Campus Navigation Application

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Abstract— Global Positioning System is the most import ant contribution in determining position of user and in direction-finding him to his target. This system uses satellites to triangulate the position of the device. Though this system has made a good impression in terms of accuracy and is the preferred location based system for outdoor positioning, when it comes to indoor environment, GPS has proved to be incompetent. The reason for its inadequacy is that in order for GPS to perform a triangulation, the appliance needs to be in line-of-sight from the satellites. Moreover, GPS system has a low eminence which make it not appropriate for indoor areas. Therefore, when it comes to indoor positioning system, other alternatives such as Bluetooth, Wi-Fi, RFID and Infrared are more pleasing. This project proposes to implement a mobile application which will be able to estimate the position of a user within a building using WiFi technology. The Indoor Navigation Framework we have proposed allows any wheelchair user to be guided to a desired location on his own, as long as the building itself is adopted to the novel system. Unlike the state of the art, where no automation exists for guiding a wheelchair in modern buildings.

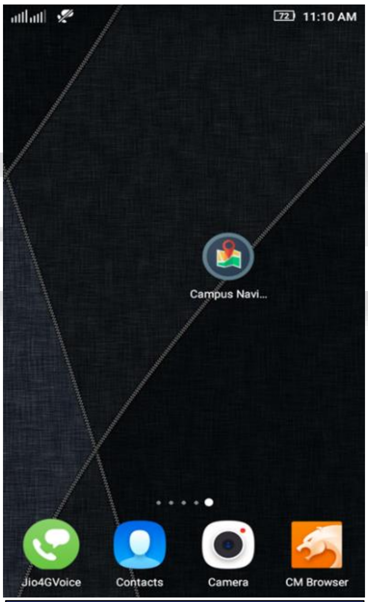
Key words: Framework, Indoor, Localization, Mapping, Navigation, Robotics

