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Advancements in Embedded Systems and IoT for Automatic Heavy and Light Vehicle Parking: A Comprehensive Review

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Abstract: *This research paper comprehensively reviews automatic heavy and light vehicle parking systems, focusing on technological advancements in Embedded Systems and the Internet of Things (IoT). The escalating challenges in urban parking demand innovative solutions, and this paper assesses various literature surveys to explore the efficacy of these technologies in addressing the unique requirements of heavy and light vehicle parking. The investigation scrutinizes embedded systems as a foundational element, examining their hardware and software integrationto develop automated parking solutions. Additionally, the study explores the role of IoT in enhancing parking efficiency, leveraging sensors and communication technologies for real-time data acquisition and intelligent decision-making. Through an analysis of diverse literature surveys, this paper elucidates the strengths and limitations of different technological approaches, providing a comprehensive understanding of the state-of-the-art in automatic heavy and light vehicle parking. The synthesized insights are valuable for researchers, practitioners, and policymakers seeking to implement effective and scalable parking solutions in urban environments.*

Keywords: Smart Parking System, Embedded System, IoT, Arduino, IoT

I. INTRODUCTION

The burgeoning urbanization and the relentless expansion of transportation networks have significantly intensified the challenges associated with vehicular parking. As metropolitan areas witness an upsurge in heavy and light vehicle traffic, the demand for efficient and automated parking solutions becomes imperative. This research paper delves into a pioneering project centered around developing and implementing an Automatic Heavy and Light Vehicle Parking System underpinned by advanced embedded systems technology.In response to the burgeoning urban landscape and the ever-increasing vehicular influx, the quest for streamlined and intelligent parking systems has emerged as a critical area of research and innovation. The focal point of this investigation lies in harnessing the capabilities of embedded systems to orchestrate an automated parking infrastructure that caters specifically to the unique challenges posed by heavy and light vehicles. This project addresses the spatial constraints exacerbated by urbanization and aligns with the broader technological paradigm shift in the transportation sector.

Embedded systems, with their prowess in integrating hardware and software functionalities, provide the backbone for the envisioned parking solution. These systems, strategically deployed throughout the parking facility, orchestrate a seamless and responsive environment that caters to the distinct requirements of heavy and light vehicles. The amalgamation of cutting-edge sensor technologies, real-time data processing, and intelligent control mechanisms forms the crux of this innovative parking system, offering a sophisticated and adaptive solution to contemporary parking predicaments.

The subsequent sections of this research paper will delve into the intricacies of the embedded system architecture, the deployment of sensors for precise vehicle detection, and the algorithmic intelligence governing the parking process. By scrutinizing the technical underpinnings and empirical results, this paper seeks to contribute valuable insights to automated parking systems specially tailored for heavy and light vehicles in the urban landscape.

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II. LITERATURE REVIEW

With more and more people living in cities, smart parking systems will soon be necessary. There is more traffic because more people utilize private transportation, which is convenient for most people but increases the number of vehicles on the road. Cruising for a parking spot is one of the most disorganized activities that cause traffic jams and increase fuel, energy, and time consumption. This study takes a technical look at smart parking solutions concerning two popular emerging areas: the Internet of Things and machine learning. The most recent cutting-edge innovations in smart parking systems incorporating the domains mentioned above are covered in depth. Along with discussing the advantages of parking 4.0, the article delves into the function of smart parking within a smart city setting. In addition, it addresses the present issues with SPS, offers potential remedies, and outlines future possibilities for implementing it.[1]

This project focuses on an intelligent vehicle with an automated parking system. The system is built around an STM32 microcontroller as its central processing unit. Other major components include a motor drive module, an ultrasonic module, an infrared obstacle avoidance module, and other similar modules. Automated tracking, speed control, sensor range, and other features can be accomplished with LUA language programming in CoppeliaSim Edu simulation. By integrating and connecting the vehicle, the storage location, and the vertex of the obstacle, this project improves the efficiency of autonomous parking by using the visible technique to plan the car's path. By fine-tuning the intelligent car's algorithm for automatic and side-direction reversing into the garage, the function can be automated in response to various parking scenarios by processing environmental data in different ways, determining the parking space thoroughly, and making different control signals. [2]

