Deep Learning-Based Smart Parking System With Dual Authentication Using Facial Recognition And License Plate Detection

Mrs. Mohanasundaram A[1], Manikandan P[2], Naveen P[3], Sudharsanam S[4], Kaleeswaran M[5]
[1]Assist prof, Dept of Computer Science and Engineering
[2, 3, 4] Dept of Computer Science and Engineering
[1, 2, 3, 4, 5] Mahendra Institute of Engineering and Technology, Namakkal, Tamil Nadu, India

Abstract- *Due to the fast-paced development of cities and the rise in the number of cars, parking has become quite challenging to manage. Conventional parking systems depend mainly on human efforts, tickets, or just basic sensors. Such approaches prove to be ineffective, expensive, and error-prone. Besides, there is no assurance of any sort of safety, making it possible for unauthorized individuals and car thefts. The system proposed is aimed at solving such inefficiencies. The system utilizes the concept of Deep Learning Smart Parking System. The system utilizes facial recognition and license plate detection, where the system can automatically identify who is accessing a particular parking bay. High-definition cameras are used to take images of both the driver's face and the license plate of the vehicle. The vehicle's identity is determined using the YOLO (You Only Look Once) algorithm that helps detect and recognize license plates. Grassmann algorithm is used for authenticating drivers in order to ensure that only authorized personnel will be allowed to enter the parking facility. It involves two methods of authentication, making the process much more secure while reducing dependency on tangible tokens such as RFID cards. Such an automated process minimizes the need for human labor and therefore results in improved management of parking facility as well as traffic flow. Moreover, the cost of hardware is reduced since there is no requirement of any special IoT sensor. Lastly, the process helps in collecting useful data regarding traffic movements.*

Keywords: Deep Learning, Facial Recognition, License Plate Detection, Smart Parking, Traffic Management, Vehicle Authentication, YOLO Algorithm

I. INTRODUCTION

Traffic jams, wasted time, environmental pollution, and inefficiency of space usage are some of the issues encountered within typical parking lots. In most of the cases, current parking lot solutions require manual tickets, RFID cards, or basic sensors that are usually inefficient and vulnerable to human errors. Modern-day situations have seen an escalation in the number of vehicles within the cities, causing a great challenge in managing parking space. The cities are experiencing extreme congestions both while entering and exiting the parking lot areas resulting in wasted time, fuel usage, and increase in pollution. Current day parking management techniques that use manual tickets, physical tokens, or even basic sensors can no longer be used due to the inefficiencies and vulnerability to human errors associated with them. These parking solutions are inefficient and cannot accommodate the need for automation required by the growth of smart cities. In order to resolve these challenges, intelligent parking solutions have been developed. Such systems try to streamline all steps involved in the parking process through automation, thus improving efficiency and effectiveness. With the use of high-definition cameras coupled with real-time image processing, it becomes possible to detect cars and their owners without any human interference, which leads to faster operations, traffic management, and a higher level of service quality for users of such facilities. For the development of the system, deep learning solutions including YOLO for car license plate recognition and facial recognition algorithms for driver identification are considered. The application of such technologies will provide two-step authentication and ensure better security for a parking facility.

i) Problem statement

There are many difficulties involved in maintaining parking systems due to the increased pace of urbanization and the rising numbers of cars. The existing parking methods are either manual, rely on tickets or are limited to the use of sensors, which are ineffective and inefficient. The existing approaches are not only associated with long lines and traffic jams but also have weak systems of verification. It means that the parking can be used by other people without proper permission and vehicles could be misused or stolen. Apart from low efficiency and ineffectiveness of the existing parking methods, they also fail to offer an automated and secure system for the identification of users and their respective vehicles. It means that the existing methods do not allow

identifying drivers and vehicles in real-time. Hence, it creates a risk of stealing the vehicle. Thus, there is a necessity to develop a smart parking method which is based on deep learning and is able to detect faces and license plates of vehicles.

