Smart Parking

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Abstract

Parking could become a nightmare on a busy day, in a city like Delhi, which has about 7.35 million cars, as per MORTH Barclays Research (2012). With an average of seventeen minutes and reasonable amount of fuel being wasted every time, there is also stress induced due to parking hassles starting from finding an empty parking spot to finding the car back after parking. We propose a system that leverages latest technologies that help motorists overcome their parking problems and at the same time, makes managing a parking space easier and cost effective by automating the entire process right from pre-booking a parking slot to making the payment. Since most of the parking spaces are equipped with CCTV surveillance cameras, we decided to use them to detect the presence of cars and measure the availability of parking spots within a parking space. With recent advancements in image processing and machine learning, the detection accuracy can be sufficiently high. The availability data is then relayed to the central server that keeps track of availability of parking spots in different parking spaces. The user app can browse through a list of parking spaces and book a spot and on arriving at the parking space, the app downloads the map of the parking space from the server that helps in guiding the user to his/her booked spot using an augmented reality interface. The same app can be used to guide the user back to the car.

It is a known fact that finding a parking space in a crowded region of an urban city can be very stressful. With wastage of fuel and time, motorists cruise around looking for parking space causing associated problems like congestion. Studies show that an average of 30% of the traffic in an urban city is due to cars that cruise for a parking space [1]. The problem is not always availability but inefficient utilization of available resources. This is because of the absence of information about availability in different parking spaces. Effective pricing policies play an important role in mitigating majority of the problems [2]. With labor getting costly, it is also a need of the hour to automate various processes involved in parking. Security is also a major concern and has to be factored in while developing parking systems.

The system consists of 3 major components –

1. Image processing system

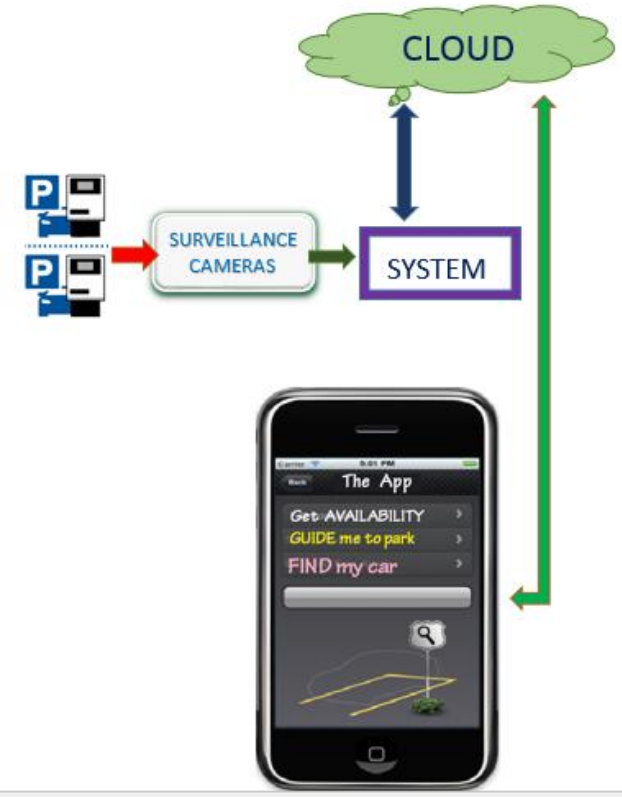
Processes CCTV feed to detect presence of cars. Markers are laid over each parking spot and if a marker is detected, the spot is occupied.

2. Central Server

Stores information about availability in various parking spaces in the region. Crunches data to predict user patterns and improve the system.

3. Mobile app

Communicates with the server to book a spot, make payment and uses marker based localization to guide the user inside the parking space.



Literature Survey

Early Smart Parking systems provided parking guidance information (PGI) to drivers in central city areas on available parking locations, including information that ranged from "lot empty" to the number of spaces available via VMS signs. [3] uses 'Bluetooth' and a handheld device as the PDA. [4] Identifies free spaces using image processing techniques. [5] uses traffic sensors to access the parking lot situation. [6] is a modular, infrastructure-based sensor system that uses overhead sensors on a stand-alone basis or as an invisible "smart" accessory for surrounding street lights. RFID technology is used for recognition.[7] uses Ultrasonic sensors to detect parking status.[8] makes use of balloons to indicate empty spaces. Car Lifting [9] is another technology that needs a completely new infrastructure for installation.

Comparison of our system with the existing ones

	Smart Meter	Advisor	Transit based	Siemens	Boston university	Balloon parking	Car lifting	Our proposal
Saving Time	✗	✓	✓	✓	✓	✓	✗	✓
Saving Fuel	✗	✗	✓	✓	✓	✓	✗	✓
Less Installation Cost	✗	✓	✗	✗	✗	✓	✗	✓
Scalable	✗	✓	✓	✓	✓	✓	✗	✓
Eco friendly	✗	✓	✓	✓	✓	✓	✗	✓
Less man power	✗	✓	✗	✓	✓	✓	✓	✓
Helps Pricing Strategies	✓	✓	✓	✓	✓	✓	✗	✓
Reliable	✗	✓	✓	✓	✓	✗	✓	✓
Data collection	✗	✓	✓	✓	✓	✗	✓	✓
Ease of Payment	✗	✗	✗	✗	✗	✗	✗	✓
Reduces Congestion	✗	✗	✓	✗	✗	✗	✓	✓

System Prototype

The developed prototype captures the key details of the system. The video can be found here: https://www.youtube.com/watch?v=NI6HxI7Q3C0

The overhead camera (≡CCTV) images the parking space. These images are processed and the empty slots are detected based on the visibility of the markers (for the prototype, we used blue colored rectangles as markers, but more sophisticated markers can be used for accurate detection) laid over each parking spot. This information is sent to the PC (≡Server). Whenever a new car arrives, the camera detects it and the PC (≡Server) sends information to a set of Servo motors (≡Guidance system/Augmented reality app) to guide the car to the nearest empty spot.