Fig.1 Automatic Car System

Every issue in metropolitan or urban regions has been resolved by developing smart city concepts, especially smart parking systems. Due to the persistent population growth, private automobiles and parking spaces are in great demand in certain locations. The number one problem drivers face, particularly during rush hour, is locating a parking spot. Problems emerge during rush hour when many cars are searching for available parking spots simultaneously, leading to a cascade of bad consequences for both cities and drivers: pollution, traffic, accidents, wasted time and gas, emotional distress, and so on. One possible solution is a smart parking system, which uses sensors installed across parking lots to identify available spots. It then uses that information to efficiently direct drivers to the spot closest to them. The issue can be resolved, and an efficient smart parking system can better utilize parking resources. The embedded sensors used by many smart parking systems could be more efficient and costly to install. The smart parking system has been the subject of several previous reviews summarised here. This article examines smart parking systems that rely on machine vision and summarises their key features, benefits, and drawbacks. [3]

The core of developing smart cities now lies in the services offered by smart parking. The central focus of this research was implementing a comprehensive smart parking solution. Among the many benefits of the proposed system is its ability to use the Internet of Things to locate available parking spots and determine the anticipated cost, time of entry, and exit. For Android mobile phones, an appealing and functional app was created. Time savings, less pollution, and less fuel usage are positive outcomes for the system. Reserve a parking spot for a whole day in advance. [4]

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Authors have covered the many kinds of smart parking systems. It is clear from the numerous examples of smart parking system deployment how effective it is in reducing traffic problems, particularly in urban areas with heavy traffic and inadequate parking. It achieves this by guiding customers and making the most efficient use of parking spots. Analyzing the benefits and drawbacks of each sensor technology allows for a comprehensive evaluation of the smart parking system's vehicle detection capabilities. The benefits of using a visual-based system for vehicle detection exceed the drawbacks, even though the latter still need their share of complaints. [5]

The suggested parking management system considers all potential predicted qualities. To manage 32-vehicle-guided parking without pandemonium, this system employs infrared and ultrasonic sensors and RFID tags/readers. Adding more levels, lanes, and parking spaces to this system will allow it to handle more vehicles. Adding a voice-guided system or tailoring the project to authenticate military gate-pass entrants are possible improvements. [6]

Additionally, the article details various smart parking sensors and how to use them in various scenarios. A data table with information on several sensors was included to identify the most often used sensors in SPS systems. Information about SPS categorization according to services, computational techniques, networking technologies, and user interfaces is also available. The various ways in which SPSs are categorized provide light on them. As a bonus, the study delves deep into the pros and cons of various SPSs in dealing with different challenges. According to this research's thorough assessment and analysis, multi-approach-based SPS will be the norm in future smart cities that rely on the Internet of Things (IoT). Common elements of SPS include a smartphone app that users can use to access services, including parking supervision, online payment, reservation, and car navigation. Several indoor and outdoor factors will determine the sensors used in SPS. Nevertheless, the most important factors to consider when choosing sensors are their installation convenience, privacy, sensing method, and coverage area. Future SPS systems will continue to focus on data transmission protocol security. Consequently, protocols for wireless communication will place a greater emphasis on data security. [7]

The model that was put into action is the safest, most practical, least expensive way to reduce energy consumption. According to statistics, the current electrical energy consumption by national highways, state highways, and local street lighting is between 35 and 40 percent. While the upfront investment and construction costs can be a dealbreaker, the entire investment cost can be cut even lower by mass manufacturing the module, thanks to technological advancements and innovations. The project's potential uses are wide-ranging, including the illumination of office buildings, grounds, walkways, and parking garages at major retail centers. Corporate buildings, commercial centers, school premises, etc., can also benefit from security monitoring. [8]

Parking spots are in high demand on city streets due to the ever-increasing number of automobiles on the road. On top of that, vehicles waste time and gas and add to traffic jams because people need to know where the parking spots are on city streets. An intuitive, easy-to-understand, and highly functional parking system is essential for Bangladesh's transformation into a smart city that is practical, environmentally conscious, and energy efficient. In addition to assisting with managing illegal parking, the technology has developed also helps decrease traffic congestion and saves us time. So, the system can handle parking management effectively in any public space in Bangladesh. [9]

