SMART PARKING

by

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CERTIFICATE

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ABSTRACT

Due to the exponential increase in the number of vehicles on the road, traffic problems are bound to exist. This is due to the fact that the current transportation infrastructure and car park facilities developed are unable to cope with the influx of vehicles on the road. To alleviate these problems, the smart parking system can be developed. With the implementation of the smart parking system, people can easily locate and secure a vacant parking space at any car park that is convenient to them. With vehicle detection sensors available on the market, the choices made may defer due to the different requirements in addition to the its pros and cons. By implementing smart parking system, we can reduce traffic congestion and easy allotment of parking spaces can be achieved. UI is also provided that allows an end user to check the availability of parking space and book a parking slot accordingly.

ACKNOWLEDGEMENT

We would like to express my sincere gratitude to our project supervisor Ms.V.Suganya for providing her invaluable guidance, comments and suggestions in every phase of our project.

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LIST OF ABBREVIATIONS

IR	- Infrared
API	- Application Programming Interface
IOT	- Internet Of Things
WSN	- Wireless Sensor Network
RFID	- Radio Frequency Identification
GSM	- Global System for Mobiles
VANET	- Vehicular ad hoc Network
SPS	- Software Product Specification
IDE	- Integrated Development Environment
UI	- User Interface

CHAPTER 1

INTRODUCTION

1.1 PROBLEM DOMAIN

Smart parking can be defined as an automated mechanism that helps car owners/drivers to locate and navigate to available parking slots in their locality. The real-time data is transferred from sensors (placed in the parking areas strategically) to dedicated applications installed in the handheld devices of users. The smart parking management setup can also help individuals book parking slots in advance, by automating payments.

There are lots of research works that exist in the area of design and development of smart parking system. Various features of smart parking system are

- Inquiry on availability of parking areas
- Pre-booking of an available parking lot
- Real-time parking navigation and route guidance
- Detection of occupancy of vehicles and management of parking lots

1.2 PROBLEM DESCRIPTION

There has been a consistent problem in finding a free parking slot in any congested place. There is lack of proper free spaces for parking due to increased unplanned housings in many places of the city. There has been increase in the number of vehicles, but without sufficient parking spaces. Such growing number of small vehicles especially motorcars and huge vehicles have created a mess in the city including the increase in traffic jam. To improve all these, there is a need to create enough parking spaces. This problem has lead to longer waiting and searching time for a parking slot for the users and increase in traffic and fuel consumption. However, with the help of smart parking system, people can easily find the nearest available parking slot.

The Objectives of this project is to:

- To reduce the driving time required to find parking spaces
- To make optimal use of available parking slots.

1.3 SCOPE

In the existing scenario any person owning a vehicle finds it difficult to find an available parking spot in a congested area which leads to wastage of time and fuel consumption. There are number of scenarios where the roads are congested because of improper regulation of parking system. By implementation of a smart parking system the above mentioned problems can be resolved.

1.4 CONTRIBUTION

Through this project the major contributions were

- Finding the nearest parking area with availability
- Detection of presence of vehicle
- Updating parking data to cloud and retrieving it
- An UI to find the nearest available parking area and slot

1.5 SWOT ANALYSIS

SWOTs are defined based on the following criteria:

- ✓ Strengths are internal attributes of the organization that are helpful to the achievement of the objective.
- ✓ Weaknesses are internal attributes of the organization that are harmful to the achievement of the objective.
- ✓ Opportunities are external conditions that are helpful to the achievement of the objective.
- ✓ Threats are external conditions that are harmful to the achievement of the objective.

1.5.1 STRENGTH

1. Reduction of fuel consumption.
2. Reduction of traffic congestion.
3. Time people spend to find a parking spot is reduced.

1.5.2 WEAKNESS

1. Cost of implementation of the above system is comparably high.
2. If internet connectivity is lost then updating and retrieving data is not possible.
3. If any component of the system fails then it can lead to inconsistent data.

1.5.3 OPPORTUNITY

1. Any person having a smartphone with internet connectivity can use this smart parking system.
2. This can be integrated with traffic control system for finding the best parking area with availability.

1.5.4 THREATS

1. If there is a new parking system being introduced in the market, our system has to be integrated with them for better results.
2. In case of any intrusion in the central service system customer data will be compromised.

1.6 TOWS ANALYSIS

- **S-O :** Reduction of traffic congestion can be potentially used by traffic control system for proper vehicle movement regulation.
- **S-T :** For overcoming integration issues, the system can be made more modular.
- **W-O :** Even if internet connectivity is lost we can provide offline version of the system to ensure its reliability.
- **W-T :** If the user encounters a situation with inconsistent or wrong data, the interface can have a reporting system.

1.7 STAKEHOLDER ANALYSIS

1. **Internal stakeholders**: Those who installed smart parking system, developers who developed the system and government organisation can

be internal stakeholder if in case this system is implemented by the government.

2. **External stakeholders:** People who use this system to find the nearest parking spot.

