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Smart Parking Management System

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Abstract - Smart Parking Management System (SPMS) is a modern system that utilizes Deep Learning and Machine Learning techniques to provide efficient and effective parking solutions. The main goal of SPMS is to optimize the utilization of available parking spaces, reduce traffic congestion, and minimize parking-related problems such as illegal parking and over-parking. In recent years computer vision technologies have been developed which are very accurate and give promising results presented real-time number plate detection system using Artificial Intelligence. Smart Parking Management System is a system that will help to automate the process of parking toll collection and management. The proposed system aims to improve the efficiency of parking toll management, reduce traffic congestion, and enhance the user experience for parking. This will benefit the pay and parking facility owners as their system management will become more efficient. This paper discusses the system architecture, implementation, evaluation and accuracy of the proposed system. The paper concludes by highlighting the potential benefits of the proposed system and discussing future research directions.

Key Words- Optical Character Recognition (OCR) Computer vision, Artificial Intelligence.

I. INTRODUCTION

With the rapid development of information technology (IT) in recent years, research has been actively conducted to eliminate inconveniences in daily life, providing people with various conveniences. Smart parking toll management is a growing concern for urban areas due to increasing traffic congestion and limited parking spaces. The traditional approach to parking toll management involves manual collection of tolls, which is time-consuming, inefficient, and error prone. In recent years, there has been an increasing interest in developing smart parking toll management systems that utilize modern technologies to automate the process of parking toll collection and management. The proposed system aims to improve the efficiency of parking toll management, reduce traffic congestion, and enhance the user experience for parking.

Automatic number plate recognition (ANPR) is a technology that allows for the automatic detection and recognition of vehicle number plates. ANPR systems are widely used for various applications such as traffic management, toll collection, parking management, and law enforcement. This technology is typically implemented using specialized algorithms and cameras that are designed to capture images of license plates. EasyOCR uses deep learning algorithms to accurately recognize text from images, making it a suitable tool for ANPR applications. ANPR systems have become increasingly sophisticated in recent years, with advances in OCR technology, camera technology, and database management systems. These systems are typically designed to be highly accurate, with the ability to recognize license plate numbers even under challenging conditions such as low light or fast-moving vehicles. The basic input to an ANPR system a camera image or scene in the case of video.

The basic goal of this system is to recognize number plate characters present in an image or scene. The live CCTV footage is converted into frames. The frames are passed through EasyOCR algorithm to detect the cars in it. The detected cars are stored in separate images in a folder. These images are sent as input to an algorithm built using a cascade model which is used to detect potential license plate regions. This image is passed through EasyOCR for character recognition. The generated characters using EasyOCR are saved as license plates in string format in the database with the time and date for future reference. This system tends to give a higher accuracy than the existing systems and has the additional advantage of being implemented in real time. The most complex part is that the number plates may have variations in the font, spaces, letters, and numbers. The main scope of the project is to detect and recognize Indian number plates with a higher accuracy.

The proposed system combines computer vision, image processing, and machine learning algorithms to automate the process of identifying vehicle number plates and detecting available parking slots in parking areas. This system has gained significant attention and adoption in

recent years due to its potential to enhance parking management, improve security, and provide a seamless experience for vehicle owners. Traditionally, manual methods involving human

operators were used to monitor and manage parking lots. However, these methods are time-consuming, error-prone, and limited in terms of efficiency and scalability. The system addresses these challenges by automating and streamlining the entire process. By training the algorithms with large datasets containing diverse parking scenarios, the system can adapt and learn to handle various lighting conditions, vehicle types, and environmental factors. This enables the system to achieve higher accuracy in number plate recognition and parking slot detection, even in challenging situations.

The system offers several benefits, including improved parking management efficiency, reduced human error, enhanced security through accurate vehicle identification, and a more seamless parking experience for drivers. It can be implemented in various settings, such as public parking lots, commercial complexes, airports, and residential areas. In conclusion, the smart parking management system is a sophisticated solution that leverages computer vision, image processing, and machine learning technologies to automate the process of number plate recognition and parking slot booking. This system has the potential to revolutionize parking management, enhance security, and optimize the overall utilization of parking spaces.

This literature review explores the existing research and developments related to smart parking management systems, focusing on their key components, technologies, benefits, and challenges and provides valuable insights into the advancements in this domain. The Research Gap provides an insight on the gaps that were identified and filled using our research paper.