Both academics and businesses are investing time and energy into researching automated driving. An essential component of fully autonomous driving systems is automatic parking, which entails autonomous driving in a limited parking scenario involving low-speed maneuvering. It is also a significant achievement from the vantage point of a more advanced system that incorporates features from earlier generations of driver assistance systems—such as collision warning, pedestrian identification, etc.. Using computer vision algorithms as a lens, this article delves into the planning and execution of an automated parking system. The design process for a functionally safe, low-cost system is lengthy and fraught with difficulty because of the need to account for every possible scenario in the final product. Show how important camera systems are in handling automated parking use cases and strengthening systems based on active distance measurement sensors like radar and ultrasonics. The primary vision modules enabling parking use cases are 3D reconstruction, free space identification, parking slot marking recognition, and vehicle/pedestrian detection. Combine the vision modules to make a strong parking system and review all the key use cases. As the writers know, this is the initial comprehensive commercial automated parking system analysis. [10]

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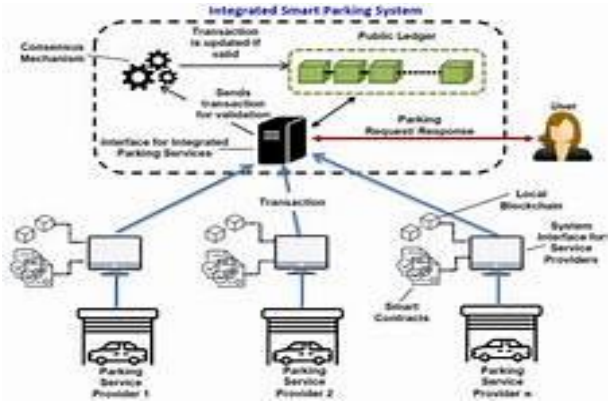

Fig.2 Integrated Smart Parking System

The idea of "smart cities" was very popular in its early stages. To track and communicate the availability of individual parking spots, the suggested smart parking system calls for the on-site construction of an Internet of Things (IoT) module. In this research, A coordinated framework based on the Internet of Things (IoT) checks slot availability and provides an efficient and straightforward vehicle parking method. Thanks to state-of-the-art automated technology, we now monitor the number of vehicles in the parking lot simply by sensing when they drive in and out. Thanks to infrared (IR) sensors placed at the entry and exit, this automated car parking system displays the available parking space on an LCD displayer, drastically reducing the time it takes to look for a spot. This project was created using a microcontroller. [11]

. This article introduces a smart parking management system that operates in real time. The developed system includes features that address the described difficulties. It dynamically allocates parking slots depending on the overall parking situation, allows users to book a specific spot using an AI-based application, and has a method to check if the car is parked correctly. A motion sensor is the basis of the first solution, while a range-finder sensor forms the basis of the second. After taking a picture of the license plate with an Internet of Things device, a plate detection and identification system was able to identify the car. The technique is designed to identify both the English alphabet and Hindu-Arabic numerals that have been extracted. Constructing and testing the suggested smart parking system in the field was necessary to demonstrate its usefulness. Measured and analyzed critical data, including processing delay time, transmission delay time, and car plate detection accuracy. [12]

The scarcity of parking places in densely populated areas is the primary motivation for parking management systems. The cities were built when cars were still seen as a luxury; this is the result. Cars used to be possessed by the wealthy 1%, but now the middle class (about 40% to 60% of the population) needs them for survival. This shift occurred for several reasons. Therefore, the previous methods of parking would not work anymore. This article discusses the several kinds of parking systems, some of which are automated and others manual. Also covered were the pros and cons of the various parking methods. The available space, the initial investment, and ongoing maintenance costs all play a role in deciding on a parking system. Additionally, this study covered smart parking, which employs sensors and the Internet of Things to determine if a parking spot is accessible. Also covered the different kinds of sensors, how to use them, their benefits and drawbacks, and their varied applications. The primary factors in the selection process are the sensor's location and the infrastructure's state. [13]

