is selected to display latitude and longitude.

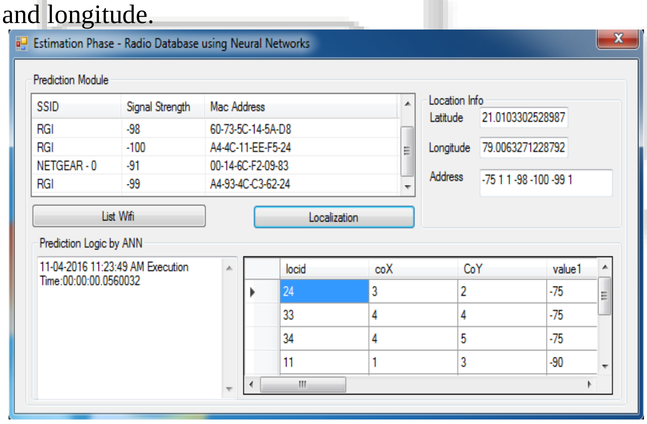

Fig. 7: Estimation Using ANN

The experimental results are also compared with KNN (k-th nearest neighbour) algorithm which does not work on the selected set of supervised data but takes the entire set of data for computation thereby consuming more time.

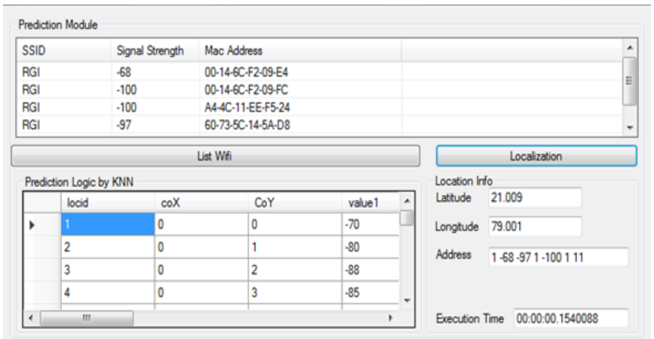

Fig. 8: Estimation using KNN

VII. PERFORMANCE ANALYSIS

The performance of supervised ANN algorithm is compared with KNN algorithm and a graph is plotted as shown in fig 7.

which shows a considerable difference between execution time of both the algorithms. The graph is plotted by taking the samples at (0,0),(1,1),(2,2),(3,3),(4,4),(5,5) respectively. The execution time required by ANN is comparatively low as compared to KNN because it uses only the supervised data that is matched or nearest to match during the estimation process.

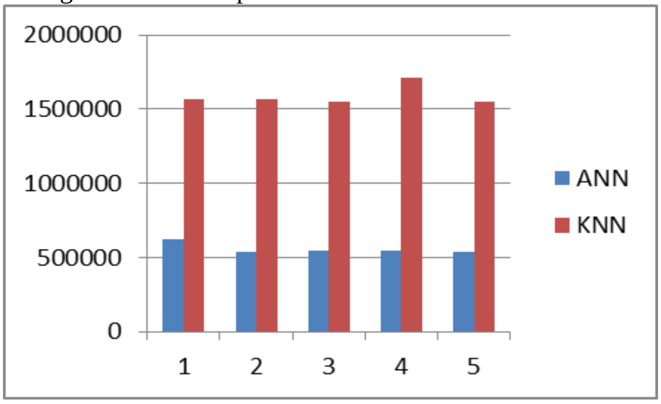

Fig. 9: Execution Time Comparison

VIII. CONCLUSION

The power-based localization approach like RSS does not require any special hardware and require low processing and energy. So the use of artificial neural network with the positioning system based on RSS reduce the computational overhead required per iteration with the help of supervised learning algorithm as it uses some samples out of all the trained samples. The datasets recorded at different time intervals will help in achieving the positioning accuracy of the system. Compared to KNN algorithm ANN gives better performance in terms of execution time as well as computational time required per iteration.

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