1.8 FEASIBILITY ANALYSIS:

The system identifies the nearest parking spot available using maps API (fetches the list of nearest parking spots) and in each parking hub the available slots will be calculated with the help of Arduino circuit.

1. **Market**: In the era of smart cities, smart parking systems will definitely play a crucial role. Since there are many malls and commercial places with frequent ingress and egress of vehicles this system will be helpful for efficient management of parking spots.
2. **Technical:** As the components used for this project may not be available in the future, this system has to be designed in such a way that it supports new interface for the upgraded version.
3. **Financial:** The system involves a large amount of capital for installation. Once installed the cost of maintenance is minimal.

1.9 PESTLE ANALYSI

1.9.1 POLITICAL FACTORS

Interference of government in this project plays a major part. Because, various implementations of the tech may need permission from government. Eg: In government-reserved parking slot, we might need permission to install this system. So it all depends on where the idea is implemented the political implications may exist.

1.6.2 ECONOMICAL FACTORS

This project mainly involves a lot of hardware components, cloud service and Maps API. These hardware components are costly and thus it is very expensive to install this system. But once this system is installed, it will be of immense help to the customers.

1.6.3 SOCIAL FACTORS

Smart parking systems will be very helpful for the customers because they can easily find a parking slot with less waiting and searching time. The traffic congestion due to imparking waiting will be reduced. Fuel consumption due to long searching time will be reduced.

1.6.4 TECHNOLOGICAL FACTORS

This project enables to open paradigms like cloud services and Iot enabled parking. This implementation can lead to even more future technical scope.

1.6.5 LEGAL FACTORS

This project does have legal implications regarding installation of this system in an already existing parking areas.

1.6.6 ENVIRONMENTAL FACTORS

This project doesn't affect the environment in any way and completely aims at enriching the lives of the users. Fuel consumption by the vehicles is also reduced.

CHAPTER 2

RELATED WORKS

The recent works are found in the areas of using RFID technology and embedded systems so that the user finds it helpful in checking the availability of parking space over the Internet. Image processing have also been used to detect cars. A mono-parking wireless sensor network has also been descried where wireless sensors have been deployed in a parking lot, with one sensor node for each car. Multiparking systems are also in proposal nowadays where outdoor car parking management, e.g. in streets, guiding towards a car parking lot within a city. This requires collboration between multiple car parking managers. Wireless technologies and wireless applications are used to acquire information about the status of availability of parking slots in parking areas. This information is transmitted to a central information collection hub or gateways like cloud. [12] proposes an idea called iParking, that monitors the ingress/outgress of vehicles using a WSN. iParking finds the availability of parking spaces and gives away the information to the users. In [13], a street based parking system based on a Wireless Sensors Networks. The state of the availability of parking lots by deploying a magnetic sensor node on the space A vehicle detection algorithm has been proposed to accurately detect a car that has been parked. Adaptive sampling techniques have been used to reduce the fuel and energy consumption. [14]ParkSense, a cloud-based applicaton that can be installed in any mobile phones that detects any free parking spots. Most of the recent studies either suggest RFID or WSN for vehicle detction and focus on traffic congestion elimination through efficient installation of smart parking system in the parking areas.

Starting with a the Base Station(BS) location problem, algorithms like Dynamic Programming to genetic algorithms have been proposed for finding the optimal placement of nodes in topology optimization. The BS location problem demands a set of points to be covered with the objective of optimizing a given objective, like distance between the points and their closest availablity place. This is similar to the Maximal Covering Location Problem(MCLP)[19-20], referred to as the Location Problem in WSNs, where a large number of points are to be covered in a fixed radius.

Looking at the advancements in the field of Iot, a lot of research people have proposed several techniques for optimal placing of nodes for topology control. For maximum coverage sensing,[21-26] are similar to the Base Station Location Problem, they work on minimizing the sensors while maximising the coverage. Many greedy algorithms are also used for the optimal placement of sensors. Techniques like virtual force method for sensor deployment have also been adapted.

There are many ways for the optimal connecting of sensors through resolution of an location of the sensor, reveals that such optimal placements can also reduce energy consumption. [16-18] propose a heuristic solution for multiple car parks using the placement problem is formulated as a non-linear optimizatio problem which can be solved using the self-incremental algorithm that adds nodes one at a time to the network in the most efficient identified way. The optimal placement of static sensors in a network is used for helping an agent to navigate in finding a parking area by using range measurements to the sensors. For the study of different regular grid positioning methods for sensor networks, [10] proposes th ways to find the minimum numbers of sensors required to provide full coverage, and the fault-tolerant system is expressed as the minimum number of sensors that must be shut down so that it doesnot degrade the network coverage on the whole.

Looking at the sensor positioning in the point of view for data transmission, the [13] divides the terrain sensors into cells and then analyses how these group of N nodes of sensors can be distributed among the cells, so that it avoids network bottlenecks and data loss. Mostly greedy algorithms are adopted for selecting the location and positioning of sensors with minimal number of nodes using grid model and probilistic coverage model for sensors. With geospatial constraints, this model allows the inclusion of the effect of obstacles and incorporation of an important factor of consideration of coverage of data transmission by the sensors.