In Proposed Methodology the technical details of the system including the algorithms and techniques employed, are presented comprehensively to provide a clear understanding of the system's implementation, ensuring transparency and reproducibility of the research findings and giving a detail description of how they are used. In Result and Analysis, the various test cases are shown analyzing the working of our model in different conditions and changing surroundings. The data and model used is explained in detail. The performance and accuracy of the system is analyzed. In Future Scope the potential areas for further research and possible improvements are discussed. The Conclusion concludes on a summary of the system working and how the system can benefit its users and surroundings based on the result and performance of the system. It discusses the drawbacks of the system and improvements possible. The references section serves as a comprehensive compilation of all the cited sources and references utilized throughout the project and research paper.

II. LITERATURE REVIEW

This literature review focuses on recent research and studies related to parking management systems and strategies. It aims to examine various approaches, technologies, and best practices employed in the field of parking management. The review encompasses studies from both academic and industry sources,

knowledge and identifying gaps for further research. There are various existing models that perform number plate recognition, but the main drawback of these models is the trade-off between object detection accuracy and its real-time speed. Future research can explore the use of other technologies, such as computer vision and edge computing, to improve the accuracy and efficiency of the proposed system.

Research work by Bharti Priya and Gopinath proposes an IoT based Smart parking system that integrates with mobile Application. The paper starts by explaining the architecture of the proposed system which uses RFID readers to identify the vehicle and using Infrared Sensors and LED Display to identify the available parking slot. They emphasize mainly the implementation and techniques used in the research paper. The authors conclude by stating that the prototype is suitable for single storage parking slot, but this model can be extended for multi storage parking space.[1]

Research analysis by Idris, Leng and Noor discusses the car park occupancy detection aspect of the model. The author states the various intrusive and non-intrusive sensors that can be installed in every parking spot detect the presence of a vehicle in any spot. The author also discusses the implementation of various vehicle detection technologies in commercial systems and research. The research paper concludes by analyzing the pros and cons of each sensor technology and discussing which are best suitable.[2]

Research analysis performed by Janak Parmar, Pritikana Das and Sanjaykumar Dave shows the demand and presents the state-of-the-art review of models and studies on the parking system. Problems related to and due to the parking, various parking characteristics and their applications, parking choice behavior of drivers, development of demand models considering various factors and review of parking policies as an integral part of the urban transport system are discussed in detail.[3]

This research analysis conducted by Alica and Kristian focuses on the parking situation in Slovak city Žilina. The

authors carried out an extensive traffic survey in private and city-owned parking lots. Not only were occupancy data collected, but also the opinions of the drivers who parked there. The second half of the paper is based on results from the survey. This paper teaches that cities are responsible for more than 75% of waste production, 80% of emissions, and 75% of energy utilization. It is estimated that vehicles cruising for free parking spaces cause 30% of the daily traffic congestion in an urban downtown area which can be reduced using our model. [4]

The research paper by Amin and Norlia proposes a new parking system that uses ultrasonic (ultrasound) sensors to detect either car park occupancy or improper parking actions. Different detection technologies are reviewed and compared to determine the best technology for developing SPS.[5]

Authors Amira and Mahmoud of the research paper propose a parking system that depends on Arduino parts, Android applications, and based on IoT. This paper focuses on infrastructure and hardware used in building the system and implementing an integrated solution for smart parking.This paper discusses an improved approach to security and privacy using RFID applications. It provides an overview of a system that helps automate the process of parking without the use of iot sensors. This paper shows that time constraint systems are an essential part of any real-time system including parking management systems.[6][7][8]

A survey conducted by Chirag, Dipti and Atul shows the analysis automatic number plate recognition system on various models and multiple vehicles to identify their number plate characters and lastly provides with an overview of the result analysis of the system. This paper proposes a system explaining the various optical recognition techniques used for automatic number plate recognition. The paper concludes with the analysis that computer vision is beneficial for number plate recognition as compared to other techniques.[9][10] Research paper by Wang, Zhang and Guo proposes a system that can be used for automatic parking based on a recent technique known as a Bird's eye view vision system. It explains the benefits and drawbacks of using this technique. They achieved an accuracy of 96.34%.[13]