A. Embedded Based System

Combining safe driving with artificial intelligence is the next trend of transportation development as intelligent vehicles transition from concept to reality. Control algorithms and model recognition are the foundation of autonomous driving technology. Using deep learning (YOLOv4) and updated ORB algorithms, this study proposes a cloud-based interconnected multi-sensor fusion autonomous driving system that can identify pedestrians, cars, and different traffic signs. To provide car owners complete control over their vehicles at all times, an interactive system is developed that is hosted in the cloud. Autonomous speech recognition (ASR), a vehicle following mode, and a road patrol mode are just a few of the ways that multi-sensor fusion processing has expanded the capabilities of autonomous driving vehicles to

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satisfy a variety of applications. These features make autonomous driving suitable for uses like watering crops, putting out road fires, and facilitating contactless deliveries during fresh coronavirus epidemics. At last, an intelligent vehicle was constructed for experimental validation utilizing the embedded system hardware, and the system's overall recognition accuracy exceeded 96%. [14]

This paper aims to find a suitable solution to parking-related problems from various angles. Parking is becoming an increasingly pressing issue as residential and commercial areas try to squeeze more people into smaller areas. This has led to a new problem that people encounter daily: where to park their vehicles in public places like malls, theatres, etc. Embedded memory sharing is at the heart of the proposed system, which aims to aid smart car parking systems. This proposed system uses two parking slots that users can access as shared memory. Employ two UTLP KITs to transfer memory between slots throughout the design and implementation phases. The parking slot is created using the Eclipse IDE and Ubuntu as the OS. The user must input their assigned slot number on the keypad to retrieve the vehicle. Once a slot is used to retrieve a vehicle, it will become available for the next user. The cars are thus filled appropriately.[15]

A suggested FPGA-based emergency-conditions-based automated vehicle parking system can monitor the driver's status and respond accordingly, issuing warnings and guiding the vehicle into a parking spot based on the driver's actions. Traveling long distances on a highway can cause drivers to lose focus and fall asleep. Statistics show drivers are likelier to nod off on lengthy, monotonous highways when traveling at high speeds. 4–6 a.m. and midnight–2 a.m. are the most common for accidents. On top of that, other drivers will be at risk if you suffer a heart attack while behind the wheel. These factors will make the chance of an accident higher. This work proposes an autonomous vehicle parking system that uses field-programmable gate arrays (FPGAs) to detect the driver's condition and carry out certain tasks, such as warning the driver and automatically parking, depending on their actions, in an emergency. Concurrently, this system can evade all road obstructions and vehicles occasionally. The purpose of the input data management unit was to serve as a control unit for the input and output control sensors. The central processing unit was the speed and steering controller throughout the design. A speed controller is a device that detects road barriers and uses that information to regulate the vehicle's speed. With sensors around the vehicles, the steering controller was programmed to manage the automated parking system. Sensors were tested with various materials to make the system adaptable to any situation. This project utilizes 676 registers and 1083 logic elements, with an operating frequency of up to 1.6 GHz. After detecting a heart attack in the driver, the entire design can automatically park itself in a safe spot and avoid obstructions in the host vehicles' path. Afterward, the hospital receives GPS coordination via GSM. [16]

Fig.3 Embedded System in Cars

This paper aims to create a method to denote the empty lane. A system with an infrared transmitter and receiver in each lane and an LED display outside the vehicle parking gate is described in the article. People can use this technology to find out which parking lane is available without lifting a finger. This document shows two lanes, with two slots in each lane. Infrared transmitters and receivers are set up at the entrance of each slot to identify which vehicle is available. A 7805 three-terminal regulator and a regulated power supply of 5V and 500mA are utilized for voltage regulation. A full wave bridge rectifier is utilized to correct the alternating current (AC) output of the secondary of a 230/12V step-down transformer. [17]