CHAPTER 3

REQUIREMENT ANALYSIS

The Requirements for the system is categorised as

1. Functional
2. Non-functional
3. Software requirements
4. Hardware requirements

3.1 FUNCTIONAL REQUIREMENTS

Functional requirements are the functions or features that must be included in any system to satisfy the business needs and be acceptable to the users.

Based on this, the functional requirements of the system are as follows:

- The System should be able to detect the vehicle when it is parked in the parking spot.
- The System should be able to perfectly sense the entry and exit of the vehicles.
- The System should be able to process sensor input in real time and update it in the Cloud.
- The System should have an ambient user interface to display the correct data to the user.

3.2 NON FUNCTIONAL REQUIREMENTS

Non-functional requirement is a description of features, characteristics and attributes, the system as well as any constraints that may limit the boundaries of the proposed system.

Based on this, the non-functional requirements are:

- The System should be very accurate.
- The System should not have inconsistent data because of sensor failure.
- The System should be scalable.
- The System should be suitable any dimension of any vehicle.

3.3 SOFTWARE REQUIREMENTS

- Python
- Flask framework
- Ardiuno IDE
- Any enabled Cloud service

3.4 HARDWARE REQUIREMENTS

- Infrared sensors – 2 numbers
- Ultrasonic sensors – 2 numbers
- Ardiuno boards(Genuino/ Uno) – 2 numbers
- 4 GB RAM Computer
- Jumper wires
- Ethernet cable

