Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 10, October 2021: 4583-4592

Finding a Car in an Indoor Parking Structures

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Abstract

Nowadays, most of the shopping malls, airports, hospitals, etc. have underground parking lots where hundreds of vehicles can be parked. However, first-time visitors find it difficult to remember the parked location in the indoor parking structures. Hence, in this project a navigation system for visitors to find their cars in indoor parking garages is proposed. The proposed system comprises a positioning-assisting subsystem and a car-searching mobile app. The subsystem uses beacon technology for indoor positioning and supporting Mobile app for self-guidance. In the phase of setting up this position assisting system, local coordinate is estimated to support the identification of the locations of parking spaces, beacon devices ranges and to overcome the trilateration issues. The position-assisting subsystem is implemented using Moko H2 navigation beacon devices and a car-searching mobile app was designed to using Android platform. The proposed system is deployed on real time car parking platform and the experimental results verified that the system works well to provide the visitors with route guidance. The designed system also finds its scope in providing flexible guidance to people in confusing, unknown buildings and building complex.

Keywords: indoor parking, navigation, beacon, mobile app,

Introduction

Parking management is an important issue in intelligent transportation systems (ITSs), largely due to the growing number of cars worldwide. In parking management, parking guidance in order to facilitate the search for vacant parking spaces is a fundamental service Car-searching is also an essential service when car owners attempt to find their parked cars. As the parking layout of parking facilities is often quite uniform in the indoor parking garage, and may consist of hundreds or thousands of parking spaces, it's difficult for car owners to memorize and identify their parking spaces. In addition, car owners with poor sense of direction may lose their ways to the spaces of their parked cars, and therefore may not find the car.

Recently, studies have investigated the issue of pedestrian navigation. Typically, pedestrian navigation focuses on how to plan the guidance of the route to the destination effectively and efficiently. The solution to the navigation of car searching is similar to that of representative pedestrian navigation. For car searching, the following three tasks should be performed: positioning, route planning, and guidance information presentation

- Positioning aims to identify the location of the pedestrian and parking space.
- Route planning involves the determination of the route from the car owner's location to the parking space of the car.
- Given the planned route and environmental information (e.g., a map or floor plan), the presentation of guidance information physically shows the planned route and/or direction to the car owner, possibly in visual, audio, haptic, or hybrid forms. Significantly, if not using an efficient navigation strategy, the car owner is likely to come into difficulties when searching for the parked car.

The global positioning system (GPS) is a conventional and widely used approach for user localization but may not be accurate for indoor environments because of the indoor shadowing effect.

Prior studies have proposed feasible mechanisms for indoor positioning. The mechanisms use information and communication-based technologies, such as infrared, Wi-Fi, Bluetooth, and the vision-based method. The micro-location technique based on beacon technology provides another localization technique in the indoor environment. Beacon technology operates over.

Bluetooth Low Energy (BLE), as shown in Figure 1 is a wireless form of technology with low power and low cost, and is presently considered as the primary form of wireless technology in mobile devices [16].

Figure 1. BLE Beacon

As a result, beacon technology is regarded as an appropriate indoor positioning solution. Mobile devices have currently become prevalent for human beings, and thus it is quite suitable for car owners to use a mobile device to obtain navigation information.

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The project proposes a BLE-based pedestrian navigation system for car searching in indoor parking garages. As car owners search for their own cars and walk toward the spaces where their cars are parked the proposed system provides the navigation path. The main concept of BLE-PNS includes self-guiding and effortless navigation. Self-guiding indicates that pedestrians obtain the navigation information according to their mobile devices instead of the facilities of parking garages, e.g., liquid-crystal display (LCD) or light emitting diode (LED). Effortless navigation implies that the proposed system provides intuitive and accurate navigation information to pedestrians. In this work, the Navigine app has been custamized by adding the map of the selected venue. Becons were added on the map as per they were fixed in the parking.Navigation is done using the app's navigation algorithm.

Literature Survey

This section briefs about various related work in the domain of the proposed system here. There are discussions on the various systems that have put to use the idea of Indoor Navigation System.

Jan Vascak and Igor Savkodeal with the possibility to use BLE beacons in the indoor navigation together with a modified version of Kalman filter as an efficient means for noise elimination in "Radio Beacons in Navigation system"[1] The localization they did is based on measuring the so-called received signal strength and subsequent trilateration.They is finalized the proposed navigation systemby creating a navigation map using BLE beacons and a depth sensor.They worked on localization by BLE technology ,calculating distance using RSSI,Modification of KF for Noise Elimination. They also worked on tilateration,creating maps and navigation directing the user to its destination.