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Vehicles that can safely maneuver themselves using onboard sensors and minimal or no human intervention are known as autonomous vehicles (AVs). The technical groundwork for realizing AVs has been laid by developing hardware devices and advancing 5G networks. A fully automated road system might have many advantages, including safety and ease of use. This project report shows that an autonomous driving vehicle prototype was built using a Kia Soul car. Techniques for fully autonomous operation of the vehicle's steering, accelerator, and brakes are all part of this. This research examines the Kia Soul's current steering, throttle, and braking systems. The autopilot method, based on preexisting hardware, is further detailed in the study. At the IAG research center, scientists ran a battery of tests to learn about the car's many sensors and determine whether it would be possible to control the vehicle's movements with electric impulses. It concludes by discussing potential extensions of these preliminary studies for future implementations. [18]

Finding an open parking spot and using it as a security system are both possible with the help of the proposed solution. This can be executed in real time, and the related data can be computed and shown on the website or mobile app. This system effectively solves the real-time challenge while reducing the need for human labor. As a result, this layout is good for many things. The system has met basic needs, such as locating a vacant parking spot within the mall's parking lot. However, the processor and sensors have run on a constant power source. Improving the app in the future would allow users to pay for parking time based on their specific vehicle and pay online by linking their bank account to the app. Using the camera is another way to determine how long parking will take.May record the approaching cars at the mall and use those photographs to create barcodes. [19]

This paper will explore various parking-related challenges and try to identify a suitable solution. The parking problem is caused by the increasing concentration of residential and commercial activities on limited land. As a result, consumers encounter a new problem every day while parking these automobiles in public places like theatres, shopping centers, etc.The suggested approach aims to aid smart vehicle parking systems using shared memory in embedded systems. The suggested approach uses the shared memory of two parking slots that users can access. Two UTLP KITs were to transfer memory between slots during the design and implementation phases. Programming in the Eclipse IDE with Ubuntu as the operating system creates the parking slot. The user must input their assigned slot number using the keypad when picking up the car. Slots become accessible for the next user once they are emptied, such as when someone retrieves a vehicle. As a result, the automobiles are properly filled. [20]

B. IoT Based System

Problems with parking and traffic are inevitable outcomes of urban areas' high population densities and the high volume of automobiles on the road. The world is now confronted with the unprecedented problem of parking vehicles. There is evidence that one million vehicles use oil every day. An autonomous, real-time system for parking vehicles autonomously is suggested in this article. The Internet of Things has successfully implemented this system (IoT). In a typical scenario, the two physical devices share data or information through IoT. The suggested setup makes use of an Arduino Uno microcontroller. An integral part of the proposed system, Arduino allows for the communication of digital devices and interactive objects with the ability to detect and manipulate physical ones. An Arduino Uno board for vehicle parking and a Node MCU to link the parking lot to the Internet were used to implement the suggested system. Each parking spot in the planned system would have an infrared sensor to track when a spot is available. The user can reserve a parking spot in plenty of time, and the server has the necessary knowledge. Passwords and usernames are unique for each user. The system will notify the appropriate party in the event of any misuse. [21]

Using a variety of sensor circuits and the cloud, an Internet of Things (IoT) based smart parking system has been put into operation (server). The parking system is effective and helps alleviate traffic congestion. A completely automated system utilizing the multilayer parking approach and an automated billing system is added to this work as smart car parking systems. Tools for security include tracing vehicle numbers and facial recognition for drivers. Additionally, precautions have been taken to ensure that no unauthorized vehicle enters the designated parking space by assigning a unique OTP to each user and checking that the same individual parked in each slot. [22]

Many urban areas experience a surge in visitors due to revitalization, expanded transit services, and increased societal mobility, leading to a parking crisis. The solution lies in an Internet of Things (IoT) based parking management system. IoT employs sensors to link physical parking infrastructure with technology, offering cloud-based smart services. A

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mobile application allows users to check parking availability, book spaces, and view real-time status and payment details. Control systems at each lot monitor occupancy, notify users of availability, and automate gate opening upon vehicle arrival, providing a seamless parking experience. [23]

Fig.4 IoT-Based Smart Parking System

The layout and construction of a parking system that runs on the Arduino platform are detailed in this article. One of the most fundamental rules for parking a car in a parking lot is the need for driver or user consent. The goal is to make a basic automated system that uses Arduino and other basic components to solve the parking space allocation problem. The parking door will open and let the user park the vehicle in the lot if space is available and the user is approved. Otherwise, even if the user is authorized, they can still not park. Electronic devices that generate light to detect objects in their surroundings are known as infrared (IR) sensors. The LCD screen uses the infrared sensor to show parking spot details and allows for space monitoring. An integral part of any mobile app for system monitoring is the node microcontroller unit (MCU). The mobile app shows the number of slots occupied and admission and exit times. Additionally, it is useful for indicating which parking spot is open in a multi-story garage. [24]