3.5 FLOW DIAGRAM

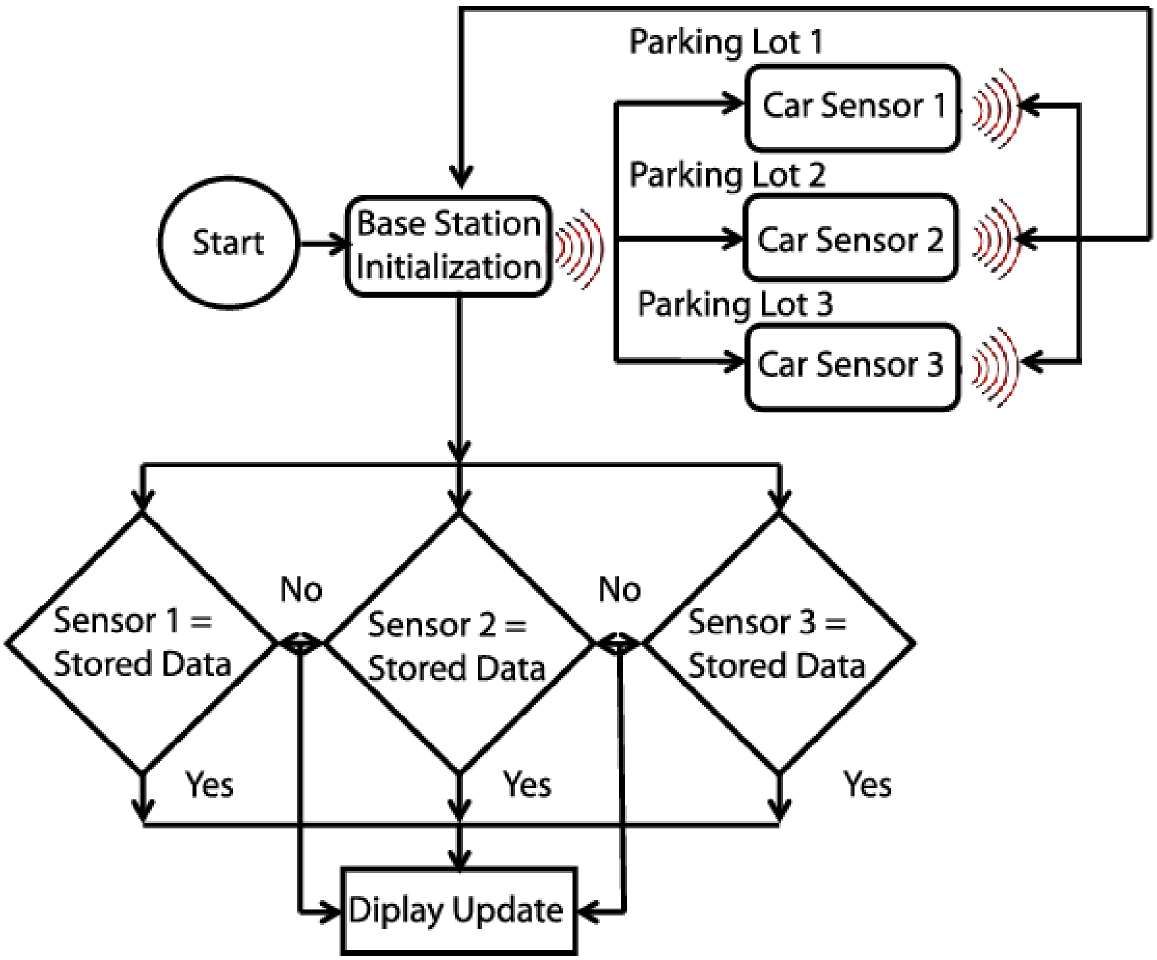

Fig 3.1: Flow Diagram

CHAPTER 4

SYSTEM DESIGN

4.1 ARCHITECTURE DIAGRAM:

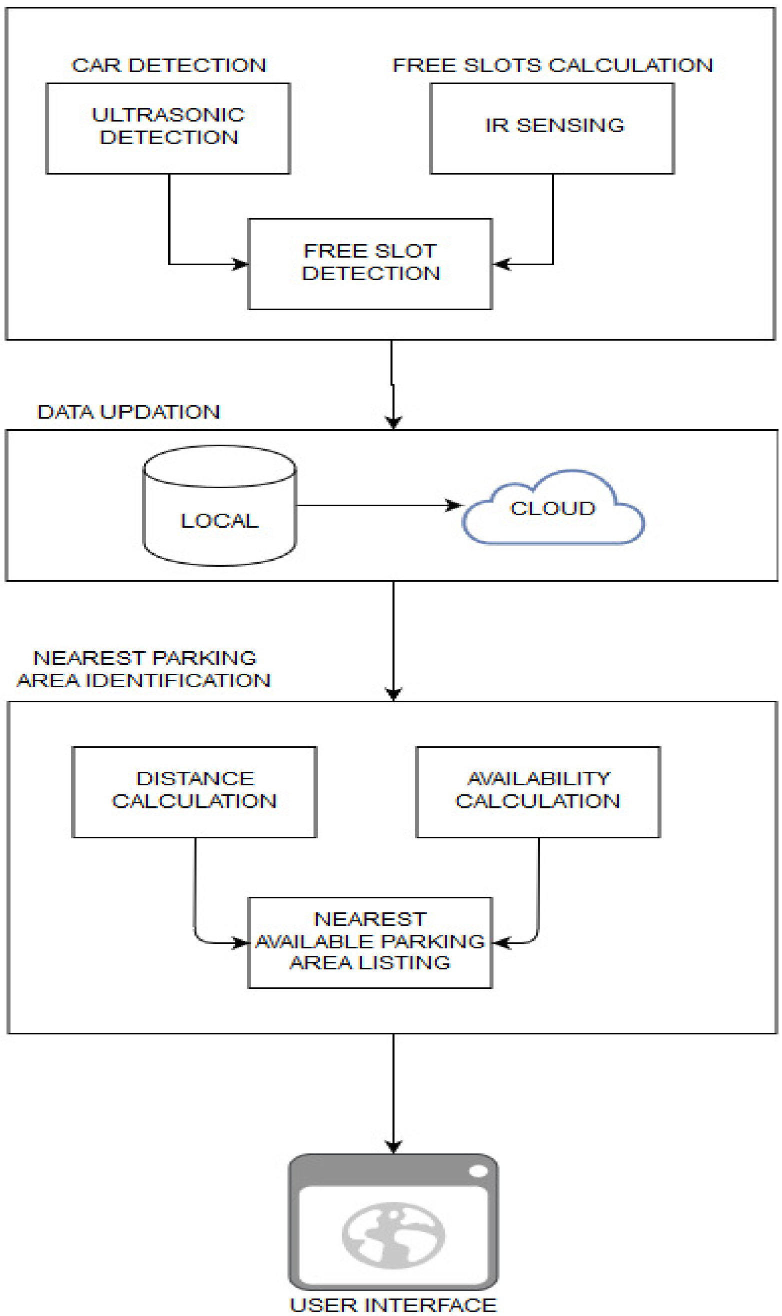

Fig 4.1: Architecture Diagram

4.2 MODULE SPLITUP:

- Vehicle sensing and free slot detection
  i. Car detection
  ii. Free slot calculation
  iii. Free slot detection
- Data updation
  i. Local database
  ii. Cloud
- Nearest Parking Area Identification
  i. Distance Calculation
  ii. Availability Calculation
  iii. Nearest Available Parking Area Listing
- User Interface

4.3 VEHICLE SENSING AND FREE SLOT DETECTION

4.3.1 FREE SLOT CALCULATION

Free slots calculations are done with the help of IR sensors. The working is that the IR transmitter will transmit the IR radiation and when these radiation fall on the surface of an object it gets reflected. The reflected IR radiations are received by the IR receiver. Whenever the IR receiver receives a reflected radiation, it indicates the presence of an object. Two IR sensors are placed in the entry point, when a vehicle enters or leaves the number of cars inside the parking area is calculated accordingly.

4.3.2 CAR DETECTION

Car detection is done with the help of Ultrasonic sensors. The principle of ultrasonic sensors is that ultrasonic sensors measure distance by using ultrasonic waves.The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception. When a vehicle enters the free parking slot the Ultrasonic sensors will be triggered and the slot will be marked as occupied.

4.3.3 FREE SLOT DETECTION

The output of the above two modules are combined together and the number of free slots are calculated and which slot in the parking area is free will be identified and sent for database updation.