A research analysis by Fernandez, Estrada and Roca shows the formulation of parking slot assignments in various environments and models used for urban parking distribution. I focus on the techniques and methods used and their pros and cons. The paper shows a systematic approach for path tracking and control of automatic parking model. In the later half it explains how time delay influences the overall system. The paper explains a system that can recognize the presence of a preceding vehicle based on learning from sample images. This paper uses machine learning model to train a large dataset and hence can recognize the number plate of the preceding vehicle.[14][15][16]

This paper provides a research of car license plate area algorithm and car tail lamp area extraction algorithm which can be used for various systems. It provides a detailed analysis of the methodologies and techniques used in the proposed system. The authors analyzed different test cases with different parameters and achieved an accuracy of 94.26%.[17]

The research analysis by Higgins and Cairney discusses the benefits of using an RFID tag for the identification of vehicles in various parking systems. This paper also discusses the various risks associated with the idea.[18]

Research paper by Yang and Wei proposes a machine learning model that can be used for predicting block-level parking occupancy in real time. The case study also shows that, in generally, the prediction model works better for business areas than for recreational locations.[19]

This paper by Xian and Zhai proposes a novel parking occupancy detection method based on a Haar-AdaBoosting algorithm and a convolutional neural network (CNN) achieving an accuracy of 99.67%, which provides intelligent video surveillance in public parking areas, especially gas stations.[20]

Research analysis conducted by Debaditya and Kourosh proposes a Real-time image-based parking occupancy detection system using deep learning. They provide a detailed analysis of parking space occupancy in outdoor environments and its result analysis.[21] A distributed Parking slot Allocation Framework based on Adaptive Pricing Algorithm and Virtual Voting is proposed in this paper by Vikas and Vinay. They propose a model that provides a fair, fast and cost-optimal parking slot allocation method. [22].

Analyzing the existing literature in the field of parking management, this study has observed few research gaps. Many car parking systems are designed for standard parking lots with well-defined parking spaces. However, there is a research gap in developing computer vision algorithms that can handle more complex parking environments, such as multi-level parking structures, irregularly shaped parking spaces, or outdoor parking lots with varying lighting conditions. Occlusion occurs when one vehicle obstructs the view of another vehicle in a parking lot, making it difficult to accurately detect and track individual vehicles. There is a need for research in developing computationally efficient algorithms that can process high-resolution video feeds from multiple

cameras in real-time, while maintaining accurate and reliable parking slot detection and occupancy estimation. There is a need for research on developing robust algorithms that can accurately detect parking occupancy even in challenging environments, such as underground parking lots, outdoor lots with changing lighting conditions, or crowded parking structures where occlusions are common.

III. METHODOLOGY

To address the limitations in the existing approaches the work introduced an integrated system capable of overcoming the research gaps as discussed earlier. The model first requires installation of a surround view camera system comprising multiple cameras strategically positioned around the parking area. These cameras need to capture continuous or periodic video frames from each camera in the surround view system and ensure synchronized time stamps for accurate data analysis. These cameras should provide a comprehensive view of the parking spots, capturing different angles and perspectives.

In this work a top view of the parking lot is required for the recognition of the availability of a vacant parking spot. The model also requires camera installation at the point of entry and exit of the parking area to capture the front and back view of the vehicles entering and exiting the premises. The camera should be installed at the position where the vehicle license number plate is in position with the camera and the camera is able to capture the license number plate in the most optimum angle. The main aim of the camera present at the entry and exit of the parking premises is the capture of picture of entering and exiting vehicle and process the image for further recognition of the license number plate characters for future identification of the vehicle. The camera captures a picture of the entering vehicle.

This picture is then pre-processed to remove any noise present and prepare them for efficient number plate detection and recognition. This noise can include the presence of dirt, objects, etc. The preprocessing includes Resize the acquired image to a standardized size suitable for processing. This step helps ensure consistent image dimensions, which can improve the performance of subsequent processing steps.

Enhance the image quality to improve the visibility of the number plate. Common techniques include contrast adjustment, histogram equalization, or adaptive histogram equalization. These techniques aim to enhance the visibility of characters and reduce the impact of lighting variations or noise. Applying noise reduction techniques to remove unwanted noise and artifacts from the image. This could involve using filters such as median filters, Gaussian filters, or bilateral filters. Noise removal helps to improve the clarity of the number plate and reduce false detections caused by noise. Convert the enhanced grayscale image into a binary image, where the number plate regions are represented by black pixels and the background is represented by white pixels. Applying morphological operations to further refine the binary image and remove unwanted noise or small artifacts. Use edge detection or contour analysis techniques to detect and localize the potential number plate regions within the pre-processed image. This step involves identifying contours that exhibit characteristics consistent with number plates, such as rectangular shapes, specific aspect ratios, or size constraints.