iii) Objectives

Firstly, one of the main purposes of the system under development is to create an automated parking system that uses deep learning algorithms to control the entrance and exit of vehicles. It will use technologies such as license plate detection based on YOLO and face recognition to identify users' cars and individuals properly. In addition, the development will facilitate automation and make the processes of managing parking places much more effective. Secondly, one of the essential goals of the system is to provide additional security and safety. Therefore, the system will be based on a two-factor authentication system that includes verification based on license plates and faces to confirm their identity and give permission to park. This approach will help to avoid the entrance of unauthorized persons into parking spaces, minimize cases of theft and misuse of infrastructure, and provide more reliable protection. Moreover, the creation of the parking lot system will optimize traffic flows and improve the use of parking lots. Due to real-time monitoring and processing of data, it will help to avoid bottlenecks at entry and exit points and increase the speed of data validation.

II. RELATED WORK

Tekouabouetal.. [1] This research is directed at improving the ability to forecast the availability of parking spaces using the Internet of Things (IoT) and ensemble-based approaches to machine learning in urban areas (Smart Cities). The IoT devices used in parking spaces collect real-time information regarding when a parking stall has been occupied, when it is vacated, and how long the parking stall will not be available based on when it was last occupied. Ensemble-based approaches are used to enhance prediction accuracy via algorithms combining many machine learning approaches to lower the error rate and improve the reliability of the prediction results. The use of ensemble-based machine learning models allows for advanced prediction of parking space availability, resulting in the ability to manage traffic better and reduce congestion within cities. Additionally, real-time parking data are provided to end-users using connected IoT systems to provide current parking availability. The study highlights the need for scalable systems for smart cities. This smart parking solution enhances the ability to make decisions for both the user (driver) and the parking authority. The ensemble-based model operates effectively within the unpredictable nature of urban parking, leading to fewer problems in searching for a parking space. Overall, this study will improve the performance of smart parking systems through the application of predictive analytics.

Ashrafetal.. [2] This study aims to enhance the usability of car parking applications and to improve the overall experience for users through the examination of how users interact with the parking system and the identification of usability issues. Design recommendations will be based on user-centered design principles and designed for ease of understanding and use. The researcher will receive feedback from users in order to improve the overall functionality of the system. This research will focus on how simple navigation, clear instructions, and user satisfaction can improve the user experience within a smart parking application. This will be achieved using the human-computer human interaction perspective and applying those principles directly to the design and development of the interface; therefore, ensuring that the system works well for all users including non-technical users, therefore helping to reduce confusion while using a parking operations. By enhancing system functionality, the researcher hopes to improve the usability of parking system operations. Finally, this study will help to improve the user experience of smart parking applications.

Elfaki, et al. [3]The proposed research describes a smart parking control and monitoring system, using a mixture of sensing and communication technologies. The smart parking control and monitoring system continuously monitors occupancy of parking spaces via the sensors and cameras installed on the parking lots, in real time. The system provides updates via a central monitoring system on the availability of a parking slot. The data acquired from the sensors and cameras is transmitted to a central/monitoring platform. The system is designed to efficiently manage the flow of vehicles within a parking lot. The research focuses on automating and reacting to sensor data in real time, thereby improving the efficiency of parking management within urban areas. The smart parking system also aids traffic control authorities with decision-making processes. Improved monitoring of vehicles entering and exiting the parking lot helps improve safety. The study demonstrates the significance of processing real time data, and ultimately improves the performance and reliability of the smart parking system.

Channamallu, et al. [4] The purpose of this paper is to examine the impact of machine learning (ML) models on urban parking efficiency. To achieve this objective, this paper utilizes a variety of different machine learning models to better understand how to efficiently allocate parking spaces based on parking “patterns” found via analysis using multiple

machine-learning algorithms. By using both historical and real-time data analyses, this paper aims to provide better predictive accuracy for determining the best time to allocate parking resources based on peak demand times. Additionally, this model provides a means for minimizing traffic congestion related to searching for available parking spaces before the driver arrives at the destination. This paper emphasizes the benefits of applying artificial intelligence (AI) toward improving the overall mobility of cities, as well as assisting with improving decision-making processes for managing parking system. Finally, the approach outlined in this paper allows for scalability for larger metropolitan areas and enhances operational efficiencies in smart cities. Overall, this paper provides evidence that machine learning models can be an effective method of improving the operation and effectiveness of transportation systems. Therefore, the proposed approach may lead to the development of intelligent parking systems, which will benefit future generations.

