Literature Review on Parking System

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Abstract— **Finding a suitable parking space has become a significant concern for people residing in metropolitan cities. The main reason behind this is a lack of parking space. The traditional parking methods cannot be used today as they are ineffective at utilizing space; hence it is vital to find alternative parking systems. Tracking of parking slots is also an essential factor, which can be done using an IoT system integrated with sensors. This paper explores the application of an IoT-based Car parking system. The paper also explores the use of various types of sensors for car parking systems.**

Keywords— Parking system, IoT system, sensors, safety..

I. INTRODUCTION

Due to an increase in the number of cars in the cities, finding a suitable vehicle parking solution has become vital. The traditional parking methods cannot be used today as these methods require a considerable amount of area, and to meet the parking requirement lot of area would be required. The cost of land has grown exponentially in cities, so it becomes essential that the parking solution requires the least possible space and can accommodate the maximum amount of vehicles. An average person spends 10 to 15 % of his travel time looking for a suitable parking spot in metropolitan cities.[1]

The parking system requires a working mechanism that can operate the system. In addition to this, a detection system is required to help the person know whether there is an availability of a free parking spot. The need to consider the safety of cars and humans alike when designing this system. In this paper, the different types of parking systems and various kinds of sensors used to increase safety and efficiency are discussed.

II. PARKING ISSUE IN INDIA

A. Need for Cleaning System

The biggest issue with owning a car in a metropolitan city in India is finding a suitable parking space due to a lack of parking space. The number of cars in India is more than 40 million, which corporations and personal individuals own. And the number is increasing day by day because of the affordable prices of cars and the improvement of the economic status of a middle-class person. In recent time there has been an increase in the number of vehicles, but the space for parking has not increased according to the requirements. As a result, around 40% of road space is utilized for parking instead of transport activity. Which increases road accidents. [1]

III. SOLUTION TO PARKING PROBLEMS

The parking problem can be eliminated by using various parking solutions in this paper; the various parking systems and their advantages & limitations are discussed.

A. Modular or Puzzle Type

Puzzle-type automated multilevel parking is inspired by the children's game of '15-sliding puzzle'; a 4*4 grid has one empty slot. For parking or removal of the car, shuffling of cars should be done to bring it to its desired location. Major components of this system are shelves/shuttles, a lift for vertical movement in multilevel, AGVs, I/O points. Here shelves/shuttles can be either movable in X and Y direction or stationery. The major drawback is the complicated management of the system. There are various proposed retrieval methods in movable shuttles, such as optimal dual load retrieval and multiple load retrieval methods. Some shelf management strategies are autonomous shelf strategy and AGV powered shelf management strategies. [2]
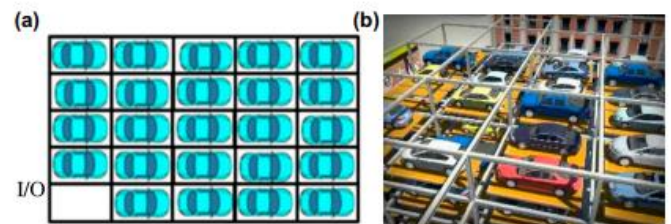

Fig. 1. Top View, (b) 3D-view of a Puzzle Type Car Parking System [2]

1) Advantages
i. These systems allow a very high storage efficiency in surface and volume.
ii. This system is very quick as the time required for accessing a car is low.

2) Limitations
i. The system is complex, and the speed of operation is also slow.

B. Elevated Type or Tower

A tower-based automatic parking system is a system with a cylindrical appearance. A component in the design, i.e., a tower crane, can simultaneously perform two types of movements. Up and down motion in the Y-axis direction and Anti-clockwise rotation and clockwise rotation. The shuttle

can move along the diameter of the tower to the opposite parking space. [3]

1) Advantages
i.   Optimal utilization of space.
ii.   Lower maintenance and operational costs.
iii.   Lower construction cost.
iv.   Secure and environment-friendly nature (the underground implementation saves open space)
v.   Comfortable for the drivers.

2) Limitations
i.   Noise and air pollution to the surrounding environment.
ii.   Regular cleanliness is required.