Currently experiencing problems caused by an inadequate supply of fuel. It follows that we are heading in the direction of EVs. However, consumers must still prepare to choose electric vehicles over their current models. The high cost and limited number of charging outlets are the main reasons. It is still important to set up additional time to charge the vehicle, regardless of how few charging stations are accessible. Additionally, parking has become a huge problem in modern cities. So, by considering these factors, commercial buildings can offer smart parking with charging availability. The time and energy spent looking for a parking spot will be lessened. The Internet of Things (IoT) and wireless power transfer are described in this article. Reviewing existing Internet of Things (IoT) smart parking technologies, this article compares and contrasts two types of systems: those that mix parking and charging and those that keep the two functions distinct. [25]

In turn, this strategy would lessen congestion caused by cars searching for parking spots. Since this eliminates the needless delay, the vehicle's carbon emissions can also be lowered. The automobile will be turned off once the electronic copy is used, found at https://ssrn.com/abstract=3904862. This proposed system aims to deliver a more accurate, low-power, cost-effective solution that works effectively in real-time. When applied to the system, the Internet of Things (IoT) and its principles will pave the way for a more sophisticated future, thanks to all these advantages. This system necessitates bold construction. Results from simulations confirm the efficacy of the approach. The outputs (results) of this proposed method prove it conserves energy more than competing methods. Everyone using the smart parking system now has a solid foundation thanks to the detailed descriptions of potential issues and their solutions. The installation of a smart parking system guarantees individuals the convenience of living. [26]

C. System with different technologies

The importance of artificial intelligence and computer vision in solving important problems in seaport management, especially in transportation and container movement, has been highlighted by a comprehensive study. This comprehensive literature review has demonstrated the importance and promise of these technologies for creating environmentally friendly and economically viable parking solutions at seaports. Also found that they are important for

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improving traffic management, allocating parking spaces efficiently, and moving containers more quickly within seaports. Developing smart port solutions further to boost efficiency, sustainability, and global economic benefits, as well as integrating IoT sensors to improve traffic flow and real-time AI algorithms for dynamic parking allocation, are potential areas for future research paths. They revolutionize seaport management by harnessing the potential of AI and CV in these domains. Smarter, more resilient, and more efficient seaport operations are the result. Insights gained from this study highlight the revolutionary potential of AI and CV technologies as they pertain to port management, and they encourage additional investigation and development in this exciting area. Allbelieve that AI and CV will lead toward more sustainable, efficient, and responsive seaport operations as they negotiate the intricacies of urbanization and international trade. [27]

Fig. 5 RFID-Based Parking System

This article discusses smart parking systems for automobiles. Here, utilize the infrared sensor to identify the car and direct the owner to an ideal parking location. The parking issues can be alleviated with the aid of this project. Urban areas place a premium on parking spots. The demand for parking spots is essential due to the significant automobile increase. Therefore, there is an immediate requirement to create a system capable of controlling these parking spots. This project aims to create a system that can identify whether parking spaces have empty lanes. An infrared sensor and an Arduino are part of the system, which also features an LED display outside the automobile parking gate and in each lane. Someone from the relevant authority checks each parking spot. The document describes the system's inner workings and provides specifics regarding the components employed. Also included in the document is the project's future scope, which will guide the country towards transformation. [28]

Developing and implementing an automated parking system for vehicles was the primary goal of this article. You can choose between ON, OFF, and EMERGENCY modes with the suggested approach. The built-in technology uses an infrared sensor to detect when cars are parked at the main gate. The IR sensors send their data to the PLC (programmable logic controller). There is a worldwide trend toward automated car parking systems that can precisely determine the available parking space and collect fees from drivers because of the scarcity of trained labor and parking places. This new plan enhances and standardizes the existing vehicle parking system, and it is easy to implement thanks to its low cost and efficient use of solar panels and inexpensive infrared sensors. [29]