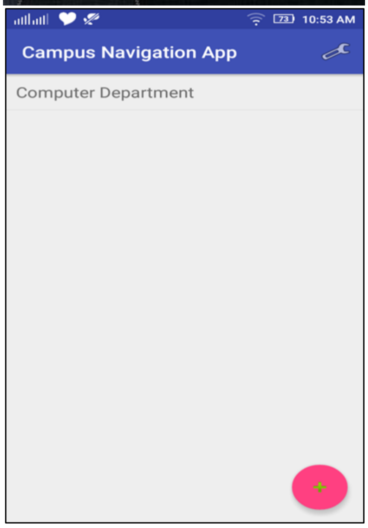
I. INTRODUCTION

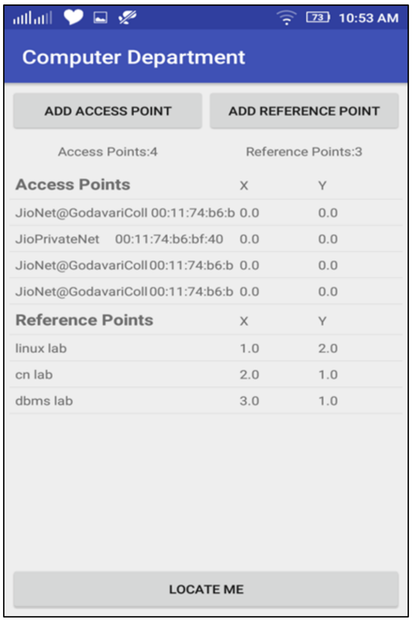
A. *Project Context*

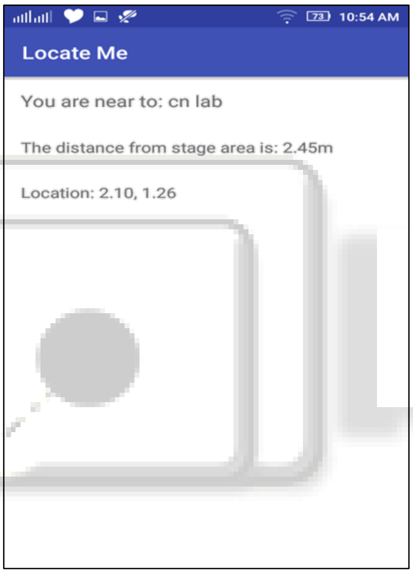
Within living memory the domain of navigation is of great interest and was regular researched and further developed. Nowadays, navigation and the possibilities provided by it have only very little in common with the orientation at landmarks and simple maps back then. Prerequisite for the development of navigation systems are sophisticated positioning methods which are able to provide the current location of a user or device with an adequate accuracy for a given context. Various technologies are available for different fields of application. The accuracy of these technologies range from several meters, up to a some centimeters, depending on the specific context. With the Global Positioning System (GPS), the Galileo system and other satellite navigation systems, several globally operating positioning technologies are available nowadays. These systems already proved its suitability for daily use in various products, such as car navigation systems and smart phones, or will do so soon. In most environments the globally operating positioning systems work well. However, in specific areas, such as urban neighborhoods (so called urban canyons) and indoor environments, these systems operate unreliably or, in the worst case, not at all. Various technologies are available to determine the location of a user or device in a local manner. These technologies are often based on optical, acoustic, or radio methods. Depending on the area of application and the specific environment these systems have various advantages and disadvantages. As Lorenz and Ohlbach [LO06, p. 102] state, "car navigation systems are becoming a more or less standard commodity nowadays [... and ...] the problem of navigating cars through large road networks has been well investigated and the solutions are mature". Less investigated is the domain of navigating pedestrians through indoor environments. An actively assisted indoor navigation system would be beneficial, especially in large buildings, such as airports, hospitals, supermarkets, and office buildings. Due to the wide distribution of smart phones and the numerous possibilities that those provide, this device class represent a suitable platform to implement an indoor navigation. system. Multiple sensors and external services can be utilized to determine a location as accurately as possible. The location information can be used within the navigation.

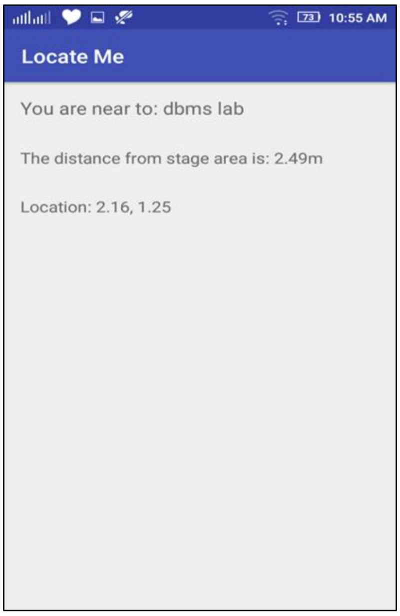
II. SNAPSHOT











III. DESIGN

A. *Location Fingerprinting*

The WiFi network inside a building makes it possible to distinguish different locations as they would receive different strengths from various routers. The received signal strengths thus act as a fingerprint for a location. Location fingerprinting based positioning systems usually works in two phases: calibration and positioning.

In calibration phase, several positions inside a building are chosen and RSS values from the different access points are recorded. Each of the n measurements become a part of a radio map and is a tuple.

$$(q_i, r_i) \qquad i = 1, 2, \ldots, n$$

Where

$$q_i = (x_i, y_i)$$

are the geographical coordinates of the ith location and

$$r_i = (r_{i1}, r_{i2}, \ldots, r_{im})$$

are the m RSS values from m access points at that location.
In positioning phase, the RSS values are recorded from n unknown location and a location estimator algorithm is used to and its coordinates from the previously created radio map.

B. *Weighted k-Nearest Neighbours (WKNN)*

The location estimator algorithm being used is the weighted k Nearest Neighbours Algorithm [5]. It is a two step process:
1) Find out the k nearest neighbours in the radio map:
Input: Set of all n readings from calibration phase

$$(q_1, r_1), (q_2, r_2), \ldots, (q_n, r_n)$$

Reading from current unknown location, r
Output:
Set of k nearest points.
Procedure:
Sort the n points in increasing order of Euclidean distance with current reading r. Euclidean distance is calculated by considering the readings as vectors.
Return first k readings in the sorted list

$$(q_1, r_1), (q_2, r_2) \ldots (q_k, r_k)$$

2) Calculate the coordinates of the current unknown location:

