Parking Management Application using Smart Phonex

Chirag Bhatt
Assistant Professor
Institute of Technology, Ganpat University, Kherva

Nikita Joshi
Research Scholar
DA-IICT, Ghandhinagar

Abstract

As the number of vehicle increases on this earth, the traffic also increases which leads to scarcity of parking. Studies shows that 30% of traffic is in urban area is due to drivers looking for parking and not able to find proper parking location. The technology makes traffic management very easy using some sensors in the smart phones only. Application of smart phone sensors for checking parking availability is easy to implement idea since everyone nowadays carries Smartphone with them. In this paper we have discussed some available parking management applications and explained their limitations. we have proposed an system for parking availability using GPS sensor and Accelerometer sensor and implemented using android. Its limitations are discussed and future work is suggested.

Keywords- Parking, GPS, Accelerometer, Mobility, Wi-Fi, localization

I. INTRODUCTION

In the urban area nowadays parking is an expansive and scarce resource which leads to high demand for parking space management because drivers spends their maximum time in finding the available appropriate parking for them during busy period of the day. The current parking availability systems available nowadays need dedicated infrastructure which leads to higher cost.

A study shows that 30% of the parking is due to unavailability of parking information to the driver [1]. When real-time occupancy of on-street parking is disseminated to drivers, it results in a reduction of 15% in total travel time [2]. In [3], author shows that 30% of the 483 surveyed drivers changed their intended parking destination in response to road-side guidance sign indicating space availability at car parks. If the information about avail- ability of parking is available before the start of journey, the person might change the decision to change the method of transportation or change the route or select some other place to go if possible(like for movie, malls or restaurant we may have other options).

Many researches are going on for getting availability of parking but many of them requires special architecture embedded on roads or vehicles[4] [5]. These architectures involve significant hardware cost for the instruments required. However, building a smart phone based application will be as better idea since everyone nowadays has easy access to smart phones. There are some architecture available using smart phone sensors like Wi-Fi access points, GPS, accelerometer to detect when the driver has vacated the parking area and make that parking available for other users.

Unparking detection through mobile phone sensing can have a significant impact on the battery life of users' mobile device. Therefore, minimum battery requirement is most important parameter for detecting an unparking event for any application to be acceptable. Low accuracy is accepted for such an application. The SFpark [4] system, an infrastructure based parking detection system deployed in the city of San Francisco, considers 70% detection accuracy as acceptable [6] for estimating parking occupancy. This assessment is justified by the fact that a parking availability information system estimates availability based on aggregated data from multiple users in a given area. Inaccuracies in the sensing data are therefore less important as long as the number of participating users is high.

The remaining paper is organized as section 2 explains existing systems for parking availability and compares their performance, section 3 focuses on proposed architecture for parking management system, section 4 gives implementation details and section 5 concludes the work and throws some light on future work.

II. RELATED WORK

Pay and park concept is widely accepted nowadays where user pays for the duration of parking it requires in advance. Based on these concept typical sequences of event is as following:

1) Users park the car and make payment and initiate the parking event by mobile payment
2) User walks away
3) User comes back
4) User drives the car and vacates the parking

Event 2) and 3) are more important for us to detect the parking is vacated. For these events to be detected we need two type of sensors in our system namely, location sensor to match the location of user with location of parking and make the decision that user has come back and second sensor is accelerometer to decide that user is driving the car and parking is vacated.

A. Location Detection

To detect the location different sensors and concepts are used three of them are discussed here namely network based location, Wi-Fi based location, GPS based location.

1) Network Based Location

Current smart phones have API for network based location. This API will collect the SSID from the nearest Wi-Fi access point. This SSID is sent to server by phone. Server has the database for SSID and its corresponding location. Thus the location corresponding to paring is stored.

The energy consumption for network based location is lower than GPS but the location is retrieved from the war driving database which includes network queries. To avoid cost of these network queries generally cache is used which makes this approach less suitable for continuous tracking. Another limitation of this approach is Wi-Fi access points must be available near parking are and wherever the user moves to collect the location details which is not practically possible everywhere.

2) Wireless Based Sensing

Park sense application [7] uses this approach to get the location of user. It performs multiple scans for Wi-Fi access points when user is doing payment for parking after parking the vehicle and stores the signature of Wi-Fi access points in following format.

$$Sp = \{sp(1), sp(2), ..., sp(n)\}$$
$$Wp = \{wp(1), wp(2), ..., wp(n)\}$$

Where sp (i) is the SSID of ith network and wp (i) is the beacon reception ration calculated by vp (i)
where vp (i) is number of times beacon received and m is number of times scan performed. It saves this signature and then periodically performs new wireless scans as the user moves away from the vehicle. From each successive window of size m, it creates a new signature with St and Wt in the same manner as described above.

