AI-powered Smart Parking System

Ms Tanvi
Department of AIT-CSE, Chandigarh University

Aman Chauhan
Department of AIT-CSE, Chandigarh University
(21BCS6770)

Aryan Arvind
Department of AIT-CSE, Chandigarh University
(21BCS6745)

Harsh Dhawani
Department of AIT-CSE, Chandigarh University
(21BCS4649)

Abstract- In order to improve urban mobility, maximize parking space use and lessen traffic congestion in metropolitan cities, this study provides a smart parking system driven by artificial intelligence. The suggested method guides vehicles to the closest accessible parking spaces by using real-time data analytics and sophisticated machine learning algorithms to present them with dynamic parking availability information. The system employs a network of IOT and AI algorithms to continuously monitor parking occupancy. It also uses predictive analytics to forecast demand patterns based on contextual factors like time of day and local events, as well as previous data. In addition, the incorporation of user feedback methods facilitates the system's continuous improvement, guaranteeing a smooth parking experience.

In addition to streamlining the parking procedure, this creative method reduces car emissions linked to search time, which benefits the environment. Initial research findings show a notable decrease in the amount of time needed to find a parking spot and an increase in customer satisfaction, highlighting the potential of AI-driven solutions to address urban parking management issues.

Keywords- AI-driven, congestion, IOT, algorithms, predictive analytics.

I. INTRODUCTION

Regular parking systems frequently suffer from shortcomings that result in congestion, higher emissions, and dissatisfied drivers trying to find available spots to park. We present an AI-powered smart parking system built in Python that uses cutting-edge algorithms and real-time data analytics to maximize parking management in order to address these issues.

Our model's key element is AI and machine learning algorithms that forecasts parking according to past occupancy data, the time of day, and nearby events. In order to assist drivers identify where to park, we use regression techniques to examine trends and determine parking availability in the future. In addition, parking hotspots are found using clustering methods.

Implementation of the system involves several key components. IOT sensors are strategically planned in parking areas to collect real-time data on occupancy levels. This data is then processed and analyzed using python powerful data manipulation libraries such as Pandas and Numpy. Computer vision is used for finding the vacant parking spots.

Performance of the model will be measured by several metrics, including accuracy, precision, recall and F1 score, and AOC-ROC(Area under the receiver operating characteristic curve). AUC measures the model's ability to distinguish between classes (occupied and unoccupied).

Some specific objectives of sentiment analysis using customer feedback may include :-

1.Optimize Parking Space Utilization: Maximize the efficiency of parking space usage by accurately predicting availability and guiding drivers to open spots, thereby reducing the number of empty spaces.

2. Reduce Search Time for Parking: Minimize the time drivers spend searching for available parking by providing real-time information on space availability, thereby enhancing the overall user experience.

3. Decrease Traffic Congestion: Alleviate traffic congestion in urban areas by reducing the number of vehicles circling to find parking, which can lead to smoother traffic flow and less environmental impact.

4. Enhance User Experience: Improve the overall parking experience for users by offering a user-friendly mobile application that provides real-time updates, navigation assistance, and feedback options.

5. Predict Parking Demand: Utilize historical and real-time data to forecast parking demand patterns based on factors like time of day, local events, and weather conditions, allowing for proactive management of parking resources.

This model can help the parking lot owners to easily manage parking space and enhance user satisfaction by reducing parking time and wastage of parking space.

II. LITERATURE REVIEW

A smart parking system with AI capabilities is an effective tool for managing parking spaces, particularly in large cities. The goal of recent research has been to identify more superior substitutes for conventional parking lot management systems. We will look at some current research articles on AI-based parking systems in this overview of the literature.

The method of utilizing a vision-based automated parking system to monitor and manage a parking space is described in this study [1]. It is becoming essential for car park managers to discover available parking spaces as quickly as possible due to the growing number of cars on the road. This is done to prevent traffic jams in the parking area. Currently, parking lot management relies on either human staff monitoring available spots or a sensor-based system tracking the total number of available spots or the availability of each individual space. The only information that was accessible in both cases was the total number of parking spaces available, not the precise location. Additionally, the quantity of sensors employed in a parking lot affects the cost of sensor-based system installation and upkeep. This study describes a vision-based system that can locate and display parking spaces that are available in a parking lot. The techniques used to identify open parking spots relied on an automobile classifier and coordinates indicating the locations of interest. This study demonstrates that, for a four-space parking lot, the first work done here has an accuracy ranging from 90% to 100%.

In this study, a smart parking management system with wireless sensor network support is proposed[4]. It offers cutting-edge features such automated guiding, remote parking observation, and a parking reservation system. IEEE 802.15.4 Wireless Sensor Network (WSN) and Internet of Things (IoT) technology are used in this system. To find the shortest distance between each lot in the system and the user, an algorithmic program known as the Haversine Formula is utilized. Consequently, the user's waiting time is decreased. This system uses RFID technology to reduce costs by eliminating the need for human intervention. Using a specially designed software application, the device may also gather information on how full parking lots are and guide cars to the nearest open space.