4.4 USER INTERFACE

The list of parking areas will be sent as a JSON to the front end and will be tabulated accordingly and will be displayed to the user. The user can update the list will the help of update availability button.

4.5 DATABASE UPDATION

4.5.1 LOCAL DATABASE UPDATION

Number of vacant parking slots and slots available in a particular parking area is identified in the previous steps and the corresponding data will be updated in local database. We have used mongodb for database as it is more scalable than traditional relational databases.

4.5.2 CLOUD DATABASE UPDATION

In order to offer worldwide access and to communicate between the modules in our application we have updated the number of vacant parking slots and the slots available in a particular parking area in the cloud database.

4.6 NEAREST PARKING AREA IDENTIFICATION

4.6.1 DISTANCE CALCULATION

The distance between the user's current location and the parking areas are calculated using the google maps API.

4.6.2 AVAILABILTY CALCULATION

The data that was updated in the cloud or local databases are fetched and will be used in calculating the availability in every parking area.

4.6.3 NEAREST AVAILABLE PARKING AREA LISTING

The parking areas are then rearranged based on the shortest distances from the current location and the availability in the parking area.

CHAPTER 5

ALGORITHMIC DESIGN

ALGORITHM: Nearest available parking area detection is that algorithm that has been used to find the nearest free parking area with free slots available for the smart vehicle parking.

5.1 COUNT CALCULATION ALGORITHM

IR Sensors: IR1, IR2

Steps:

- IR1 and IR2 will be installed at the entrance of the parking space.
- When a vehicle enter the parking space IR1 will be triggered first and then IR2. This triggering sequence indicates a vehicle has entered. In this sequence the count is incremented.
- When a vehicle leaves the parking space IR2 will be triggered first and then IR1. This triggering sequence indicates a vehicle has exited the parking space. In this sequence the count is decremented.

5.2 DISTANCE CALCULATION ALGORITHM

Google Maps API uses a modified version of Dijkstra’s algorithm to find the shortest distance between two points.

5.3 DIJKSTRA’S ALGORITHM

Dijkstra's algorithm computes the cost of the shortest paths from a given starting node to all other nodes in the graph.

Our project has implemented this algorithm to find the shortest path between the source (user’s location) and the list of all parking areas, which has available parking slots.

Input : User’s location, List of all parking areas which has available parking slots.

Output : Distance between the user’s location and corresponding parking areas. The list of parking areas will be rearranged in ascending order.

CHAPTER 6

TESTING

Module Name	Sample Input	Expected Test Results
Ultrasonic detection	A vehicle	The vehicle must be sensed
Prerequisites	NIL	
Pass / Fail Criteria	Pass: The vehicle is detected within the sensor’s proximity Fail: Any obstacle is also detected by the sensor.	
Test Procedure	Connect the ultrasonic sensor to the microcontroller, Power up the microcontroller. Upload the code for vehicle detection to the microcontroller. Monitor the serial transfer of data The vehicle is sensed by the ultrasonic sensor when placed in the proximity of the sensor	
Assumptions/Constraints	The vehicle will be detected only when the distance between the sensor and the vehicle is < 5cm. Input should only be a vehicle and not any obstacles like a human or dog.	

Actual Output

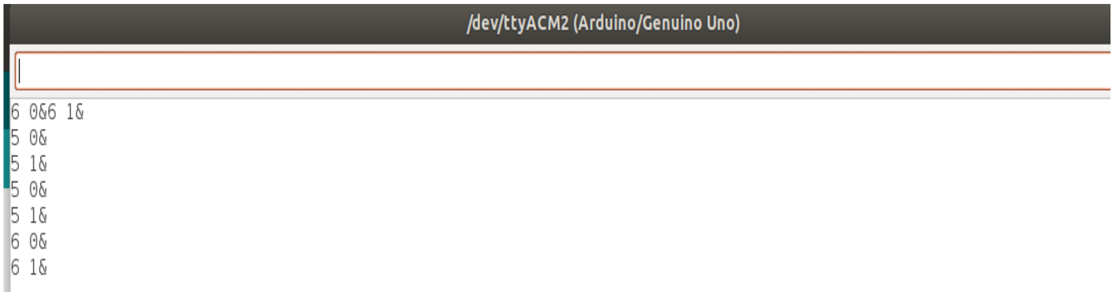

Fig 6.1: Ultrasonic sensor using Arduino

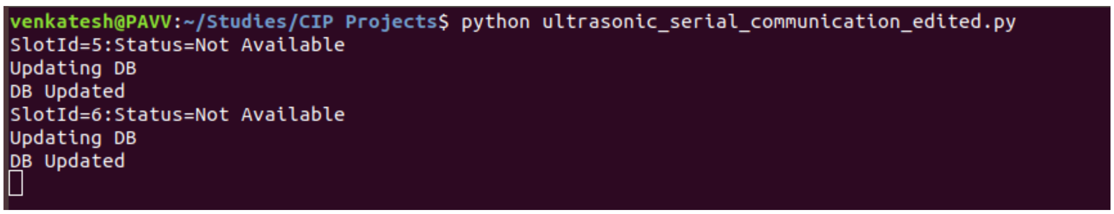

Fig 6.2:Ultrasonic sensor using Python

Additional Testing considered for the Module (□):