EasyOCR's text detection algorithm is then applied to this preprocessed image to locate the potential number plate regions. This is the most important step as if the number plate region is not located correctly then the further model will not be able to identify the number plate characters. This can result in incorrect vehicle detection and allocation. EasyOCR uses advanced techniques like text detection based on CRAFT (Character Region Awareness for Text detection) and other methods to identify regions containing text. Once the number plate regions are identified Easy OCR's text recognition functionality is used to extract the alphanumeric characters from each region.

Easy OCR utilizes deep learning models and techniques like convolutional neural networks (CNN) to recognize and extract text. After recognizing the text certain post-processing steps are required to refine the extracted number plate characters further. This can include removing noise, correcting errors, or applying specific formatting rules, depending on the number plate's requirements. Finally, the recognized characters are post-processed to improve accuracy and eliminate false positives. This can involve techniques such as spell-checking, character grouping, and confidence thresholding. Once the number plate characters are successfully extracted, it can be used for vehicle identification and allocation of parking slots in the future as shown in Figure 1. The second half of the model includes the identification of a vacant parking spot for allocation to vehicles for parking process. For this the model requires the presence of a surround view camera strategically positioned around the parking area. In this work a top view camera is used which captures the picture of the parking lot. This image is then preprocessed to remove the presence of any noise. The preprocessing techniques include applying noise reduction techniques to minimize the impact of noise, such as sensor noise or compression artifacts, in the images.

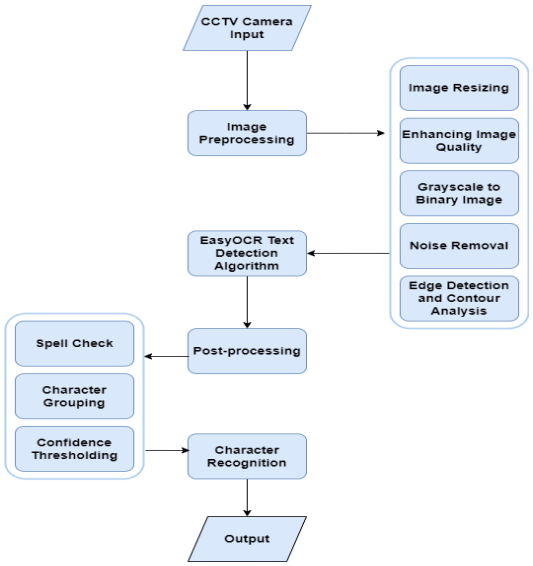

Fig1. Proposed Flow of Number Plate Recognition system.

Common approaches include using filters like median filters or Gaussian filters to smooth out the noise while preserving the essential details. Perform background subtraction to separate the moving objects (vehicles) from the stationary background. This technique helps identify the regions of interest where vehicles are present. Background subtraction can be achieved by creating a background model based on historical frames or using more advanced methods like adaptive background subtraction.

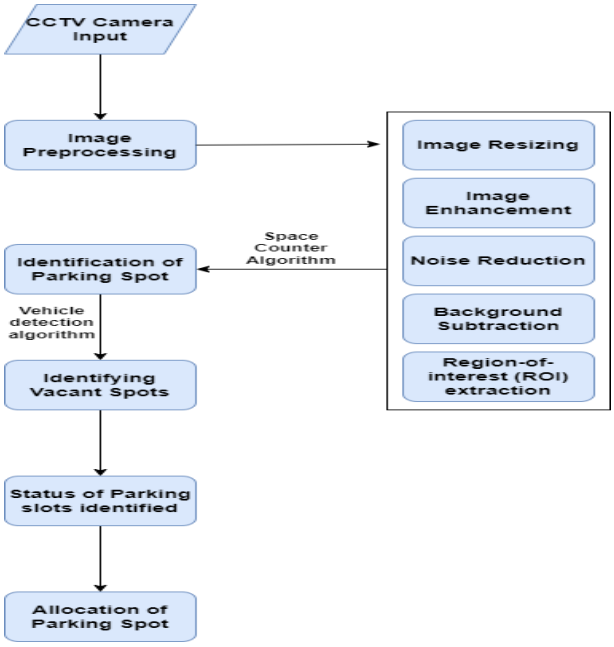

Fig2. Proposed Flow of Parking Occupancy Detection Model.