Jayakanth Kunhoth, AbdelGhani Karkar , Somaya Al-Maadeed & Abdulla Al-Ali reviewed different computer vision-based indoor navigation and positioning systems along with indoor scene recognition methods that can aid the indoor navigation in "Indoor positioning and way finding system"[2]

They mentioned various communication technologies, such as Wi-Fi, Radio Frequency Identification (RFID) visible light, Bluetooth and ultra-wide band (UWB). They worked on the navigation system by making three modules, Indoor positioning system, Navigation module and HMI module.

Sheng-Shih Wang deals with navigation system for car owners to find their cars in indoor parking garages in "A BLE-Based Pedestrian Navigation System for Car Searching in Indoor Parking Garages"[3]. In his navigation system he proposed system comprises a car-searching mobile app and a positioning-assisting subsystem.The app guides car owners to their cars based on a "turn-by-turn "navigation. He described the working as, developing number of anchors in the aisle of the parking, and these anchors broadcast the location using beacons by sending radio signals. Next, the user's bluetooth recieves the location sent by the anchor and finally the app in the user's smartphone guides him to his parked car.

Proposed System

This section gives detailed view about the entire proposed system in the form of modules and the various required system configurations for the indoor car parking navigation system. The proposed system is aimed to find the car parked in an indoor parking lot using Bluetooth low energy beacons and navigation system as shown in Figure 2. This is done by making two modules, positioning module and navigation module. These modules are explained in the next section.

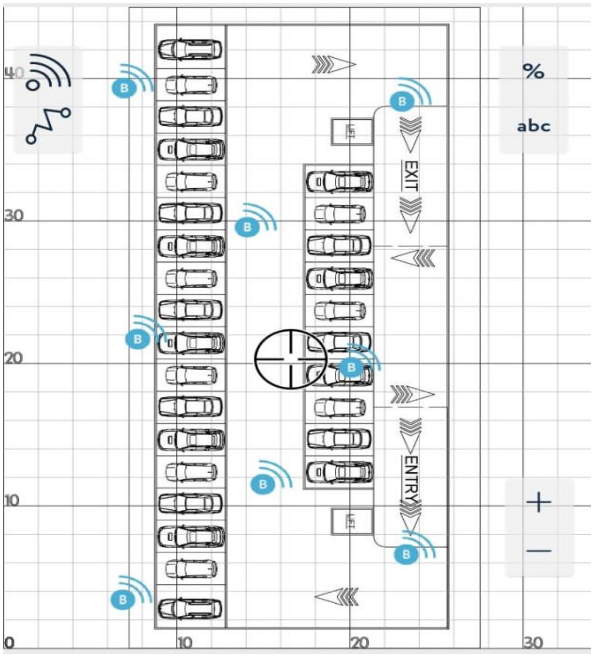

Figure 2: Beacons on map

Positioning module

In this module, designing of the map of venue and positioning of the beacons (on map ad in the parking) and the position of user is done.