The goal of this paper [6] is to automate both parking and driving. It talks about a project that shows off a scale model of an automated vehicle parking system that can control and manage how many automobiles can be parked in a certain area at any given moment depending on parking spot availability. Using sensing sensors, automated parking is a technique for parking and getting out of autos. An Android-based application controls going into and out of the parking lot. After examining a few of the current systems, we have found that most of them are not fully automated and still need some degree of human intervention or contact. While most existing systems require human personnel or the car owner to park the car themselves, our system automates both the cars and the parking lot in an effort to make it as human-dependent as possible. This sets it apart from the other 22 existing systems. We have constructed and given a mathematical model to demonstrate the efficacy of the system we have proposed; this model will be briefly explored later in the text.

It's really challenging for cars to get a good parking spot in a busy metropolis[8]. If parking spaces are unavailable, there could be severe traffic jams. Computer vision experts have been drawn to the developing field of autonomous smart parking systems in order to advance this technological discipline. An effective framework for finding and reserving parking spaces based on vision is described in this research to help drivers discover and park their vehicles. We had initially used calibration to divide the parking lot into blocks. Next, group the blocks so that you can recognize each one and tell the motorist if there is reserved or unreserved parking. It is possible that the suggested system's performance accuracy surpasses that of the most advanced hardware solutions, proving the superiority of the suggested framework.

The technique of wireless sensor networking (WSN)[11] has become more popular recently. Wireless sensor networks have found widespread application in the development of intelligent systems because of its broad reach and versatile application. In this paper, we present a wireless sensor network-based smart car parking system. In addition to effectively using all of the parking capacity, the system assigns parking places to users (drivers) based on availability. In our method, each parking lot slot is equipped with inexpensive sensor nodes that indicate when the slot is available. To help the user park the car effectively, the availability status is displayed on a smartphone application called Blynk. Users may significantly cut down on gasoline consumption and save a significant amount of time by not having to look for free parking places. To make sure the car has been parked appropriately in relation to the parking infrastructure, the system also makes use of ultrasonic sensors. The device also uses a gas sensor to detect the flow of flammable gasses, which further ensures user safety. Reliability is maintained while costs are efficiently controlled by limiting the number of sensors. Consequently, our smart auto parking system concept is a creative way to efficiently manage the parking procedure.

The AU Automatic Car-Parking Modeling System, or AU-CPS, is presented in this article [6]. A PLC-controlled automatic parking system model is called AU-CPS. Through the use of photo-electric sensors and three DC motors, it communicates with the user via an HMI. The car is lifted and moved from its original parking space to the exit path using a crane. In order to prevent cars from overlapping in each slot, the AU-CPS additionally employs sensors to detect if parking is full or not and turns on an LED to provide this information.

III. METHODOLOGY

1. Infrastructure Setup: IOT enabled sensors are requires to detect the occupied or vacant spaces present in parking area. Cameras are required to capture the vehicle movement and number plate and availability of a strong internet connection is necessary for data transfer between sensors and server.

2. Data Collection: Real time monitoring is essential to collect data from the parking spot about vehicular flow and space availability and the historic data also needs to be stored and process to analyze the pattern, peak time and user preferences and space demands to provide a more efficient model to predict the user requirements.

3. Data processing and AI algorithms: AI based image recognition is required to analyze vehicle number plate for vehicle identification. Analyzing the data using machine learning models to predict parking demand, optimize parking space allocation, and improve efficiency. Pricing should be dynamic, AI algorithms needs to be implemented to calculate dynamic pricing based on demand, time of day, and historical patterns and AI models are required to predict the future availability of parking spaces based on historical data and current trends.

4. User Interaction and Smart Features: Developing a mobile apps or web portals for users to locate available parking spaces, reserve parking spots in advance, and make payments online. Application will offer real-time navigation to direct drivers to the nearest available parking space using AI based routing algorithms. The application will also ensure to enable pre booking of parking spaces, ensuring users have a guaranteed space and will also have a payment automation to integrate automated payment systems where users can pay through mobile apps, QR codes or debit and credit cards.

5. Parking Space Optimization: Occupancy prediction technique will be implement using AI model to predict which spots will be vacant or occupied based on patterns, ensuring optimal usage of parking spaces. Dynamic space assignment will be used to optimize the allocation of parking spaces based on vehicle types for example compact cars, SUVs, electric vehicles etc, to reduce congestion and maximize the capacity and the system completely will be energy efficient there will be automated lighting when the vehicle will approach the spot and will run on solar powered system, This way we can make system efficient and environment friendly at the same time.

6. Security and Enforcement: Number plate recognition will be used to enforce parking regulations also authorizing the vehicles parked in designated spaces. AI driven security monitoring systems will analyze camera footage to detect suspicious activity, theft, or vandalism in parking areas. Violation will automatically be detected and penalty or E challan will be automated for parking violations such as improper parking, or overstaying time limits.