	Stress Testing		□	Performance Testing
	Interface Testing			Recovery Testing
□	Integration Testing		□	System Testing

Table 6.1: Ultrasonic sensor testing

Module Name	Sample Input	Expected Test Results
IR sensing	A vehicle	The vehicle must be sensed.
Prerequisites	NIL	
Pass / Fail Criteria	Pass: The vehicles are correctly sensed. Fail: All objects are sensed.	
Test Procedure	Connect the IR sensor to the microcontroller. Power up the microcontroller. Upload the code for vehicle detection to the microcontroller. Monitor the serial transfer of data The vehicle is sensed by the IR sensor when the vehicle passes by the sensor.	
Assumptions/Constraints	The sensor must be installed in a height such that it detects all vehicles.	

Actual Output

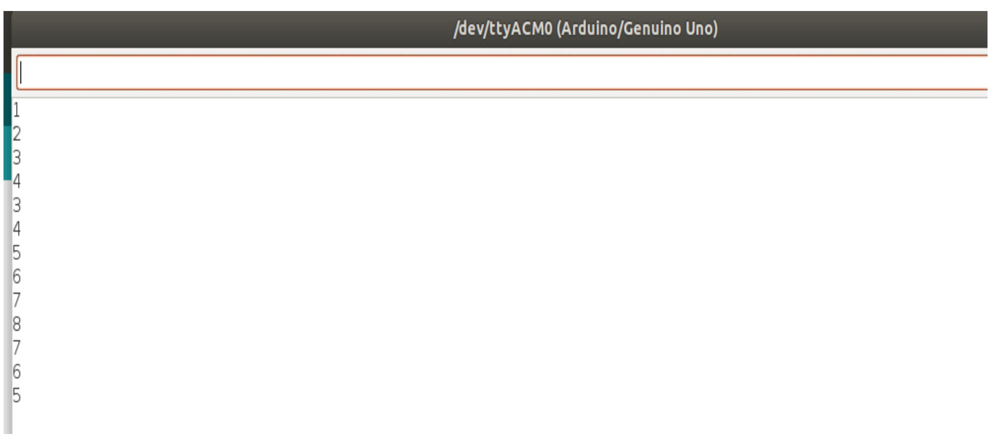

Fig 6.3: IR sensor using Arduino

Additional Testing considered for the Module (□):					
	Stress Testing		□	Performance Testing	
	Interface Testing			Recovery Testing	
□	Integration Testing		□	System Testing	

Table 6.2: IR sensor testing

Module Name	Sample Input	Expected Test Results
Free slot detection	A parking area with free and occupied slots	The number of free slots are to be counted
Prerequisites	IR sensing, Ultrasonic detection	
Pass / Fail Criteria	Pass: The number of free parking slots are successfully counted Fail: When any sensor fails, inconsistent data occurs.	
Test Procedure	Drive a car through the exit/entry point. Park it in the free slot. The number of free slots will be updated.	
Assumptions/Constraints	Input is an image (Not video) Some objects are stationary Multiple objects are not considered. Occluded images are not considered.	

Actual Output

```
venkatesh@PAVV:~/Studies/CIP Projects$ vi arduino_serial_communication_final.py
venkatesh@PAVV:~/Studies/CIP Projects$ python arduino_serial_communication_final.py
Number of cars
1
Updating to cloud
Updated in cloud
Number of cars
2
Updating to cloud
Updated in cloud
Number of cars
3
Updating to cloud
Updated in cloud
Number of cars
4
Parking Full
Number of cars
3
Updating to cloud
Updated in cloud
Number of cars
4
Parking Full
Number of cars
5
Parking Full
Number of cars
4
Parking Full
Number of cars
```

Fig 6.4: IR sensor using python interface

Additional Testing considered for the Module (✓):

	Stress Testing			**Performance Testing**
	Interface Testing			**Recovery Testing**
✓	**Integration Testing**		✓	**System Testing**

Table 6.3: Integration testing

Module Name	Sample Input	Expected Test Results
Data Updation	Sensor data about parking availability	Data has to be successfully updated in the cloud database
Prerequisites	Ultrasonic detection, IR sensing, Free slot detection	
Pass / Fail Criteria	Pass: The data will be successfully updated to the cloud. Fail: If there is no internet connection, data cannot be updated to the cloud, leads to incorrect data.	
Test Procedure	Pass the sensor to the Mlab Mongo Cloud platform. The data will be updated to the db.	
Assumptions/Constraints	Active internet connection persists	
Actual Output		