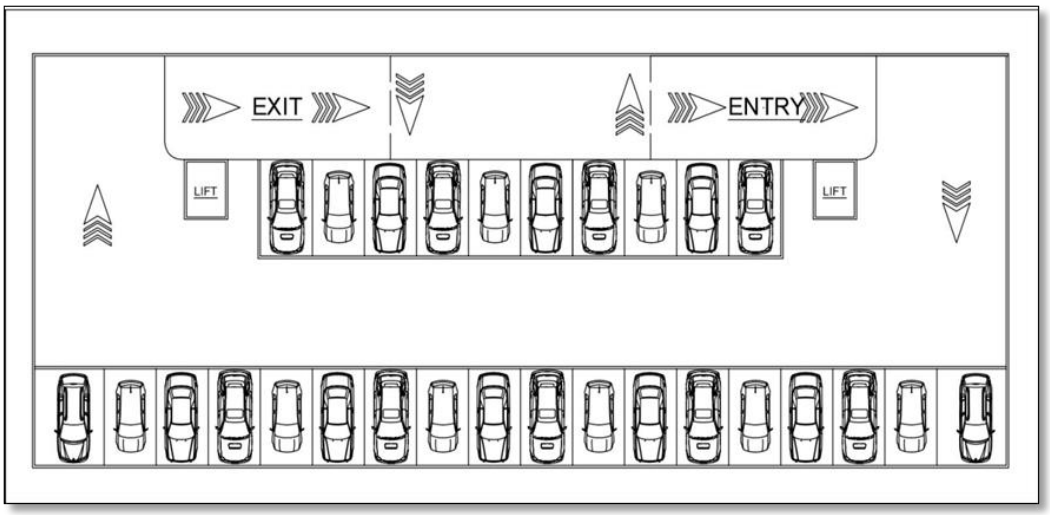

Figure.3 Map of the venue

First step to be done is creating the desired map as shown in Figure 3 of the venue. Next, the Positioning of the beacons in the map and in the parking lot is done. Beacons were implemented in

the map and in the parking simultaneously as shown in the Figure 4 . Position of the beacons is marked same in the map as they are deployed in the parking lot as shown in Figure 5.

Figure 4. Beacon in the parking lot

Maximum Range of the moko h2 beacons used is 100m, these beacons have battery lifetime of 30-40 months.

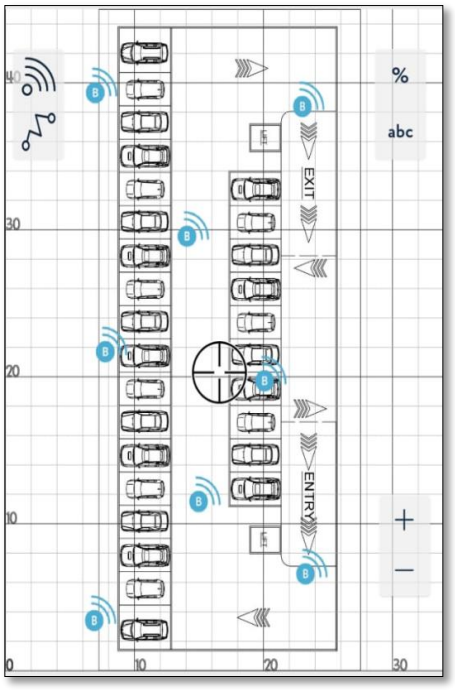

Figure 5. Beacons in the map

Navigation module

RSSI value is given by the beacon as shown in the Figure 6 to the user device when the Bluetooth is enabled in the user's device. Through this RSSI value the distance between the user and the beacon is also calculated. RSSI value also play major role in trilateration.

```
-71.0
-73.0
-80.0
-84.0
-86.0
```

Figure 6. RSSI value from beacons

Trilateration is the process or method used to calculate the position of the user with more accuracy. Taking the distance of three beacons through RSSI value, three imaginary circles having distance as radius are made as shown in Figure 7 and their intersection point is calculated. This intersection point in the form of (x,y) (where x and y are the local coordinates of the map) is considered as the current position of the user.