A space counter algorithm using OpenCv is applied to this preprocessed image which calculates the size and position of each parking spot that is present. The algorithm then makes a red color bounding box around each of the parking spots. The bounding box is then numbered which acts as the parking spots identification that is further used for the allocation of spots to vehicles. A vehicle detection algorithm is then applied to this image which further detects the presence of a vehicle in the parking spot. If the algorithm identifies the presence of a vehicle in the parking spot it changes the color of the bounding box to green and that parking spot is assigned as empty. This image containing the red and green color bounding boxes is then processed to assign the parking spot as 'True' if it is empty and 'False' if it is filled. This assignment helps in identifying free spots and allocating it to vehicles in the model. This data is then saved in a csv file which contains the status of each parking spot as empty or filled as shown in Figure 2.

The above-mentioned two parts of the model work together to implement the working of complete parking management system. The workflow of the complete model is explained further. When a vehicle enters the parking premise the cctv captures its image and extracts the number plate characters. The timestamp of check-in is also saved along with the license number plate. The extracted text is saved as the identification of the vehicle which will be used further. The moment when the number plate is extracted the parking lot cctv captures the image of the parking lot and identifies the status of the parking spots. The system then analyzes the parking spot status file and allocates a single spot to the vehicle. This allocation is done based on the number that is assigned to the spots and the lowest vacant parking spot is assigned first.

When another vehicle enters the premises, the system extracts the number plate from the vehicle. The parking lot cctv again takes a picture of the parking lot and now the before empty slot is assigned filled as the previous vehicle will now be visible in the image and the algorithm will identify that spot as filled. If by mistake a user parks his/her vehicle in a wrong parking spot as assigned to it, the system will still be able to identify this possibility as when the next vehicle will enter the assigned parking spot will be identified as empty and the spot taken by previous vehicles will be identified as filled as a new picture of the parking lot is taken each time a vehicle is entering the premises.

While check-out the camera present at the check-out point will capture the image of the vehicle and extract it number plate using the EasyOCR algorithm. The system will then identify the check-in time in the database and calculating the time for which the vehicle was parked on the premises will generate a bill. The parking lot camera will identify

the parking spot that was earlier allocated to this vehicle as empty and will be ready to be assigned to a new vehicle.

IV. RESULT ANALYSIS

The proposed system can identify vehicles in front of the camera and segment the license number plate from the vehicle's image and give machine text output. The dataset used for training and evaluation consists of diverse images with various lighting conditions, angles, and vehicle types. The number plates in the dataset were manually annotated to serve as ground truth labels. The number plate detection model was developed using a convolutional neural network (CNN) architecture, specifically tailored for this task. The model incorporates layers for feature extraction, region proposal generation, and classification. Model used for training purposes is russian-harcasscade-model. Although the model's accuracy values seem desirable, they do not identify the license number in very dark lighting conditions accurately. However, blur images that are not very similar to other classes will be recognized correctly by the system, but with a lower accuracy of 0.7604.

The model was tested in different lighting conditions and different car positions as shown in Figure 4 and Figure 6. Figure 5 and Figure 6 are the result analysis of the test cases. The model accurately identifies the presence of a number plate and can detect the characters on the number plate and output it in string format. The model may struggle with detecting number plates that are partially occluded by objects, such as car accessories or dirt. Enhancing the model's ability to handle occlusion scenarios could lead to improved performance.

While the model generally handles different lighting conditions well, there is room for improvement, especially in challenging situations such as nighttime or glare. Incorporating additional techniques, such as adaptive illumination normalization, could enhance performance in these scenarios. The number plate detection model demonstrated strong performance in accurately detecting and localizing number plates. The high precision and recall values indicate its effectiveness in various conditions. Precision ranges from 80% for '0' to about 96% for '1,' 'A,' 'J,' etc. Recall has reached near perfect in labelling '2', 'N' and '8' symbols. '0' has a low recall due to confusion with symbol 'O'. The parking occupancy detection model is successfully being able identify the free spaces and allocate them to the incoming vehicles as shown in Figure 3 and Figure 8.

