A Non-GPS Technology Approach for Complex Indoor Scenes Navigation using Android as a Platform

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ABSTRACT
Android has been emerging as powerful mobile platform which has provided handy functionalities for the development of indoor navigation software. Traditional GPS technology has its own drawbacks in the indoor navigation scenes. This paper focuses on the use of a non-GPS technology approach for the navigation in complex indoor scenes. The approach to achieve the optimal results in the complex indoor navigation includes use of Wi-Fi triangulation method, a* algorithm, 2-D code and block's color sequence for navigation purpose.

General Terms
Android, Mobile computing

Keywords
Wi-Fi triangulation, indoor navigation and positioning, 2-D code, Non-GPS navigation

1. INTRODUCTION
Navigation domain is mainly influenced by the use of the GPS technology. GPS stands for Global Positioning System, is widely used for its accurate positioning. Most popular example of application using GPS technology in android is Google Maps. But this GPS technology has its own set of drawbacks when indoor navigation comes into the picture. GPS technology makes use of signal strength which works perfectly in outdoor conditions, performs poorly in indoor conditions. This is because indoor scenarios consist of so many obstacles including thick walls which cannot let signals penetrate through them. And thus faulty navigation and positioning comes into the picture. Therefore, the existing navigation system is not suitable for precise positioning and navigation since the satellite signals can't be correctly received inside large buildings, underground construction, skyscrapers and some other complex indoor environments.

There are certain technologies other than GPS can be used for indoor navigation purpose and these includes some wireless and wired technologies. Wireless technologies includes WPS (Wi-Fi-based positioning system), Bluetooth beacon, [1,2] RFID (Radio-frequency Identification), Long range sensors, Infrared while wired technology includes some hardware which uses ultrasound, UWB (Ultra-wide band) technology, etc. But apart from the WPS, rest of the technologies have some limitations. Bluetooth beacon, Infrared doesn't provide accurate results, also the short range is a matter of concern. While RFID, long range sensors provide accurate results but they are expensive. Wired hardware technologies are needed to install the separate hardware inside each and every place for better result and accuracy. This makes use of wired hardware technologies inside the complex indoor scenes not a cost friendly solution and slightly inconvenient for use as every time they may require to carry cables along with the person.

WPS can be used where GPS is inadequate. It is affordable and can provide accurate results. The received signal's intensity [3] is measured for positioning purpose with wireless access points. Wi-Fi hotspot or wireless access point which includes SSID and the MAC address of the access point can be used for geolocation purpose. For better results and accuracy, it is necessary to increase number of positions of places into the database. Along with the number of positions, a separate table consisting of SSID, MAC ID of devices and their strength is needed to be maintained.To overcome the problem of range, it is recommended to provide more number of wireless access points which will also help in the Wi-Fi triangulation process for calculating the real time position of the user inside the complex indoor scene.

This paper focuses on solving the technology block point of mobile phone indoor navigation. And the approach emphasizes on using Wi-Fi triangulation technique for positioning, a* algorithm for the generation of the path, 2-D code for storing landmarks information located on the map and color block sequence for efficient navigation purpose. To solve current existing navigation technology problems, these solutions and applications are efficient enough to achieve effective navigation with accurate positioning. In other word, the system has great practical value. Notable contributions in this paper are as follows:

- Proposing a reliable non-GPS navigation system framework for indoor complex scenes.
- Focusing on using WPS technology which gives optimal results at affordable price.
- The creative ideas include 2-D code and A* path positioning algorithm techniques, and the block-color-sequence to understand the navigation path for the indoor complex scenes.