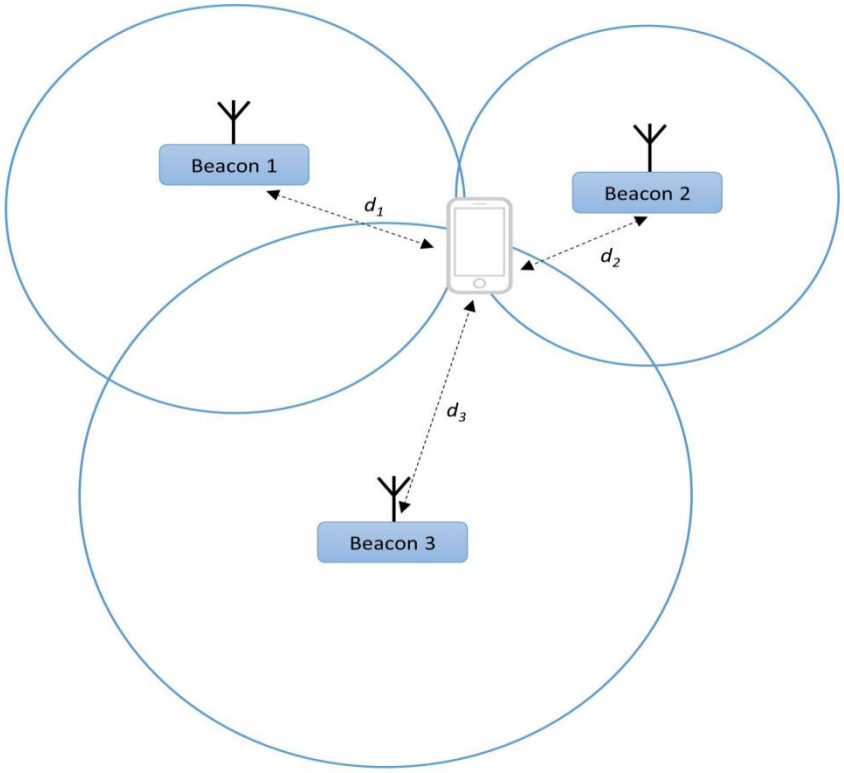

Figure 7: Trilaterationt

Navigation is done in the following steps:-

1. Position of the end point (destination) is taken as input by the user.
2. The nearby active beacon for that specific endpoint location with highest RSSI sends the value to the server.
3. Current location point of the user and the destination point are connecting with the line showing the user its path to reach the destination point.
4. Finally the updated map showing the path to the user to his parked car is shown of the screen of the user device.
5. Users also get to know the approx time to reach the destination point and the distance he needs to travel to reach there as shown in the Figure 8.

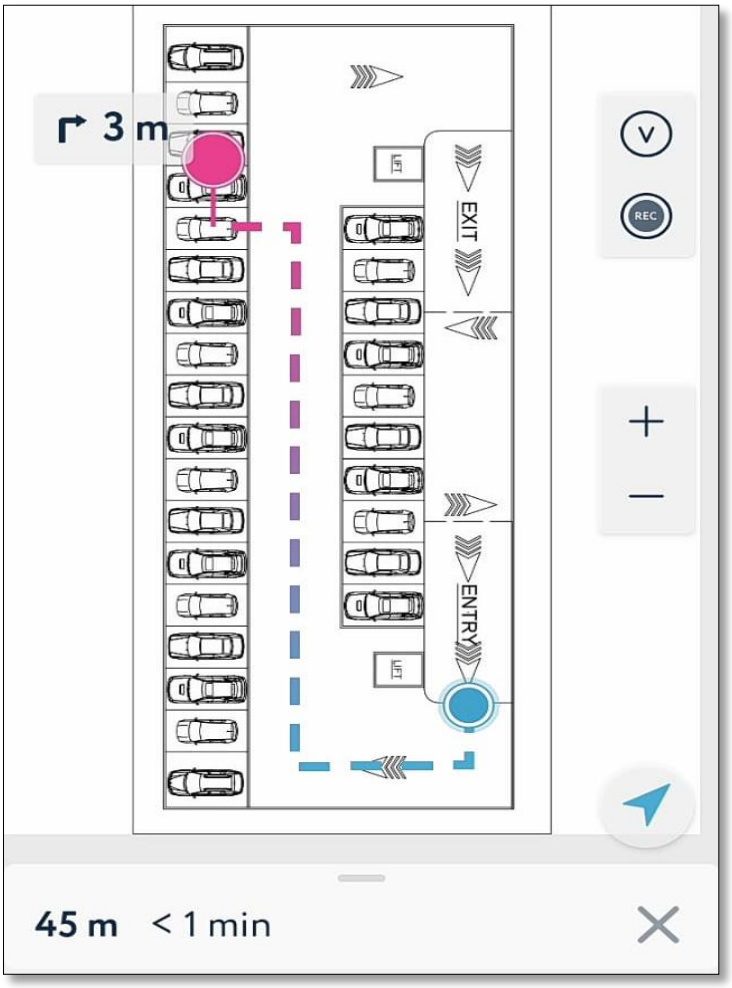

Figure 8. Map showing path to the destination

Algorithms For Trilateration

This section explains about the algorithms that were tried upon the data set obtained from the land and discusses about which works well for the system.

The RSSI value collected from the beacons is used to determine the position of the user by applying the algorithm of the trilateration .Through the coordinates of the beacons from the map and their distance of each beacon from the user's device through RSSI [17]. The intersection point of three imaginary circles made by taking distance as radius is calculated.