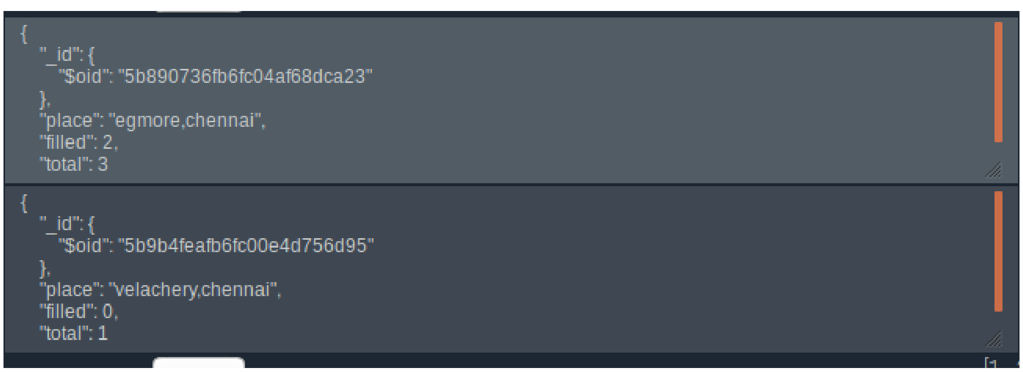

Fig 6.5: Cloud Storage

Additional Testing considered for the Module (□):				
□	Stress Testing		□	Performance Testing
□	Interface Testing			Recovery Testing
	Integration Testing		□	System Testing

Table 6.4: Cloud Storage testing

Module Name	Sample Input	Expected Test Results
Nearest parking area Identification	Current location of the user	Nearest parking area with availability is found out.
Prerequisites	Cloud with updated data.	
Pass / Fail Criteria	Pass: The nearest parking area to the user with availability is found out Fail: NIL	
Test Procedure	Set the current position of the user as the source. The shortest distance parking area is found out.	
Assumptions/Constraints	The user’s current location of the user is considered as Chennai, India.	

Actual Output

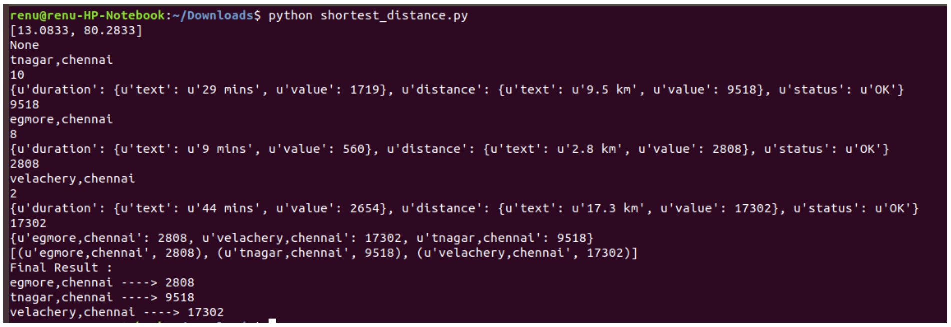

Fig 6.6: Shortest Distance Calculation

Additional Testing considered for the Module (□):

	Stress Testing			Performance Testing
	Interface Testing			Recovery Testing
	Integration Testing		□	System Testing

Table 6.5: Shortest Distance Module testing

Module Name	Sample Input	Expected Test Results
User Interface	NIL	The parking areas are listed
Prerequisites	Sensing, Data updation, Nearest parking area identification	
Pass / Fail Criteria	Pass: Correctly lists the set of parking areas with availibity ordered based on distance. Fail: Fails in case of inconsistency of data in DB or sensors	
Test Procedure	User runs the webpage that has been hosted for this smart parking system.	

Assumptions/Constraints	Active internet connection is present for immediate availability of updated data.