User App

The video demo of the app can be found here: https://youtu.be/bQu5jSu-eQM

The app is used to search and pre-book a nearby available parking spot and on arrival at the parking space, the app guides the user to the booked spot using marker based localization and augmented reality.

Guidance inside parking space using marker based localization

The parking space is already mapped and markers are installed near junctions. The smart phone downloads the map on arrival. By imaging these markers and referring to the downloaded map, the smart phone localizes itself inside the parking space and with the help of an augmented reality interface, guides the user to his/her booked spot. The app can also be used to find the car back using the same interface.

Value Proposition (in terms of app users)

1. **Assured, stress free parking solution**: Pre-booking options and guidance through the shortest path with AR interface. Users need not cruise for finding available parking, thus solving congestion issues.
2. **More options**: Users can decide among various nearby parking spots based on cost, time, availability, traffic etc. Based on the needs, users can choose appropriate parking, thus preventing situations like parking in a busy area and paying more when they can park elsewhere or travel at different time of the day. Users can also avoid parking on the streets which causes congestion and robberies.
3. **Easy payment**: Saves time at the parking space, safe and payment on the go.
4. **Safety**: Any damage to the parked vehicle can be traced back as the system would have the details of the nearby parked cars.
5. **Getting to the car back**: Particularly useful in large parking spaces where users tend to forget the exact location where there car is parked.
6. **Data collection to improve user experience**: Saved places, suggestions, discount offers based on frequent visits.
7. **Fair and global pricing policy**: Standard and fair pricing policy can mitigate many parking problems [10]

Value Proposition (in terms of parking space owners)

1. Easy parking acts as an incentive to customers visiting malls, theatres etc.
2. Automated monitoring: Reduces man power requirement, easy management.
3. Get data about frequent users, peak hours etc.

Technical Risk Assessment

1. Empty spot detection

Major modes of failure	Risk involved	Risk Mitigation
Occlusion (say, one car obstructing another car from view)	Could detect as empty slot	Continuous tracking from when a car enters to when it leaves
Failure in image processing (software error)	Inability to recognize empty slots	Need to update algorithms Need a backup system
Loss of camera-feed/ power	Product downtime	Intervention/ maintenance

2. Failure in localization and guidance

Major modes of failure	Risk involved	Risk Mitigation
Markers damaged/ removed	Inability to localize	Need replacement of markers
Markers not in view	Momentary loss in guidance	Can use accelerometer data
Phone not facing the markers	Inability to localize	Corrective feedback
Marker not detected/not processing correctly	Could mislead the user	Need larger markers detectable form long distance

Common Risk mitigation plan for the above: The app will have a mapped layout of the well-indexed parking space along with the allocated slot pinpointed. The user can follow the map and the index number to the allocated slot.

3. Failure of server

By choosing online cloud server, there is no need of any maintenance. The expected downtime in Amazon AWS servers is less than 0.01%.

Cost Model

The costs involved in the system are

1. Image Processing System: (Rs.1,00,000 per parking space)
2. Server Cost (Rs.6,000/month from aws.amazon.com)
3. Cost of laying markers over each spot (Rs.50 per spot)
4. Cost of installing markers for localization (Rs.200 per marker)
5. Cost of making an app (-)
6. Cost of deploying and marketing the app (-)

With the following assumptions – System covers 10 parking spaces in the region, each parking space has on an average 500 parking spots and 50 markers needed for localization in each parking space- the cost of installing the system in such a region will be approximately Rs.1500000. This would be minimum first time investment for the system to go online. Additional costs like marketing are ignored. Since we intend to design the app and other software, we ignore even that cost in the analysis.

Revenue model

The following sources of income have been identified

1. Commission from the parking space owners.
2. Advertising on the markers used for localization.
3. Selling generic data to interested companies

Scalability

1. Adding a new parking space to the system.
2. Requires installation of Image Processing System and markers.
3. Slight modification on the server.
4. Approximate estimated cost for adding an additional parking space to the system (with above assumptions) – Rs.150000.

Idea Incubation

1. Select a region: We selected Bangalore as it has high vehicle density and parking spaces are valuable, apart from being an IT hub (more Smart-phone users).
2. Contact parking spaces in the region: We target large parking spaces, malls, paid parking spaces, shopping complexes and open parking spaces, where users are more and managing is difficult and the owners are looking for alternate solutions.
3. Look for potential investors.
4. Product development
    a. Survey the premise where the system is to be installed.
    b. Procurement
        i. Server space. aws.amazon.com is a good option
        ii. Image processing systems
        iii. Markers
        iv. Additional cameras if needed
        v. Payment gateway
    c. Build software (server, availability detection, marker detection)
        i. Server software
        ii. Empty spot detection
        iii. Marker based localization and AR interface
5. Installation, testing and debugging.
6. Deployment of the App.
7. Enlarging user base: Marketing and publicity.
8. Scaling: Adding more parking spaces to the system.

References

[1] http://shoup.bol.ucla.edu/CruisingForParkingAccess.pdf
[2] http://www.parkingreform.org/
[3]http://www.google.co.in/patents/US6791473
[4]http://www.google.com.sl/patents/WO2003005323A1?cl=en
[5]http://tsrc.berkeley.edu/parkingfieldtest
[6]http://www.mobility.siemens.com/mobility/global/en/urban-mobility/road-solutions/integrated-smart-parking-solution/pages/integrated-smart-parking-solution.aspx
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[10] http://www.parkingreform.org/good-policies.html