Dahiya, et al. [5] This research examines the potential of using machine-learning techniques to predict the availability of parking spaces in environments where IOT-enabled devices exist. This research utilizes real-time data collected by IOT sensors in parking lots. The machine-learning algorithms then use that data to predict how many spaces will be available in the future, allowing users to find an open parking space before they arrive. Over time, the model's accuracy will improve based on historical patterns. The model also assists in reducing traffic congestion and wait times in urban areas. Parking availability will be updated dynamically. Smart parking management systems will benefit from increased efficiency as a result. This research uses both IOT and AI technology to achieve improved functionality; thus, providing better scalability and reliability for parking options. The proposed methods provide users with greater convenience and assist in automating the parking process. Collectively, this research enhances intelligent parking prediction systems.

Siddiqui, et al. [6] This research describes a novel approach for detecting occupancy in a car park, using an artificial intelligence technique called the Deep Extreme Learning Machine (DELM.). The purpose of the system is to determine whether or not a given space is occupied, based on intelligent learning techniques. The model uses input from either sensor devices or image-based sources to identify the current status of each parking space accurately. Compared to traditional machine learning techniques, this model allows for much faster detection of the occupancy status. There is also less computational complexity while still providing high performance accuracy. The system is highly suitable for real-time use in urban areas due to the enhancement of the capacity of each space. This will also help reduce traffic congestion caused by the time taken to locate an empty parking space. The work contributes to the development of smart city infrastructure. The results demonstrate significant relative improvement for occupancy detection. Overall, this work provides reliable and rapid decisions to support efficient parking systems using deep learning.

Ma, et al. [7] This paper provides an overview of current research on urban parking prediction systems and discusses various techniques used to predict the availability of parking in smart cities. It illustrates how machine learning and statistical models may be used in parking prediction algorithms and compares different algorithms for their accuracy and efficiency. This study highlights several challenges associated with the use of real-time prediction systems, including the importance of data quality and sensor integration. Finally, this paper provides insight into how to improve the strategies employed to manage parking and highlights the existing gaps in current research methodologies, providing a basis for the advancement of smarter parking solutions by developing an understanding of advancements made in the field of the prediction of available parking spaces.

Farid, et al. [8] This research presents a new method of detecting moving vehicles using deep learning techniques in real time in the field of computer vision. The primary focus of this work is to improve the accuracy of vehicle identification at different times of day and in varying weather conditions. To accomplish this task, the authors developed Convolutional Neural Networks to extract critical features from incoming images. In doing so, they were able to increase the speed of detection while still maintaining high levels of accuracy, thus creating a system that can deal with highly complex environments (e.g., traffic jams, etc.) and have reduced false-positive rates when making these detections. Furthermore, the developed system allows for real-time processing of information to support intelligent transportation systems, while providing enhanced performance in dynamic situations. Therefore, these findings will positively impact the accuracy of surveillance and monitoring systems and ultimately build a more robust traffic and parking automation system.

Zhang, et al. [9] This study explores possibilities to improve vehicle parking system operation through the use of multi-agent deep reinforcement learning techniques for dynamically assigning parking spaces to vehicles based on fully available and partially-connected vehicle behavior (e.g., whether the vehicle has an active connection to the internet). The DPAS uses DPIR to optimize parking resources by continually learning optimal park allocation techniques through ongoing interactions with both the user and the

environment. Through these interactions, the DPAS continually provides users (and parkers) with the best possible allocation of park resources while improving the overall efficiency of resource allocation within the parking system. By reducing the amount of time that users spend searching for a parking space, the DPAS improves overall coordination between vehicles and parking infrastructure and has the potential to respond to real-time changes in vehicle traffic conditions. In this way, the DPAS includes advanced, intelligent decision-making capabilities. The results of this research show how reinforcement learning techniques can be applied to improve parking systems' overall operational efficiency, especially in the context of smart cities. Overall, this research presents an innovative, AI-driven parking allocation solution.