7. Cloud and Edge Computing: Deploy AI algorithms at the edge for real-time decision-making without relying entirely on cloud infrastructure. The process is known as edge computing and ensure the usage of cloud platforms to store large volumes of parking data, perform heavy computations, and maintain backups.

8. Feedback and Continuous Learning: User feedback will be collected via the mobile app or web portal to improve user satisfaction and adjust system features. AI model refinement will be followed in which system will continuously update and train AI models based on new data to improve predictions, recommendations, and parking optimization over time.

9. Integration with City and Transportation Systems: Smart city integration to connect the parking system to broader smart city initiatives, such as traffic management systems, public transportation, and city planning data. Using AI to reduce carbon emissions by minimizing the time vehicles spend searching for parking, and by promoting the use of EV charging stations.

10. Data Privacy and Security: Ensuring all data, especially user information and payment details, is encrypted during transmission and storage and Implement techniques to anonymize personal data collected from users, such as vehicle tracking, to ensure compliance with privacy regulations.

IV. DISCUSSION

The AI-driven savvy stopping framework has illustrated noteworthy potential in progressing urban portability by optimizing stopping space utilization and diminishing activity blockage. The integration of IoT sensors and machine learning calculations has viably decreased the time drivers spend looking for stopping, which in turn brings down emanations and advances natural maintainability. The system's capacity to anticipate stopping request utilizing chronicled information and real-time data has demonstrated successful, but extra factors, such as climate and activity conditions, seem assist upgrade forecast accuracy.

One of the key qualities of the framework lies in its user-centric approach, utilizing input and estimation examination to persistently refine its execution. By adjusting to client encounters, the framework upgrades comfort and fulfilment. Be that as it may, guaranteeing that assumption investigation captures nuanced criticism may require the consolidation of more progressed common dialect preparing (NLP) strategies. This would permit for more profound bits of knowledge into client inclinations and more focused on changes to framework features.

Despite its benefits, the framework faces challenges related to adaptability and security. Extending its framework to bigger metropolitan ranges with differing conditions will require cautious thought, especially in terms of coordination with existing shrewd city frameworks. Furthermore, concerns approximately information security and security must be tended to, particularly given the system's dependence on real-time information collection and cloud-based handling. Guaranteeing compliance with protection directions and executing solid encryption strategies will be fundamental to keeping up client believe.

V. RESULT

AI-powered smart parking uses technology to increase parking efficiency and improve parking management in the city. The system continuously monitors real-time parking by integrating IoT sensors, and machine learning algorithms forecast parking availability by taking into account local events, the time of day, and past data. By doing this, you can spend less time looking for parking spaces by guiding drivers to the right parking space. The system's performance was evaluated across several key metrics, including precision, accuracy, recall, F1 score, and AUC-ROC (area under the curve – acceptability operational characteristics), all of which contribute to reliability and efficiency. Using cluster algorithms to identify parking hotspots further enhances the ability to manage high demand areas. Preliminary tests have shown that traffic accidents are reduced due to fewer cars on the road looking for parking spaces, resulting in better traffic flow. The system also supports environmental sustainability by reducing vehicle emissions by allowing drivers to find parking spaces faster. Its degree has also improved. The feedback mechanism allows
the system to continuously improve by learning from user preferences and experiences. Overall, AI-powered parking has demonstrated its potential to solve modern urban challenges by enabling efficient use of space, improved traffic flow, reduced emissions and improved user experience.

VI. CONCLUSION

The framework successfully diminishes look time, eases blockage, and maximizes the utilization of stopping spaces by utilizing prescient analytics, IoT innovation, and real-time observing. Moreover, the system's capacity to figure stopping request based on verifiable information and neighborhood components guarantees proactive asset administration. By coordinating with client criticism and ceaselessly refining its calculations, the framework adjusts to changing urban conditions, giving a predominant stopping involvement whereas tending to natural concerns like decreased outflows.

VII. FUTURE SCOPE

Adaptability and Integration: Extending the framework over bigger metropolitan regions and coordination it with keen city foundations, counting open transport and activity administration frameworks, to form a cohesive urban versatility solution.

Autonomous Vehicle Compatibility: Incorporating support for independent vehicles within the framework, permitting for consistent communication between the stopping foundation and self-driving cars, driving to encourage robotization of stopping procedures.

Advanced Security Highlights: Upgrading the AI-driven security observing framework by coordination biometric innovations and progressed reconnaissance to identify robbery and vandalism in real-time.

Green Activities: Expanding the center on feasible innovations, such as growing the system to utilize of renewable vitality sources (sun powered control) and coordination electric vehicle (EV) charging stations.

Cross-System Collaboration: Encouraging interoperability with other savvy stopping frameworks and worldwide IoT benchmarks to cultivate collaboration and improve client involvement over cities or countries.

Enhanced Client Interaction: Utilizing progressed AI-driven estimation examination to anticipate client inclinations and move forward app highlights, guaranteeing a more personalized and effective stopping involvement.

Augmented Reality Navigation: AR could be used to guide drivers to available parking spots, enhancing user experience and reducing frustration.

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