Next Generation Parking System with Computer Vision and Machine Learning

ECS Transactions, 107 (1) 6735-6746 (2022)
10.1149/10701.6735ecst ©The Electrochemical Society

Next Generation Parking System with Computer Vision and Machine Learning

T.Naga Swathi[a], V. Megala[b], S.Yokesh babu[c], R.Harshini[d], V.Sumedha[e]

[a,b] Department of Electronics and Communication Engineering, SRM Institute of Science and Technology, Ramapuram, Chennai, 600089, India
[c,d,e] School of Computer Science and Engineering(SCOPE), VIT, Vellore, India

Parking management is a term that describes methods for making better use of parking resources. The first step toward successful parking management is to identify the cause of the problem. Finding suitable parking is among the fastest-growing industries of all, given the ever-increasing number of cars on the road. Traditionally, traffic has been a nightmare. To address these issues, businesses adopted intelligent parking systems from large hardware vendors. These, on the other hand, are unfit for purpose and also have resulted in major parking issues at many businesses. The approach attempts to offer a practical answer to the problem of smart parking. We aim to create a functioning software that will inform requesting customers if there is still a free parking spot near their location using technologies like Machine Learning, CNN, OpenCV, and React.

1. INTRODUCTION

With the exponential increase in population and economical factors, the number of vehicles on the roads has gone up exponentially. This creates a big limitation in the amount of proper parking space available for people[1]. In countries like India with high levels of population, the need for planning parking spaces is much higher. People spend a lot of time looking for spaces and often have to wait around for cars to move for parking their cars. More often not, the congestive roads also make it harder for them to find spaces that are suitable for the vehicle they own[2]. This paper targets the parking lots available in open spaces, shopping malls, and commercial streets with established parking spaces. Implementing a technology-based video monitoring approach to automate the process of identifying parking spaces will be much more effective than implementing sensor-based work. The sensor-based approach requires intricate hardware work, higher expenditure on placement and working of the sensors, and poses a higher chance of technical failure than the proposed method of using video-based monitoring[3]. The video-based monitoring solution is implemented via technologies like OpenCV and Convolutional Neural Network (CNN). Convolutional Neural Networks are discovered to aid in the development of a classifier since they automatically collect and utilize the retrieved characteristics from the information for improved outcomes. The proposed solution is not only focused on the video-monitoring aspect, it also aims to provide a viable method for users to access the real-time identification of parking spots via an app[4]. Along with this, the app will also prove highly advantageous to the user by providing paperless payment options. The present state of parking: The desire for improved customer service is driving a need for parking applications. Parking fees may now be paid through an (online) application[5]. There have been, however, other methods to incorporate mobile apps into the parking process to make the concept of finding enough parking space a reality. Demand on cashless transactions:

Customers today demand a variety of payment options, including parking[6].Mostly the Cash payments are being phased out of the parking industry in favor of electronic payments. Credit cards and internet payments through mobile phones are increasingly accepted by parking businesses. Power demand, environmentally friendly, and practical solutions: Sustainability is a must-have, particularly now that climate change is wreaking havoc. Energy efficiency, as well as long-term solutions, are increasingly important to people. Not only is it healthier for both the environment, but it also saves money in the long run.

1.1 LIST OF ISSUES

Due to the increasing population, parking space in Indian cities has stayed steady or reduced whereas the number of cars has risen. Most municipalities suggest that parking spaces be added to ease the issue[7]. Parks and empty plots are being used as possible parking spaces, despite the restricted land area and available resources, and multi-level facilities are being built. Due to an uncontrolled pricing system, parking spots are limited. A cheap parking charge encourages more cars to be on the road, adding to pollution issues. Automobile dependency costs society a lot of money[8]. User expenses include fewer transport options and more automobile residential parking spaces, which increases the danger of an accident. Excessive automobile use is caused by external expenditures such as road and parking facilities, congestion, and uncompensated accident damages. Commercial vehicles will be unable to load or unload due to a lack of parking, which will lead them to block traffic lanes[9]. Oversupply of parking spaces and inefficient and inconsistent parking laws can be caused by local zoning ordinances, construction codes, and other development activities. Regulations and taxes may be in effect at particular times, and parking subsidies may be available to some but not all users[10]. On-street parking troubles are a common cause of delays, especially on congested highways. For both sorts of places to be used to their full potential, a tariff balance is required. Overcrowding of parking places is one of today's most common issues. The number of vehicles on the road continues to outnumber available parking spots, cluttering the roads[11]. Violence resulting from overcrowding, deformed cars as a result of a space crisis, and overcharging for parking are just a few of the issues that arise. Cruising or cars seeking a parking spot, results in long lines, traffic congestion, and pollution. Parking lots collect many pollutants that don't get absorbed and end up in water bodies after rainstorms. They also result in the production of sulfur dioxide as well as particulate matter, although both are detrimental to human health. Parking on important events causes endless traffic because a significant number of vehicles flood the streets, putting enormous strain on available parking spaces. As a result, there will be more cruising, turmoil, quarrels, and long lines than usual.