Actual Output

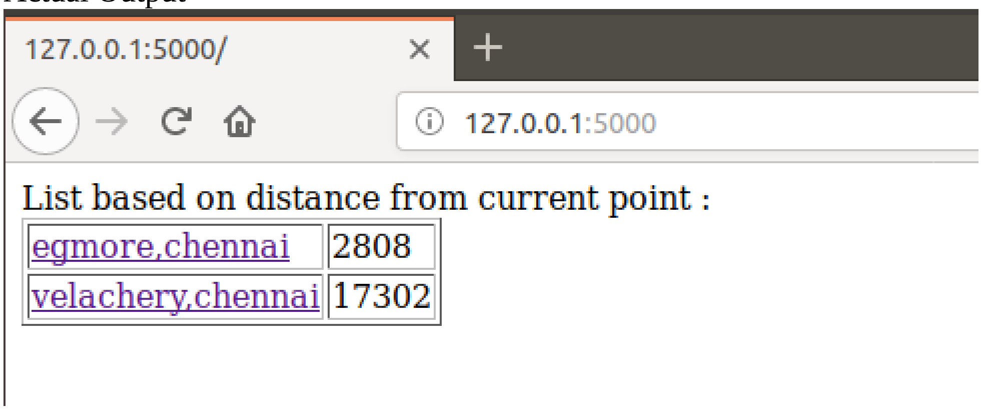

Fig 6.7: List of available parking areas

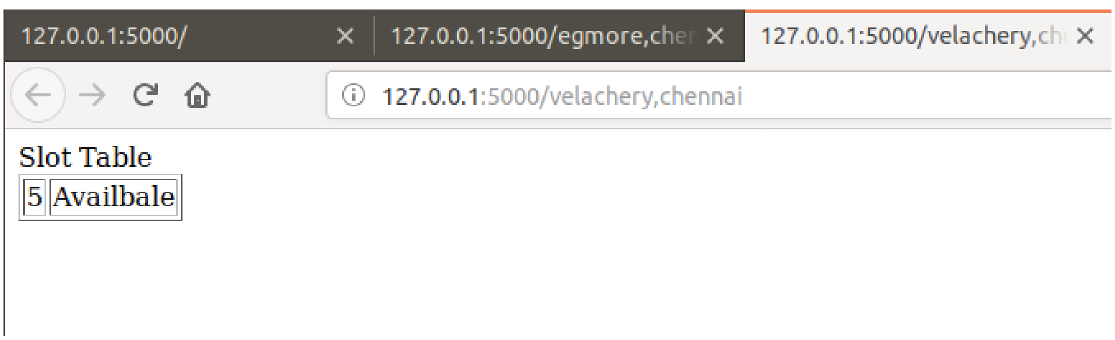

Fig 6.8: Available Parking Slots in location 1

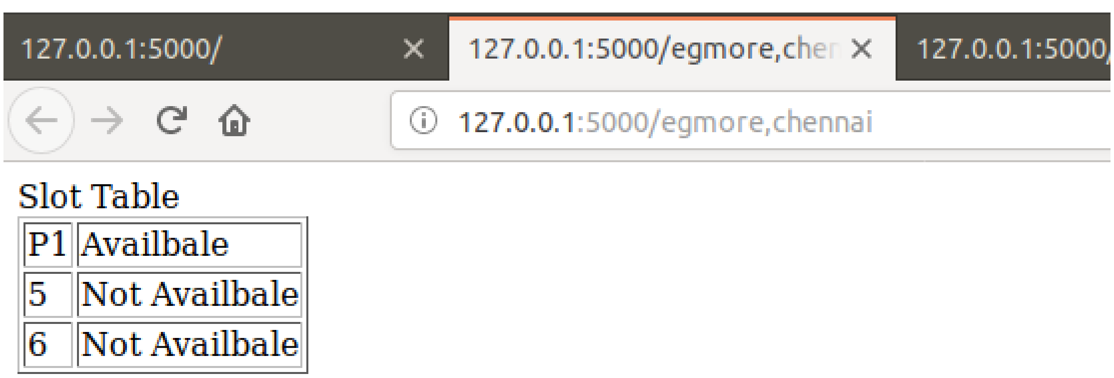

Fig 6.9: Available Parking Slots in location 2

Additional Testing considered for the Module (□):				
□	Stress Testing			Performance Testing
□	Interface Testing			Recovery Testing
□	Integration Testing		□	System Testing

Table 6.6: System testing

CHAPTER 7

RESULT ANALYSIS

7.1 ACCURACY OF IR SENSORS

The IR sensor used in our project senses any object that passes through it. For example, any dog or object passing through the sensor considers even that as a vehicle and increments the count of the vehicle. This problem is of very important consideration as this might lead to inconsistent data.

This problem can be solved by installing in a proper height and dimensions in accordance to the generic vehicle such that it senses only vehicles that passes through the sensor.

7.2 ACCURACY OF ULTRASONIC SENSORS

The ultrasonic sensor detects any object which is close to its proximity. The ultrasonic sensor used in our project can detect a vehicle only if it very close to the sensor (approx 4cm).

This problem can be resolved by using highly accurate better versions of the Ultrasonic sensors that can have better range to detect the vehicle and provide proper data regarding slot availability.

CHAPTER 8

8.1 SUMMARY

This project helps in proposing a parking system that improves performance by reducing the search and wait time in finding a free parking area. Our project helps in simulating and implementing in a real world scenario. The successful implementation of smart parking systems in major congested areas can reduced the chaos caused due to finding a parking spot significantly. The system achieved optimal solution when most of the vehicles successfully found a parking space. The average waiting time for each cark park service becomes significantly minimal and the total time of each vehicle in each car park is reduced. The security aspects of our system are to be discussed in the future scope of the project.

The Smart Cities have always been a dream for humanity. Since the past couple of years large advancements have been made in many technologies such as the development of making smart cities a reality. The growth of Internet of Things and Cloud technologies have give rise to new ideas that are helpful in building smart cities. In smart cities, Smart parking facilities play a crucial role. Smart parking facilities and traffic management systems have always been at the core of constructing smart cities. In this project, we have proposed a prototype for the issue of parking and present an IoT based Cloud integrated smart parking system. The system that we propose provides real time information regarding availability of parking slots in a parking area. Users from remote locations could book a parking slot for them by the use of our mobile application. The efforts made in this project are

indented to improve the parking facilities of a city and thereby aiming to enhance the quality of
life of its people.

8.2 FUTURE WORKS

The following works can be considered as the future works of Smart Parking Systems.

- Real-time detection of improper parking
- Estimation of each vehicle's duration of parking lot usage
- Automatic collection of parking charges
- Charging of electric cars using solar panels.

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