Oladimej, et al. [10] This research paper is meant to give an understanding of Smart Transportation Technologies and their operations in current urban environments. Additionally, there are several examples of Intelligent systems that have been used for traffic control with Wise solutions for parking spaces around cities. It also discusses the use of the Internet of Things (IoT), Artificial Intelligence (AI), and machine learning on Transportation and how they are able to improve the movement of people and decrease the amount of traffic available. Examples of Intelligent Transportation applications include Smart Parking, Vehicle Tracking and Traffic Monitoring. The paper will explain the significance of Real-Time Data Processing. Another significant factor discussed will be how Smart Transportation systems face challenges in implementation. The study will provide explanations regarding the requirements for integration for technology.The research obtained will also examine future trends for intelligent mobility solutions. The results of this research will aid in the growth of sustainable transportation systems in urban areas. A broad overview of Smart Transportation advancements will be provided through this study.

III. EXISTING METHODLOGY

Typical parking management systems use human intervention to manage vehicle entry and exit through either traditional ticket issuance methods (paper ticket), semi-automated ticket issuance methods (RFID cards, barcodes) or via a combination of these two approaches. These systems have many areas of dependency on a human in the parking process (issuing ticket, verifying user, managing space) which can create delays and large queues at entry and exit points as well as not providing an efficient use of available parking space. One example of a modern parking solution is a sensor-based technology that utilizes either ultrasonic sensors or electromagnetic sensors to detect the presence of a vehicle within a parking space. These sensors can indicate whether a particular parking space is occupied or unoccupied, and relay that information to a central system. However, most of these systems only focus on detecting the availability of a parking space, and do not provide a high level of identity verification for drivers or vehicles, which means these systems have lower security than other parking solutions. While these systems have improved on previous methods of managing parking, they all have significant limitations, including a lack of advanced security features and no ability to support intelligent authentication systems (via facial recognition, license plate verification, etc.), which creates vulnerability for unauthorized access and improper use of vehicle.

IV. PROPOSED METHODOLOGIES

The proposed Deep Learning-Powered Smart Parking System is designed to overcome the limitations of traditional parking methods by introducing a fully automated, secure, and efficient solution. The system integrates facialrecognition and license plate detection to ensure that only authorized vehicles and drivers can access the parking facility. High-resolution cameras are installed at entry and exit points to capture both the driver’s face and the vehicle’s license plate simultaneously. For vehicle identification, the system employs the YOLO (You Only Look Once**)** algorithm, which enables real-time detection and recognition of license plates even in complex lighting or motion conditions. This ensures that each vehicle is accurately identified before granting access, preventing unauthorized parking and misuse. Simultaneously, the Grassmann algorithm is used for facial feature extraction and recognition, verifying that the driver matches the registered user. This dual-authentication process significantly enhances security and reduces the risk of theft. Once both the license plate and the driver’s face are verified against the database, the system automatically allows entry or exit, eliminating the need for manual supervision, tickets, or RFID cards. This touchless process reduces waiting times, minimizes congestion at entry and exit points, and provides a seamless experience for users. The system also includes real-time monitoring of parking spaces, allowing authorities to analyze occupancy, usage patterns, and vehicle flow. This data can be used to optimize space allocation, improve traffic management, and support smart city initiatives. By combining advanced deep learning algorithms with intelligent vision-based technologies, the proposed system ensures high-speed performance, reliability, and minimal human effort. Overall, the Deep Learning-Powered Smart Parking System transforms traditional parking management into a scalable, cost-effective, and environmentally friendly solution. It provides enhanced security, reduces operational costs, improves user

convenience, and contributes significantly to modern urban infrastructure.