C. Multilevel floor Parking

In this type of car, vehicles are parked on different layers, floors of a building. These floors are accessed with the help of external or internal mediums such as ramps or other similar structures. There is a vertical lift (mechanized) for the movement of vehicles in the y-direction. This arrangement helps in less ground space which directly associates with cost reduction of the building. This arrangement helps to accommodate more cars and produce a faster parking process. Also, sensor arrangement in this system helps to control and optimize the parking procedure. The system is designed so that the ground level gets filled first and then moves to the next level above it, and once this level is filled, it moves to the next level and so on. [4]

1) Advantages
i.   Maximum utilization of ground space.
ii.   Designed for driver convenience
iii.   Multiple safety guarantees of the drivers and cars.
iv.   Quick entry and exit are due to the independent lift operation; hence, partial breakdown does not affect the other parts. The average vehicle retrieves time is less than two minutes.

2) Limitations

i.   Expensive because the whole parking and retrieval operation is multilevel.
ii.   Any fault in the multilevel car parking system causes great haphazard and inconvenience.
iii.   This system is more complex to build, and the construction cost is very high.

D. Stacker Parking System

This system consists of parking lots with a platform to park the cars.it consists of a stacker mechanism that moves centrally, and it is equipped with a robotic arm to push and pull the car.[5]

Fig. 2.   Stacker-Type Parking System [5]

1) Advantages
i.   Reduce the lane area.
ii.   Driver comfort.
iii.   Improve area utilization.

2) Limitations
i.   High Initial Investment and high cost of operation and maintenance.

E. Rotary Type

This system consists of a rotary mechanism that allows all the cars to travel in rotary motion. Cars are loaded and unloaded with the rotary motion of all cars. This system is preferable for 8 to 12 cars. [5]
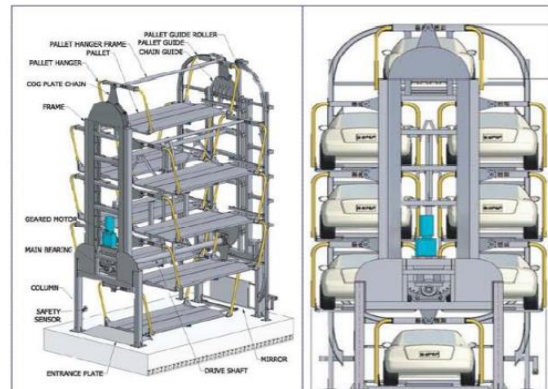

Fig. 3.   Vertical Rotary Parking Lot [5]

1) Advantages
i.   Easy to operate.
ii.   Easy parking of the vehicle.

2) Limitations
i.   All cars need to be rotated to access one car.
ii.   High initial cost and high maintenance.
iii.   Complicated Structure

F. Circulation Horizontal Parking

This system is meant for parking cars in tight spaces. The system operates in a similar principle to a conveyor-type chain drive. In this system, once the vehicle is parked, it is then put into the circulation cycle. [5]
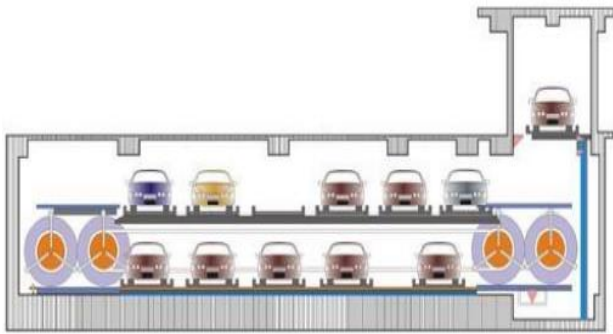
Fig. 4.   Horizontal Circulation Parking System [5]

1) Advnatages
i.   Almost no waste of space.
ii.   It can be installed in underground basements as well as podium levels.

2) Limitations
i.   The whole lot needs to be rotated to get to the required car.
ii.   This system is expensive and hard to maintain.