Park Sense detects the return of the user to the parked vehicle by com-paring the periodically generated signature sets St and Wt with the saved signature Sp and Wp . Normalized reception ratio is calculated as following.

$$\hat{W}_p = \{\hat{w}_p(1), \hat{w}_p(2), ..., \hat{w}_p(n)\}$$

Where $\hat{W}_{p(i)}$= wp (i) . These normalized beacon reception ratios can be i=1 wp (i) thought of as weights assigned to access points.

An access point that was visible in all the scans gets a higher weight whereas the ones that appear in only a few scans get lower weights assigned to them. Three matching functions are defined as following:

$$M = \sum_{i=1}^{l} \hat{w}_p(i) f \text{ or } sp(i) \; Sp \setminus St \qquad (1)$$

$$M = \sum_{i=1}^{l} \hat{w}_p(i) \, (1 - (w_p(i) - w_t(i)) \qquad (2)$$

$$M = \frac{|S_t^T S_p|}{|S_p|} \qquad (3)$$

For equation (1) $0 \leq M \leq 1$and $l = |S_t^T S_p|$. it is also called weighed matching Equation (2) is called Weighted difference matching and Equation(3) is called Percentage Matching.

If the signature matches with the signature of parking area then it is concluded that the user has come back. This approach is very robust and low energy consuming but it requires the Wi-Fi access points everywhere where the user moves and also in parking area which increases the cost of infrastructure.

3) GPS based Location

GPS based location tracking could be considered a natural choice for our application. Continuous tracking of users, after they have parked their vehicles, could allow us to determine when they return to their vehicles.

B. Detection of User Driving Away

When the user comes back to parking next part we have to decide is if user is driving away from the parking which concludes that parking is vacated. Park sense has detected that using signature only. Jaccard similarity is calculated using following equation:

$$J = \frac{|S_t^{T} S_{t-1}|}{|S_t^{S} S_{t-1}|} \quad (4)$$

Jaccard similarity is merely the ratio of the number of access points observed in both windows to the total number of access points in the two windows. As the speed increases jaccard index decreases and if it falls below some threshold value, it decides that user is driving.

Second option to detect the user is driving away is using accelerometer. Speed of the user can be calculated using accelerometer available in smart phone. If that speed is above some threshold value than it can be concluded that user is driving away.

III. PROPOSED WORK

We have proposed and architecture for parking availability using GPS and accelerometer. It works as shown in Figure 1.

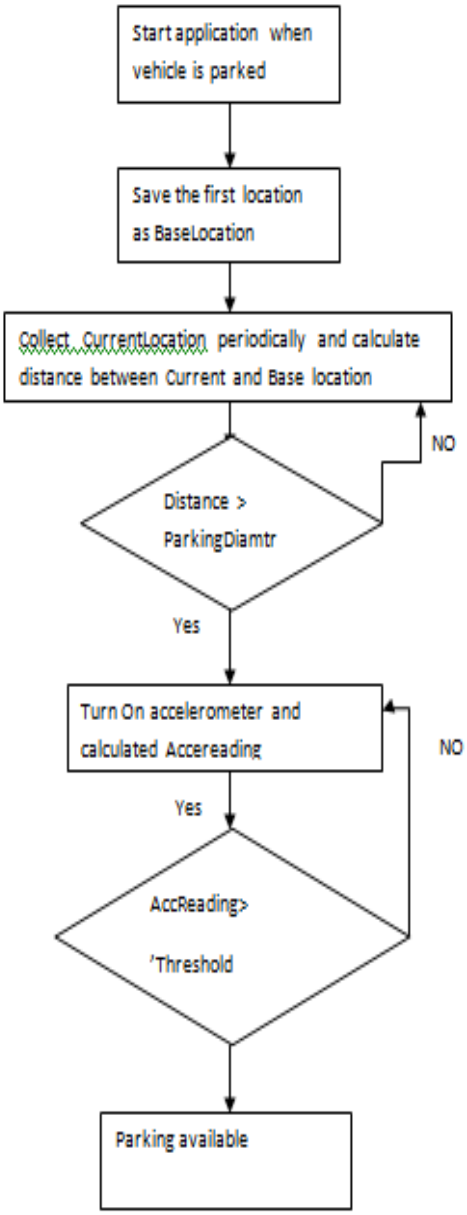

Fig. 1: Detection of parking vacating event

As shown in Figure 1, this application is actually a part of application for payment so when the user is making payment the application will start by itself and start collecting GPS location. The first location is stored as parking location. Now when user moves anywhere the GPS location is collected periodically and when the location matches with the location of parking area