METHODOLOGY

Framework Construction

The framework construction module defines the overall system architecture of the smart parking system. It integrates hardware components such as cameras with software components like deep learning models. The module establishes communication between YOLO-based license plate detection and facial recognition systems. It ensures real-time data flow between image capture and processing units. A centralized database is designed to store user and vehicle information securely. The framework supports both entry and exit point operations. It defines how each module interacts within the system. APIs are used to connect different functional components. The architecture is designed for scalability and future enhancements. It also includes security mechanisms for data protection. The system ensures efficient processing of real-time inputs. Overall, it forms the backbone of the entire smart parking solution.

Member Registration

The member registration module is responsible for enrolling new users into the system. It collects user details such as name, contact number, and vehicle information. Facial images of users are captured using a camera during registration. Vehicle number plate details are also recorded and linked to the user profile. The system ensures that all data is validated before storage. Each user is assigned a unique identification record. The collected data is securely stored in the database. Encryption techniques are used to protect sensitive information. This module prevents duplicate or unauthorized registrations. It provides a user-friendly interface for easy on boarding. Registration is the first step for system authentication. It enables future verification of users and vehicles.

Facial Features Extraction

The facial features extraction module identifies unique facial characteristics of registered users. It uses deep learning and Grassmann-based methods for feature extraction. The system captures facial images through high-resolution cameras. Preprocessing techniques are applied to enhance image quality. Key facial landmarks such as eyes, nose, and mouth are detected. These features are converted into mathematical feature vectors. The Grassmann model represents these features in subspace form. Extracted features are stored in the database during registration. During authentication, live facial data is compared with stored records. The module ensures robustness against lighting and pose variations. It improves accuracy in identity verification. This module plays a key role in secure access control.

Token Information

The token information module manages authentication credentials for system access. It generates digital tokens instead of physical access cards. These tokens are created after successful facial and vehicle detection. Each token is unique and time-limited for security purposes. The system sends tokens to registered users for verification. Token validation is required before granting access. It ensures that only authorized users proceed further. The module prevents reuse or duplication of tokens. All token activities are recorded in the database. It acts as an additional security layer in the system. It enhances authentication reliability. This module strengthens overall system security.

Verification System

The verification system is the final authentication module of the smart parking system. It checks both facial recognition results and license plate detection outputs. YOLO is used to detect and extract vehicle number plates. Facial recognition confirms the identity of the driver. The system compares both results with stored database records. If both match, access is granted automatically. OTP verification is used as an additional security step. Any mismatch results in denial of entry. The system operates in real time for quick decision-making. All verification logs are stored for tracking purposes. It ensures high-level security and accuracy. This module eliminates unauthorized access effectively.