G. D Stacker System

This system has various variants like a two-car stacker system or a three-car stacker system. The variants may be completely overground or keep the system partially underground or completely underground. In this parking system, one car is placed over the other. The pallet is lifted by using a lift mechanism once a car is parked. Multilevel Parking systems have provided relief since they have several advantages like optimal space utilization, lower maintenance, operational, construction cost. [5]
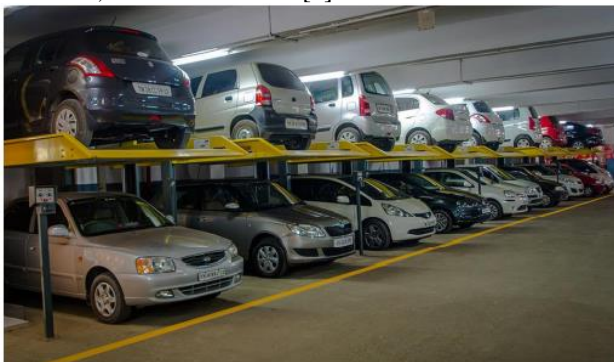

Fig. 5.   D Stacker System [5]

IV.   SMART PARKING SYSTEM

A smart parking system provides data for real-time parking space availability. A few technological approaches are used to collect this data, alleviate the urban traffic crunch, and make parking more efficient and better managed. The most widely used IoT based smart parking systems include:
i.   Cameras
ii.   Ground sensors
iii. Overhead radars/lidars

All the different types of technology have advantages and limitations, and the optimal choice depends on the system's requirement and budget.

A. Cameras

Development in computer vision and AI, the camera, can detect empty parking spaces. The advantage of cameras is the possibility to monitor many parking spaces at once. However, real-world deployments have many variables like a greater variety of lighting conditions, viewing angles, vehicle types, and weather conditions, which bring additional challenges into play. Camera-based smart parking systems are classified as:
i.   Cloud-based/server processing: Streaming the video or series of snapshots to the cloud or server.
ii.   On-board processing: Capable of executing vehicle recognition locally on only sending the parking events and a limited number of images when required.

A camera-based system can only be considered a viable approach in relatively large open surface lots (supermarket or airport parking).[6]

B. Overhead radars/lidars

Overhead radar measures radio signal or laser light reflections to detect the presence of a vehicle. This method has excellent accuracy for a small range (up to ~7m), but the accuracy dramatically decreases as the distance increase and the angle of arrival of the reflected signal. As a result, these sensors are only reliable to cover four to five parking spots.

C. Ground Sensors

Sensors are placed on each parking space to monitor the parking space occupancy. The detection method is not affected by line-of-sight interference and does not require supporting systems like pillars, walls, or any similar structural component. High accuracy, which is due to the working principle of proximity to detected objects. A 1-1 detection approach, meaning one sensor for one car.

Fig. 6.   Smart Parking System

The smart parking market is in its initial state, the system's precision, requirements, and what current IoT solutions have to offer. The ground-mounted vehicle detection sensors hold the highest promise to close that gap by combining the latest sensing, wireless connectivity, and cloud computing technologies. The ground sensors can be based on various sensing technologies; the most used are magnetometers and radar.

D. Magnetometer

Earth has a very uniform magnetic field over its surface. A magnetometer is a simple digital compass helping to measure this field's direction and magnitude and understand object-

orientation. In smart parking systems, the vehicle, a metallic object, creates a short-range distortion in the magnetic field. The magnitude of the distortion depends on the type of ferrous alloy, the distance to the sensor, and the object's size. [7]

1) Advantages
i. Low power consumption.
ii. High sensitivity and high dynamic range.
iii. Extremely compact sensor
iv. Inexpensive

2) Limitations
i. Difficulties in detecting vehicles with high clearance like SUVs, trucks, vans.
ii. Prone to interference from underground electric trains, power lines, and other EMI sources.
iii. EVs made of carbon fiber, and non-ferrous metals may be much harder to detect

E. Radar Snesor

Radar works on the same ToF (Time-of-Flight) principle and radio waves rather than sound waves or light. The radar wavelength is generally a balance between a target object size and distance to the object. In the case of an in-ground sensor-based smart parking system, radars must be at least 15GHz frequency (2cm wavelength) to measure reflection from a low clearance vehicle.[7]

1) Advantages
i. The sensor may be less sensitive to some thin obstructions due to a lower frequency of 15-20GHz.
ii. Wider beam hence is less prone to random reflections as in the IR sensor.