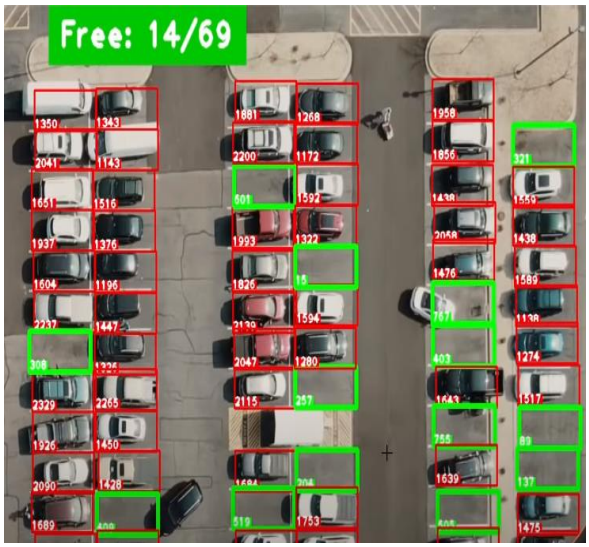

Fig 3: CCTV view of the parking lot

Fig.4: Testing model on incoming vehicle

Fig.5: Recognition of incoming vehicle number plate

Fig 6: Testing model on outgoing vehicle

Fig 7: Recognition of outgoing vehicle number plate.

	VEHICLE DETAILS	PARKING SLOT	CHECKOUT TIME
2	6J03ER056 3,	37	2023-05-11 13:10:47.683460
3	Nunber_Plate	39	2023-05-11 13:12:14.727847
4	DL 7CQ 1939	42	2023-05-11 13:12:31.491850
5	JL 7CQ 1939	45	2023-05-11 13:13:49.244204

Fig 8. Allocating the free slots.

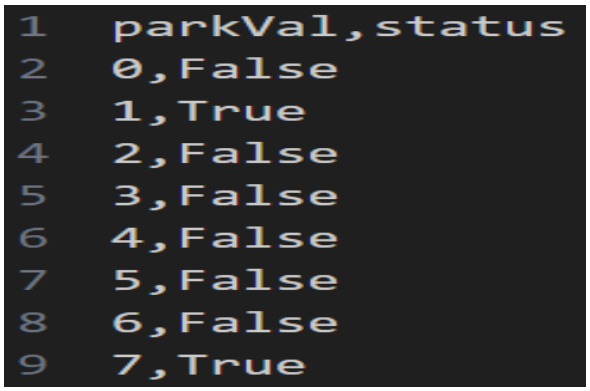

Fig 9. Slot Status

V. CONCLUSION AND FUTURE SCOPE

The results proved that the hypothesis was worth investigating. The smart parking management system seemed promising. However, certain areas in the proposed system show a need for improvement such as: There are instances when in the absence of the owner of the car it is hit or scratched by another vehicle, and the management are not able to determine the culprit. A system can be built that will be able to recognize the instance when your vehicle is hit or even touched by another car. This can be done by installing cameras at multiple angles. Using the technique of video and image processing our system will be able to determine this incident. The back draw in this idea is that installation of multiple cameras at multiple angles will be costly and difficult to maintain. One more aspect to be taken care of is if the customer keeps their vehicle for more than the specified hours, we cannot update our database and cannot assign that parking slot to another customer. In general, smart parking management systems have been found to be a promising solution for optimizing the use of parking spaces in urban areas and help to automate the process of parking toll collection and management. Benefits of smart parking management systems can include reduced congestion and emissions, improved user experience, and increased revenue for parking operators. The proposed smart parking management system offers a promising solution to the challenges faced by urban areas in managing parking tolls, and it is expected to have a significant impact on the future of urban mobility.

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REFERENCES

[1] J. Cynthia, C. Bharathi Priya, P. A. Gopinath, “Iot Based Smart Parking Management System”, International Journal of Recent Technology and Engineering (Ijrte), Vol. 7 Issue-4s, pp: 2277-3878, November 2019.

[2] M.Y.I. Idris, Y.Y. Leng, E.M. Tamil, N.M. Noor, Z. Razak, “Car Park System: A Review of Smart Parking System and its Technlogy”, Information Technology Journal, Vol. 8 (2), pp:101-113, 2009.

[3] Janak Parmar, Pritikana Das, Sanjaykumar M. Dave, “Study on demand and characteristics of parking system in urban areas: A review”, Journal of Traffic and Transportation Engineering, Vol. 7 (1), pp: 111-124, 2014.