it is concluded that user has come back. So the accelerometer is turned on to check whether the user is driving away or not. If the accelerometer shows the reading greater than a threshold value than it is concluded that user is driving away and hence the parking is vacated.

```
Data: GPS sensor node readings, Accelerometer readings,
      Parking Diameter
Result: Detection of parking availability
Base Location=First location detected by GPS when application is
 turned on;
while To Distance(Current Location, Base Location)≥Parking Diameter
 do
 | Update Current Location at every t seconds;
end
Turn on accelerometer;

AccReading = √(x^2 + y^2 + z^2) − 9.8 if AccReading ≥Threshold then
 | Parking is vacated;
else
 | Location matched but parking is not vacated;
end
```

Algorithm 1: Detection of parking availability

Algorithm 1 shows detailed working of the proposed algorithm. Here Base Location is location of parking area. To distance is a function to calculated distance between two GPS coordinates, Current Location is location collected periodically by GPS sensor, x,y and z are accelerometer x,y, and z axis readings respectively. AccReading is calculated by finding square mean average of x,y and z axes accelerometer reading and subtracting 9.8 from that since z axes of accelerometer includes gravity also.

IV. IMPLEMENTATION

This application is implemented in android. We have collected data of accelerometer to find the Threshold value required for Algorithm 1. Which shows values AccReading variable is always greater than or equal to 0.3945 when car was moving? Then we have collected 5 more data samples to verify this value by hypothesis testing. one tailed t-test was performed with 95% confidence interval which shows that AccReading is always greater than 0.3945 when the car is moving so we have kept the Threshold value 0.3945 for implementation. Parking Diameter is assumed to be 20 m. Snapshot of design application is shows in Figure 2.

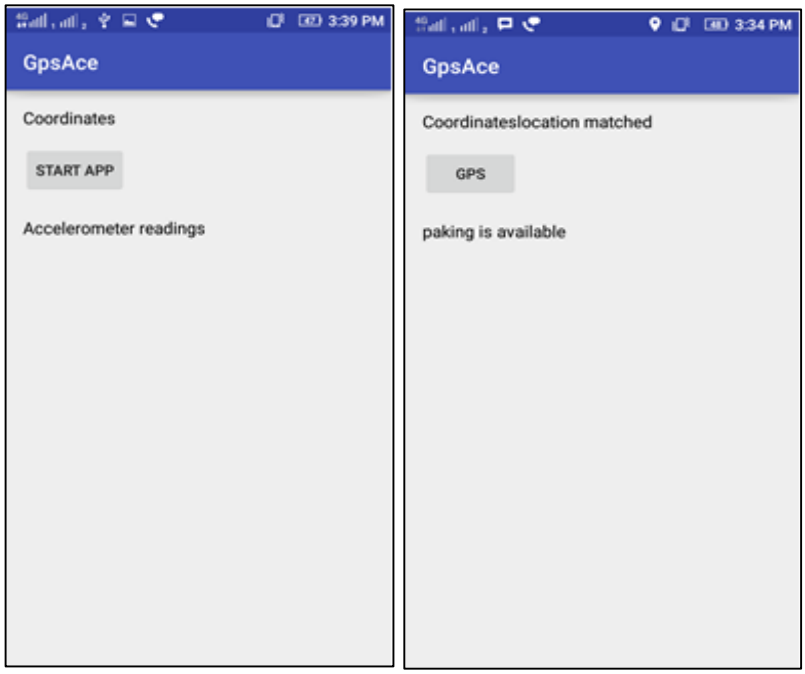

Fig. 2: Snapshots of application

V. CONCLUSION OF AND FUTURE WORK

Parking availability detection is very important task nowadays. Use of smart phone for parking management is easy to implement, low cost and feasible solution. GPS and accelerometer sensors are available in smart- phone we have designed algorithm to find parking availability using these two sensors. The limitation of this approach is delay due in GPS detection also; GPS doesn't work accurately for indoor area. Energy consumption of GPS is also comparatively high.

In future we will find the optimized period of colleting GPS location such that it requires minimum energy consumption and provides required accuracy. We may also try to find replacement of GPS sensor to detect the event that user has come back to parking.

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