2) Limitations
i. More expensive sensor and may require a unique high-frequency circuit design.
ii. Radar signal processing requires much more microcontroller horsepower.

F. Infra-red Ranging Sensor

IR sensors consist of an IR transmitter such as an LED or laser and an IR receiver. There are two general classes of infra-red (IR) ranging sensors:

i. **Reflected Intensity -** Simpler and more conventional modules consist of LED emitter and photocell measuring a proportion of reflected light by the object. The closer the thing, the stronger the reflected signal and vice versa.
ii. **Time-of-Flight (ToF) -** These builds on the above principle but uses a much more coherently operated pair of a laser and reflected light sensor capable of measuring the time of reflected light travel. [7]
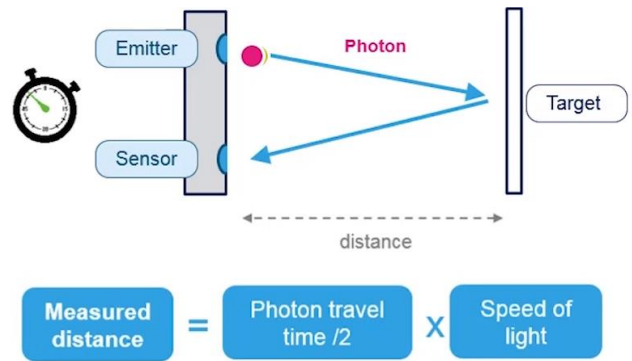

Fig. 7. Principles of ToF infra-red ranging sensor

1) Advantages
i. Can easily measure the distance to objects with reflective indexes starting from 1%.
ii. Ambient light rejection.
iii. A long sensing range which is up to 3m, can detect high clearance vehicles.

2) Limitations
i. Consumes higher power than magnetometers.
ii. Approximately three times more expensive than a magnetometer.
iii. It is very sensitive to any visual obstruction, meaning causing false readings.

G. Ultrasonic Ranging Sensor

The sensor works on a similar principle to an IR, but the emitter sends ultrasound waves instead of photons in the 40-60KHz range. Its utilization brings the advantage of seeing vehicles that exceed specific height limits. The installation of the sensor does not require the closure of the facility. [7]

Fig. 8. Ultrasonic Sensor

1) Advantages
i. Broader and better emitter beam than IR sensors makes the measurement more integral and less prone to random reflection errors.
ii. Not as sensitive as an IR sensor, meaning no false readings.

2) Limitations
i. Consumes higher power than IR Sensor.
ii. Bigger in dimension, meaning more difficulty regarding assembly.

H. GSM & RFID Technology

GSM technology works with the help of a GSM modem. The functionality of the technology mainly depends on this modem. The modem is placed at the parking end, which generally sends the message to the user if there is any

available parking slot. If there is an open slot, the user has to send the exact time and duration for which the vehicle needs to be parked. Once the confirmation message is sent, the reservation's counter automatically starts sending a message. [7]

In RFID, the vehicle owner must register with the parking owner to receive the RGID tag. This tag is to be applied on the vehicle's windshield, so as the car passes through the entry of parking, the RFID scanner scans the label and deducts the amount for parking from the linked account. With this technology, the process speeds up. The entry gate opens when the sensor detects an RFID tag which allows the car inside the parking area. Simultaneously, the parking counter increments by one. Similarly, the exit gate opens, and the parking counter is decremented. [8]

V. CONCLUSION

The main reason for parking systems is there is a lack of parking spaces in metropolitan cities. This due to the cities was developed a long time back when cars were considered a luxury. But due to various factors, cars have moved from a luxury owned by 1% to a necessity that the medium class owns, which is around 40% to 60%. Hence traditional parking solutions would not hold today. In this paper, the various types of parking systems are discussed, in which some are automated whereas others are manual. The advantages and limitations of the different types of parking systems were also discussed. The selection of the parking system depends on the cost of the system, the maintenance cost, and the area available for implementing the system.

In this paper, the concept of smart parking was also discussed, which uses sensors and IoT to detect whether there is a free parking space available or not. The various types of sensors, their applications, advantages, and limitations were also discussed. The selection criteria mainly depend on where the sensor is to be placed and the current infrastructural condition.

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