A microcontroller-based parking system is an example in this article. Here, an automated microcontroller-based system is implemented that detects the presence and motion of vehicles, determines if parking is possible based on the amount of available space, and displays this information on an LCD panel. The RFID module adds another layer of protection by allowing authorized users to enter by simply exchanging RFID cards. The parking cost the user must pay will also be settled using it. A multi-story parking lot is the intended setting for this project's autonomous vehicle parking system. [30]

Drivers, cities, and private parking lot owners all benefit from this project's cutting-edge computerized parking payment system. It makes tracking and collecting parking costs easier while charging drivers the exact time they park. Avoid rummaging for pennies using this strong RFID card as an in-vehicle parking meter. This initiative also provides an effective substitute for pay-and-display ticketing and coin-operated meters. With its low implementation costs and ease

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of use, this project can replace or supplement existing parking payment systems, making them more secure and reducing the need for human intervention. The parking card is an item that every driver possesses. Anyone wishing to park in the parking garage must present their parking card to the reader. The reader takes the vehicle's in-cabin time and transmits it to the microcontroller. The driver must present his card again at the leave of the parking centerfor the reader to record the out time. The parking fee is automatically deducted from the driver's card after the controller verifies the arrival and departure hours. A buzzer will let the user know when the card's balance is low and they will need to add funds to pay for parking. An LCD will show the amount of the deduction from the balance. [31]

This research can detect unoccupied slots to aid drivers in finding parking in unfamiliar cities. Users experience a significant decrease in the average time it takes to park their automobiles using this technology. With the suggested strategy, most cars can locate an available parking spot, which is the best possible outcome. The system based on the Arduino UNO can efficiently reduce the time it takes to find a parking spot and provide real-time information, thus solving the current automobile parking problems. Improved performance, reduced costs, and increased efficiency are all benefits of this smart parking system. When they pull into the parking space, the motorist will park their car in the nearest available slot. When a slot is in use, an LED light will illuminate; when a slot is unoccupied, the lights will automatically turn off to indicate that the slot is available. As a bonus, it eliminates the need for cars to drive through already-crowded parking lots. [32]

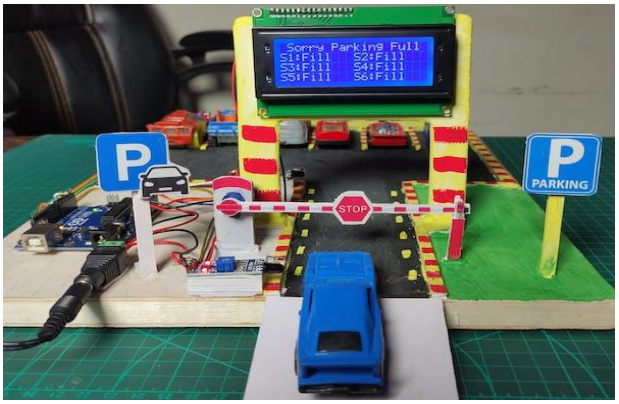

Fig 6. Arduino based system

IV. CONCLUSION

Embedded systems and the Internet of Things (IoT) have a crucial role in reducing the difficulties of urban parking, according to the literature assessment on automated heavy and light vehicle parking. Intelligent parking infrastructures can be more easily developed with the help of embedded systems because of their ability to combine software and hardware functions smoothly. At the same time, the Internet of Things ushers in a new era of thinking by facilitating data analysis in real time and exchanging information among various components.

A complex landscape emerges from comparing several literature assessments; this study highlights the advantages and disadvantages of each technology technique. Internet of Things (IoT) technology complements parking systems with increased connectivity and flexibility, while embedded systems are superior in responsiveness and accuracy. It is essential to grasp these subtleties to create and execute parking solutions that meet the specific needs of large and light cars in urban areas. The findings from this assessment lay the groundwork for further investigation and advancement of automated parking systems, which is crucial given the unrelenting speed of urbanization. A more intelligent and efficient urban parking system can be imagined by combining the advantages of embedded systems with the Internet of Things (IoT).

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