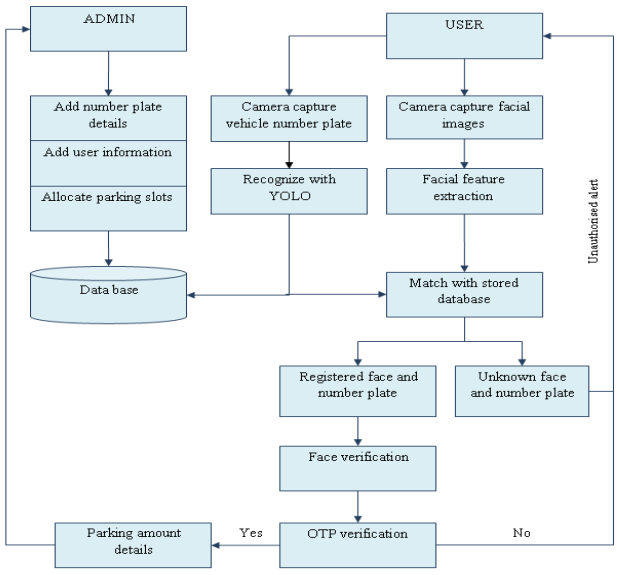

Figure 1: Diagram representation of the proposed methodology

V. EXPERIMENTAL RESULTS

According to test results, the Deep Learning-Powered Smart Parking system is much better than the traditional way of managing parking in terms of being accurate, efficient and secure. The license plate recognition software using the YOLO algorithm recorded a high level of accuracy (96-98%) despite some difficult conditions (e.g., low light, partial blockage of the plate, and moving vehicles). The face recognition module using the Grassmann algorithm also recorded a high level of accuracy (95-97%) at authenticating legitimate drivers while maintaining a low false positive/negative rate. The system was able to process vehicle entry and exit in approximately 40-50% less time than would be expected using a manual method or an RFID-based system, leading to improved traffic flow and reduced congestion at parking entrances/exits. Additionally, the two-tiered authentication system was very effective in preventing unauthorized access, thus improving the overall security of the system. The ability to monitor parked cars in real time means the system will be able to accurately report the number of occupied parking spaces at a location to a high degree (97% or greater), thereby improving space utilization and making better decisions about providing parking space. Finally, the system has demonstrated its ability to operate at a lower cost than traditional methods due to lessened reliance on physical hardware (sensors) and manual labor. Overall, the experimental data suggest that the Deep Learning-Powered Smart Parking System is effective as a solution for managing parking in modern smart cities, is scalable, and is capable of being used in many applications.

Performance Metric	**Existing System (%)**	**Proposed System (%)**
License Plate Detection Accuracy	85	97
Facial Recognition Accuracy	82	96
Overall System Accuracy	84	97
Unauthorized Access Prevention	75	95
Parking Occupancy Detection	88	97
Processing Speed Efficiency	70	92
Error Rate (Lower is Better)	18	4
System Reliabilit	80	96

Table 1: Performance Comparison Table

Results comparing old technologies to Deep Learning-Powered Smart Parkings show much better performance in every metric reviewed. The DLP-SP achieves a much higher level of accuracy in License Plate capture and facial recognition. This creates a system with much higher accuracy in identifying cars to help identify the owners (also through facial recognition). Unlike older systems that used people to operate them or were limited by available technology, the new system minimizes error and increases the overall system's reliability. In security, the double validation of drivers adds an additional layer of understanding if they are to park there. The DLP-SP allows for faster entry and exit of vehicles compared to traditional systems, therefore, results in fewer vehicles waiting and a better-flowing traffic situation on the street. The DLP-SP also has superior parking space detection and allows for quicker usage of the available spaces. Overall, the DLP-SP will outperform any current-day systems currently being used for Smart Parkings by providing better performance, better accuracy, better security, and easier operational processes.