Algorithm:-

Step-1 Knowing the positions of three beacons (x1, y1), (x2, y2), (x3, y3)

Step-2 Knowing the RSSI value and thus the distance of the beacon from the device r1, r2, r3

Step-3 Calculating the coordinates of the user through trilateration

Position of the user is (x,y)

$(x-x1)2 + (y-y1)2=r12$ $(x-x2)2+(y-y2)2=r22$ $(x-x3)2+(y-y3)2=r32$

on further solving,

$(-2*x1+2*x2)\ x + (-2*y1+2*y2)y=r12-r22-x12+x22-y12+y22$

$(-2*x2+2*x3)\ x + (-2*y2+2*y3)y=r22-r32-x22+x32-y22+y32$

In simpler form-

$Ax+By=C \qquad Dx+Ey=F$

Values of x and y are,

$x=CE-FB/EA-BD \qquad y=CD-AF/BD-AE$

Implementation and Results

The implementation and the results obtained are discussed here. The beacons are placed in the parking and at same position on the map they are marked. These beacons transmitted radio signals which in turn received by the device by enabling the Bluetooth of the device. This radio signal strength is used to calculate the RSSI value and thus the position of the user by trilateration.

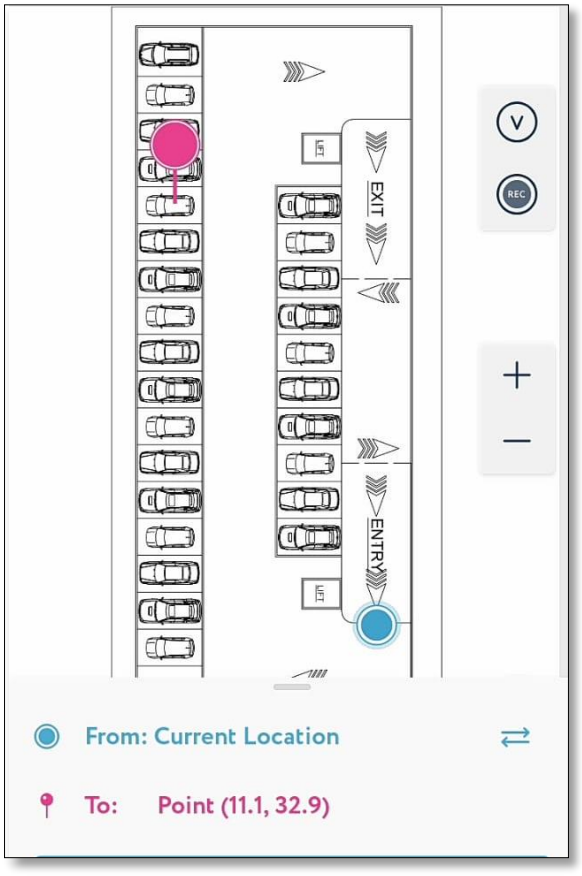

Figure 10. Setup ready to navigate

Data received by the beacons at the current position of the user. Along with major, minor and UUID of the beacon its RSSI value and its distance from the user's current position is shown same as in Figure 10.

```
BEACONS (7), entries/sec: 4.0
0,837,E2C56DB5-D…  -71.0  2.0m  (0.0s) BAT=0%
0,715,E2C56DB5-D…  -73.0  2.5m  (0.8s) BAT=0%
0,847,E2C56DB5-D…  -80.0  5.6m  (1.8s) BAT=0%
0,856,E2C56DB5-D…  -84.0  8.9m  (0.2s) BAT=0%
0,236,E2C56DB5-D…  -86.0  11.2m  (0.7s) BAT=0%
...
```

Figure 10. Data received (1)

To direct the user, sensors of the device are used for calculating the speed and the direction of the user as shown in the Figure 11.

```
SENSORS:
Accelerometer: (-0.7450, 3.2910, 8.8540, 3)
Magnetometer:  (3.7200, 33.8400, -36.7200, 3)
Gyroscope:     ---
```

Figure 11. Data received(2)

Conclusion and Future works

A Car finding system has been proposed to help user find their car parked in an indoor parking with just the help of their smart phones. There are two different modules namely the positioning module and the navigation module. The positioning module is used to make the map of the venue and the position of beacons. Beacons are placed at the ceiling and at the walls of the parking. The navigation module is used to take the destination point from the user and navigate him from his current position to the final position. Using the gyroscope, magnetometer and accelerometer sensors of the device, navigation is done.

The proposed system uses a local coordinate system to assist in the localization of parking spaces. Local coordinates (x,y) are used to in positioning the beacon on the map and are also used to show the position of the user. It uses RSSI value and trilateration to determine position with accuracy. Slot number as input can be given as input showing the final point or destination by the user. Similarly, License Number of the car can be taken as input during parking, using the camera of the device which will result in high accuracy, this will help user not to remember the slot number of the parked car.

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