[4] Alica Kalašová , Kristián Culík , Miloš Poliak Zuzana Otahálová , “Smart Parking Applications And Its Efficiency “, Sustainability, Vol. 13, pp: 6031, 2021.

[5] Amin Kianpisheh, Norlia Mustaffa, Pakapan Limtrairut and Pantea Keikhosrokiani, “Smart Parking System (SPS) Architecture Using Ultrasonic Detector”, International Journal of Software Engineering and Its Applications, Vol. 6, No. 3, July, 2012.

[6] Amira. A. Elsonbaty, Mahmoud Shams, “The Smart Parking Managementb System”, IJCSIT, Vol. 12, 2020.

[7] Zhang, L. “An Improved Approach to Security and Privacy of RFID application System”, Wireless Communications, Networking and Mobile

Computing. International Conference. Vol. 2, pp: 1195- 1198, 2005.

[8] Wegener, J., and Grochtmann, M., "Verifying Timing Constraints of Real-Time Systems by means of Evolutionary Testing. Real-Time, Systems", Kluwer Academic Publishers, Vol. 15 (3), pp. 275 – 298, 1998.

[9] Chirag Patel, Dipti Shah, Atul Patel, "Automatic Number Plate Recognition System (ANPR): A Survey", International Journal of Computer Applications, Vol. 69 (9), pp: 975-8887, 2013.

[10] S. R. Aher, N.D. Kapale, "Automatic Number Plate Recogniton System for Vehicle Identification using Optical Recogniton", International Research Journal of Engineering and Technology, Vol. 4 (6), pp: 2395-0072, 2017.

[11] Tran Duc Duan, Le Hong Du, Vinh Phuoc, "Building an Automatic License Plate Recognition System", International Conference in Computer Science, February 21-24, 2005.

[12] Mahmoud Ibrahim, Mohamed Shehata, Wael Badawy, "Automatic License Plate Recognition (ALPR): A State-of-the-Art Review", IEEE Transactions on circuits and systems for video technology, Vol. 23, 2013.

[13] Chunxiang Wang, Hengrun Zhang, Ming Yang, Xudong Wang, Lei Ye, Chunzhao Guo, "Automatic Parking Based on a Bird's Eye View Vision System", Hindawi Publishing Corporation Advances in Mechanical Engineering, Vol. 14 2014.

[14] M. Roca-Riu, E. Fernández, and M. Estrada, "Parking slot assignment for urban distribution: Models and formulations" Omega, Vol. 57, pp. 157–175, Dec. 2015.

[15] Y. Hua, H. Jiang, Y. Cai, X. Zhang, S. Ma, and D. Wu, "Path tracking control of automatic parking cloud model considering the influence of time delay," Math. Problems Eng., vol. 2017, 2017.

[16] T. Kato, Y. Ninomiya, and I. Masaki, "Preceding vehicle recognition based on learning from sample images", IEEE Trans. Intell. Transp. Syst., vol. 3, no. 4, pp. 252–260, Dec. 2002.

[17] Y. Xu, "Research of car license plate area algorithm and car tail lamp area extraction algorithm" M.S. thesis, School Inf. Eng., Xi'an University of Science Technology, Xi'an, China, 2008.

[18] Higgins, N., L., Cairney, T., "RFID opportunities and risks", Journal of Corporate Accounting & Finance, Vol. 17 (5), pp:51-57,2006.

[19] Shuguan Yang, Wei Ma, Xidong Pi, "A deep learning approach to real-time parking occupancy prediction in transportation networks incorporating multiple spatio-temporal data sources", Transportation Research Part C: Emerging Technologies, Vol. 107, pp: 248-265, 2019.

[20] Xuezhi Xiang, Ning Lv, Mingliang Zhai, and Abdulmotaleb El Saddik, "Real-Time Parking Occupancy Detection for Gas Stations Based on Haar-AdaBoosting and CNN", IEEE Sensors Journal, Vol. 17, 2017.

[21] Debaditya Acharya, Weilin Yan, Kourosh Khoshelham, "Real-time image-based parking occupancy detection using deep learning", CEUR Workshop Proceedings, Vol. 2087, pp. 33–40, 2014.

[22] Vikas Hassija, Vikas Saxena, Vinay Chamola, F. Richard Yu, "A Parking Slot Allocation Framework Based on Virtual Voting and Adaptive Pricing Algorithm", IEEE Transactions on Vehicular Technology, Vol. 69, NO. 6, 2020.

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