Input:

Set of k nearest points

$$(q_1, r_1), (q_2, r_2)...(q_k, r_k)$$

Output:

Coordinate of current unknown location

Procedure:

Calculate coordinates using the formula

$$q = \sum_{j=1}^{k} \frac{w_j q_j}{\sum_{l=1}^{k} w_l}$$

Where all weights are nonnegative

$$w_j = d^{-1}_{(r_i, r)}$$

d is the Euclidean distance between the readings.

qj is the coordinates of the jth location

WKNN has one tuning parameter, the number of nearest neighbours considered (k), which is used to control the locality of the location calculation. When k = 1, the algorithm acts as a simple look-up table.

For larger values, the location will be estimated to be somewhere in-between the calibration points.

C. Practical Difficulties

Various factors influence the level of accuracy of the system in practice, these were identified and their effects were minimized to the possible extend.

1) Fluctuating Received Signal Strength (RSS) readings:

The readings taken from a particular location could fluctuate often and can result in errors. This could be rectified by using the average of several readings from the same location

2) Identifying reliable Access points:

The access points considered for positioning purpose should be a permanent part of the structure and ideally be available at all times. Including temporary hotspots into the system should be avoided as they could negatively impact the calculations if they were relocated.

3) Orientation of users:

The orientation in which the user holds the smart phone can alter the signal strengths received at that location. This can be accounted to the users body obstructing the signals from one particular direction. Orientation specific readings should be taken in the calibration phase to counter this factor.

4) Proper positioning of Access points

The access points inside a building should be positioned in such a way that each location is uniquely identified in terms of the WiFi fingerprint described earlier. But there is limitation regarding what can be done in this matter.

D. Work Done

To perform the experiments, a prototype Android application of an indoor positioning system that works entirely on the users device (without requirement to have a back-end server) was developed. The application allows determining the position of the device using a prepared radio map and device built-in Wi-Fi chipset. The application works in the two location fingerprinting phases calibration phase and positioning case.

During the calibrations phase, user can select the reliable access points for that particular building.

This rules out readings from other access points from being considered for calculation. The experiment was done inside the top floor of CSED Lab building. The floor was divided into 5 grids as shown in Figure 1. In the calibration phase, the available Wi-Fi 5 access point RSSs are measured from different positions in the building. The measurements were taken for a defined period of time 30 seconds (readings became much more consistent then) and after that the average value is calculated and stored into the radio map.

In positioning phase, the application determines the actual position. RSS values of all the sensed APs are measured and compared to the ones in the prepared radio map to get the nearest neighbor. The nearest neighbor will be shown as a colored grid in the floor map. This method only uses the radio map as a look up table.

In calibration phase, the application has the following functionality:

1) Create/Remove a building
2) View/Add/Remove points to the selected building.
3) Perform fingerprinting by selecting the point from the list.
4) Add/Remove reliable access points from the list of available access points.

Functionality in the positioning phase:

1) Load and view map of the building.
2) Estimate position (in the form of grids as marked in the loaded map).

The readings taken from the calibration phase and the friendly WiFi list are backed up to a server and this enables new users to skip this phase by downloading these already calibrated readings.

At the time of positioning, the WiFi access points in the vicinity of the new device is compared with the saved points to dynamically ascertain the building and oor map to be loaded in the application.

A web page is created that saves the latest positions of all devices and allows users with proper priviledge to view them.

IV. Conclusion

The RSS Value at a particular location varies from device to device. So proper normalization of the readings should be done to get the application to work seamlessly in different devices.

Orientation specific values should be stored to the database in the calibrations phase. Only the values corresponding to the current orientation of the user (obtained from device sensors) should be considered in the positioning phase.

The second part of WKNN algorithm has to be implemented to get the users coordinates in between the chosen points from calibration phase.

The Wi-Fi trilateration method is using for indoor positioning and provides low accurate localization. For its improving can be used more accurate signal propagation models or expanded measures of signal strength including most number of reference point. Moreover, the further work can be continued on the Wi-Fi fingerprinting approach because the indoor localization algorithm described above may be considered as a special.

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