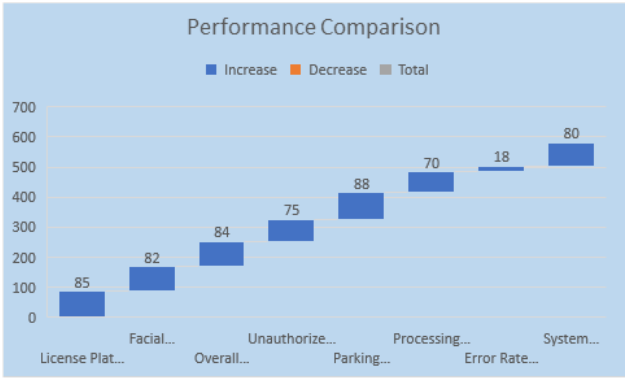

Figure 2: Performance metric chart representation

VI. RESULT

Figure 3: Home page for the smart parking

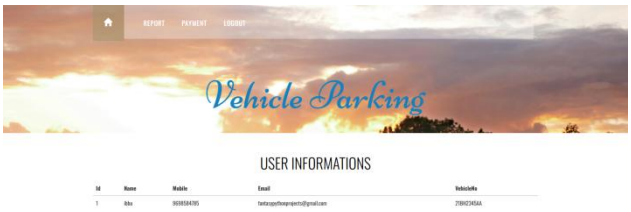

Figure 4: user details page for the smart parking

Figure 5: number plate detection for the smart parking

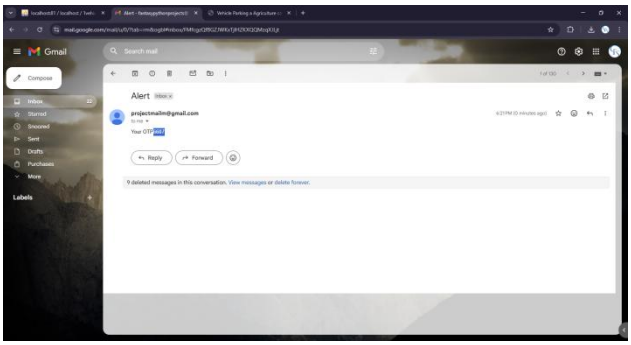

Figure 6: get OTP alert for the smart parking

VII. CONCLUSION

The proposed solution for this Smart Parking System leverages the power of Deep Learning and overcomes the challenges associated with traditional parking management systems by providing an intelligent, automated way of managing car parking. By combining the use of a license plate recognition algorithm using YOLO with facial recognition via advanced Deep Learning techniques, we guarantee real-time and accurate identification of both the vehicle and the user. As a result, there is no need for manual intervention, physical tokens or RFID type systems, reducing the complexity of operating parking facilities. Additionally, the combination of facial recognition along with the verification of illegal vehicle number plates through a dual-authentication mechanism provides a high degree of security for the system. The mechanisms in place to verify the identity of individuals entering and exiting will greatly reduce the opportunity for unauthorized access, vehicle theft, and abuse identified with the traditional model; thereby reducing the likelihood of incidents in these environments. The proposed system employs image processing in real-time along with deep learning models to provide dependable systems with credible results under less-than-ideal conditions of low light and motion blur. In addition to providing an enhanced level of security and automating processes, the system will also allow for more efficient traffic management through the optimization of the use of parking space due to the real-time monitoring and collection of data on parking activity. This data can then be used to better understand parking trends, and thus enhance urban planning and development efforts. Ultimately, the proposed system is an intelligent, efficient, scalable solution to help meet the requirements of a contemporary smart city, thereby increasing user ease and comfort while minimizing congestion and negative impacts on the environment.

REFERENCES

[1] Tekouabou, Stéphane Cédric Koumetio, Walid Cherif, and Hassan Silkan. "Improving parking availability prediction in smart cities with IoT and ensemble-based model." Journal of King Saud University-Computer and Information Sciences 34.3 (2022): 687-697.

[2] Ashraf, Anika, et al. "Park with ease: Evaluating usability to design intuitive interfaces for car parking applications." 2023 IEEE 9th International Women in Engineering (WIE) Conference on Electrical and Computer Engineering (WIECON-ECE). IEEE, 2023..

[3] Elfaki, Abdelrahman Osman, et al. "A smart real-time parking control and monitoring system." Sensors 23.24 (2023): 9741.

[4] Channamallu, Sai Sneha, et al. "Enhancing urban parking efficiency through machine learning model integration." IEEE Access 12 (2024): 81338-81347

[5] Dahiya, Anchal, et al. "Machine Learning-Based Prediction of Parking Space Availability in IoT-Enabled Smart Parking Management Systems." Journal of Advanced Transportation 2024.1 (2024): 8474973.

[6] Siddiqui, Shahan Yamin, et al. "Smart occupancy detection for road traffic parking using deep extreme learning machine." Journal of King Saud University-Computer and Information Sciences 34.3 (2022): 727-733.

[7] Ma, Changxi, Xiaoting Huang, and Jiangchen Li. "A review of research on urban parking prediction." Journal of Traffic and Transportation Engineering (English Edition) 11.4 (2024): 700-720.

[8] Farid, Annam, et al. "A fast and accurate real-time vehicle detection method using deep learning for unconstrained environments." Applied sciences 13.5 (2023): 3059.

[9] Zhang, Xinyuan, et al. "Online parking assignment in an environment of partially connected vehicles: A multi-

agent deep reinforcement learning approach." Transportation Research Part C: Emerging Technologies 138 (2022): 103624.

[10] Oladimeji, Damilola, et al. "Smart transportation: an overview of technologies and applications." Sensors 23.8 (2023): 3880.