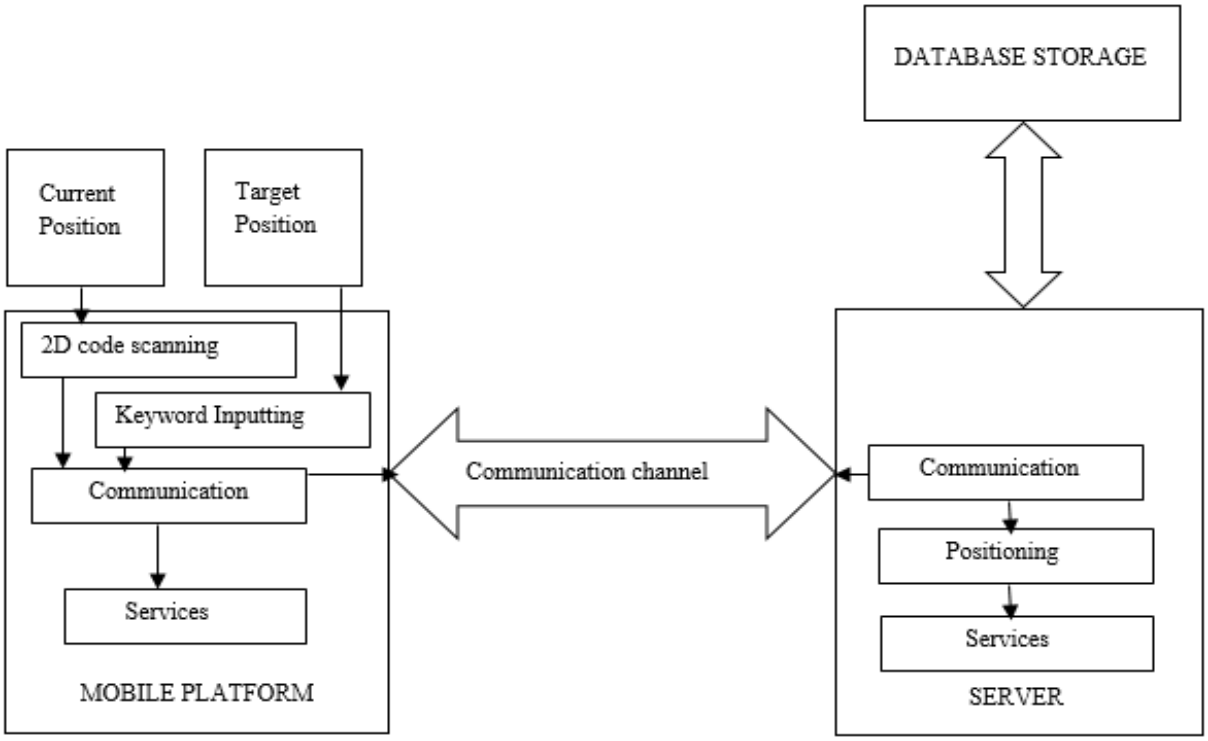

Fig 1: Architectural Model

2. ARCHITECTURAL MODEL

1) The architectural model comprises of the three main components – Mobile platform, database storage and server.

2) Each location present in the map has its own unique 2-D code.

3) In the mobile platform component, user's current location can be retrieved by 2-D code scanning. 2-D code's positioning can be more accurate with wireless access points than satellite's positioning and base station positioning.

4) And the user who wants to reach the desired location, has to enter the target position's keyword.

5) The database storage component keeps the track of all the locations which are present in the map and wireless access points as well.

6) And the last component is server. Server hosts a SQL server (database) and it pools the positioning and services which include navigation, path computing, location service, map service, etc.

7) All the communication from one component to the other component takes place through the communication channel.

8) The main characteristics of the proposed model can be listed as:

—All the locations of the map have their own 2-D code.

—User's current position is determined by Wi-Fi triangulation.

—the path to the target position from user's initial position is generated by a* algorithm.

— Block's color sequence for efficient navigation and

—Local servers and localization techniques are used to implement the non-GPS navigation system.

3. 2-D CODE

2-D code is known as two-dimensional code. It is often recognized by the names like QR code, bar code [15]. Storing the information both horizontally and vertically is the main feature of 2-D code. It records the symbol information by some black and white graphics. It has storage capacity up to 7089 character. Although it is more complex than 1D bar code and require more powerful scanners, it is very mature. It is mostly used in electronic commerce, logistics and other industries. However it is not used in the complex indoor scene positioning and navigation yet. But it can be used in the area of location service. A 2-D code of many geometric shapes with respect to the binary code, represents text-numerical information which can be recognized by scanners or the image input device. In complex indoor scene all the locations will have their own unique 2-Dcode on the scene map. It will follow certain rules in two-dimensional directions. The 2-D code of predefined location is posted on the wall accompanying with predetermined color block system. All the outputs of an intersection are marked with distinguished color blocks. Finally A* is implemented for path finding.

4. WI-FI TRIANGULATION

Wi-Fi triangulation [10] is a process of determining the position in the whole area or only confined part. The triangulation method is based on knowledge of reference point positions and the distances to them. Wi-Fi triangulation is also referred as Wi-Fi lateration. The Wi-Fi triangulation or lateration method makes use of

—Frequency of Wi-Fi signal,

—Its signal strength,

— The network MAC-addresses and

— Real coordinates of Wi-Fi access points in the location.

In [8] Shchekotov M. has described two methods for Wi-Fi lateration, signal propagation model and signal strength data collection. And for the proposed navigation system, signal strength data collection method is used.In this method, thesignal strength received by mobile device can be used for distance estimation between the AP (Access Point) and the mobile device. By usingthis method one considers three or more APs allocated in the building. The RSS (Received Signal Strength) decreases exponentially based on distance between transmitter and receiver and random noise factor. Thus this dependency can be considered as function of distance. The distance estimated by RSS is presented as a circle around an access point. The intersection of three APs radiuses provides a point or an area of receiver. This model can be shown as such equation system [9]:

$$d_1^2 = (_1)^2 + (_1)^2$$
$$d_2^2 = (_2)^2 + (_2)^2$$
$$\dots$$
$$d_n^2 = (_n)^2 + (_n)^2$$

Where $_1$, $_2$, $_n$ and d_1, d_2, $d_n$are the coordinates of access points, estimated distances, respectively.

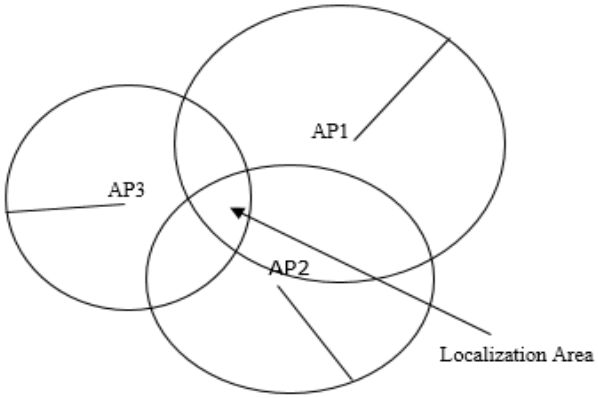

Fig 2: Indoor localization area provided by trilateration approach

Thus the Localization area is the result obtained by applying triangulation technique on three Aps, which indicates the position of the user in android mobile application.

5. A* ALGORITHM

A* algorithm [4] is very efficient path finding algorithm. A* algorithm is used for the evaluation of shortest path between two points. So that the traversal path between source and destination can be plotted easily. A* algorithm starts the search at initial node and it computes the actual distance–plus heuristic value [5] cost required for each of its adjacent nodes excluding those occupied by obstacles. And moves onto the one with smallest distance plus heuristic value cost. Initial node is called as a parent node and the last node is called as a child node it continues till the goal node is found, after that by using backtracking [6,7] It is easy to construct the actual path between parent and child. A* algorithm works by evaluating cost function given by -

$f(x)= g(x) + h(x)$

Where,

— f(x) is actual distance between source node and destination node.

— g(x) is distance from initial node to the n^{th} node

—h(x) is heuristics distance between source node and destination node.

In Fig 2. The red line represents the navigation path from start position to the target position, which is generated by a* algorithm.

6. BLOCK'S COLOR SEQUENCE

To fulfill the requirement of smart navigation, here comes the idea of the block's color sequence into the picture. To generate certain sequence, it is necessary to assign blocks with some distinguish color. Such that each block with unique color will represent particular direction. For example, In Fig. 3 there exist four blocks with color indigo, purple, yellow and brown representing turning in the direction left, right, down and up, respectively. The path generated by a* algorithm is highlighted with red line, is also the path from user's current position to the target position. The alignment of the color blocks should be of one-to-one correspondence for left to right and up to down, respectively. This alignment is displayed in the map at the beginning or current position of the user and at the point of contact where possible paths meet. The current position of the user is also considered as the point of contact. The displayed number of blocks is equal to the number of possible paths which are meeting at the point of contact. The color blocks intersected by the red line are taken into account to determine the turning direction. The intersection will always be taken place in between two color blocks of different color at the point of contact. In Fig. 4 While displaying the block's color sequence, the later block which is intersected with the prior one is only selected.

The main purpose of using the block's color sequence is to terminate the ambiguity in the turning direction while navigating in the 2D view map. The use of the color block sequence may not be suitable for people with color-blindness, but the problem can be solved by using the colors of different intensities which can easily be identified by the disabled person.

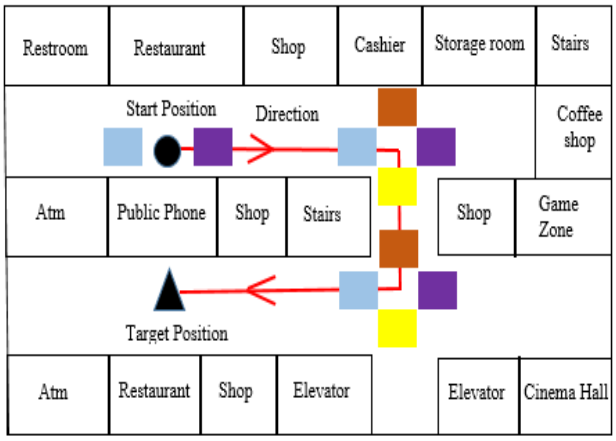

Fig 3: A map view for Mall with color block's intersection

Fig 4: Path with color block

7. CONCLUSION

The paper is proposing a new model for a non-GPS indoor navigation system which uses 2-D code, efficient a* path positioning algorithm and block's color sequence for smart navigation. This idea can be implemented very easily and it can be deployed for the large-scale indoor environments such

as shopping malls,large buildings, big theaters, underground constructionand skyscrapersto provide good location services.The future scope for the idea can be stated as – use of voice input instead of text inputting, smart switch functionality for disabling GPS and enabling Wi-Fi in the android phone when user enters into the indoor environment from outdoor environment.

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