2. ISSUE ON FOCUS AND EXISTING SOLUTIONS

The issue on focus - A more sustainable and efficient parking solution using mobile applications for digital payments. Existing solutions - T2 Systems Include T2 Devices specializing in the development of parking facility solutions. Permit management, inter-pay stations, business information, and event parking facilities are all services offered by the firm.Swarco AG - Swarco provides road marking, signage, urban traffic management, parking, highway and tunnel management, public transportation, and street lighting, among

other sustainable mobility. Management of traffic, road labeling, parking management, e-Mobility, and linked driving systems are all services provided by the business.

3. CURRENT STATISTICS

India, one of the fastest-growing third world countries globally, is seeing a massive rise in cars on the roads. The number of people is growing exponentially, vehicles (especially cars) along with the rise in population, but the space for parking has remained stagnant or has even diminished. This causes a lot of inconvenience, pollution and is also one of the causes of road accidents[12]. The pressure of developing intelligent solutions for parking in our country is high, more so given the lack of big parking spaces. For instance, the average road area per person in New York's midtown is 33.3 square meters, while it is only 1.7 square meters in Mumbai's Null Bazaar[13]. This means that a car in Mumbai is roughly 20 times more expensive than one in New York.

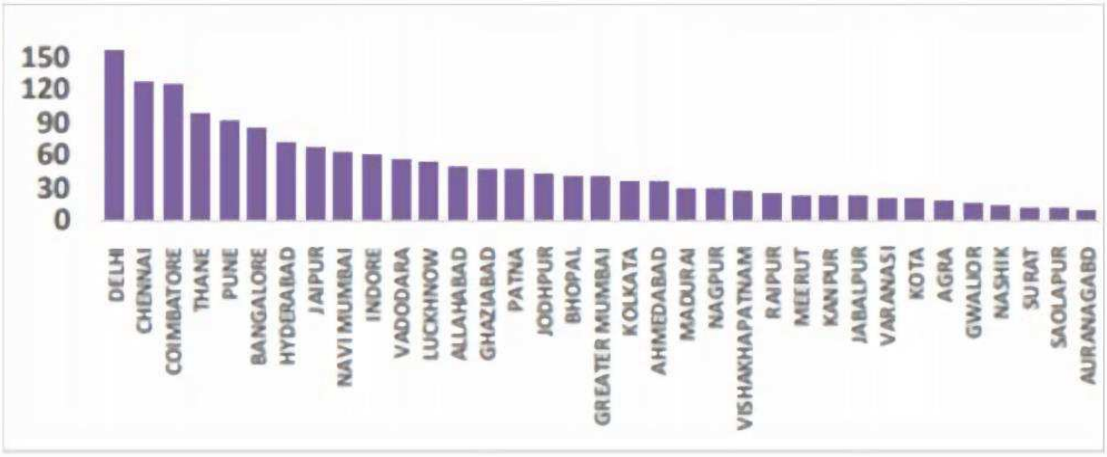
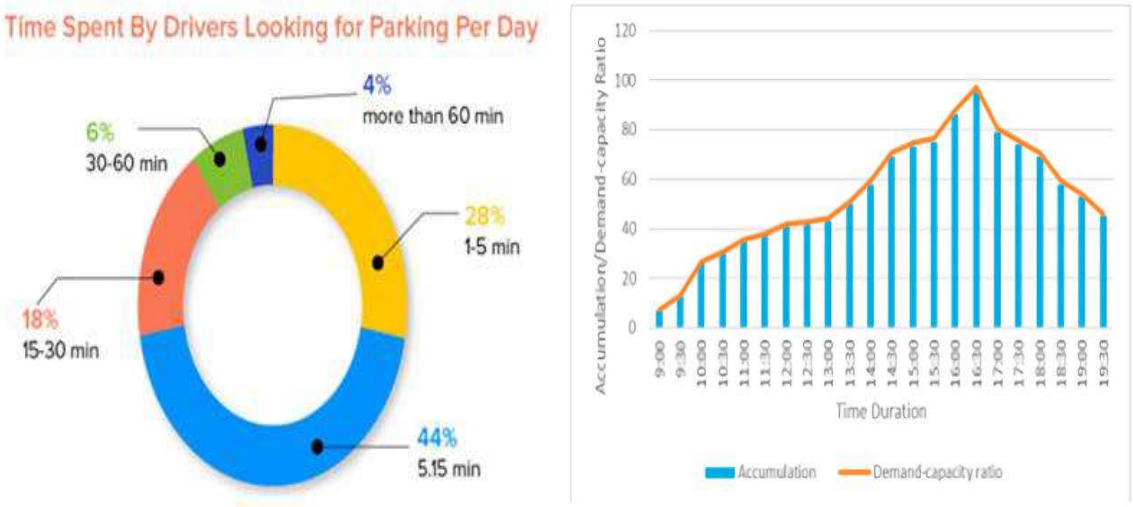


Figure 1. This image shows us the number of times drivers spend in a day looking for parking, this startling number tells us the dire need for innovative parking solutions in the country.



a b

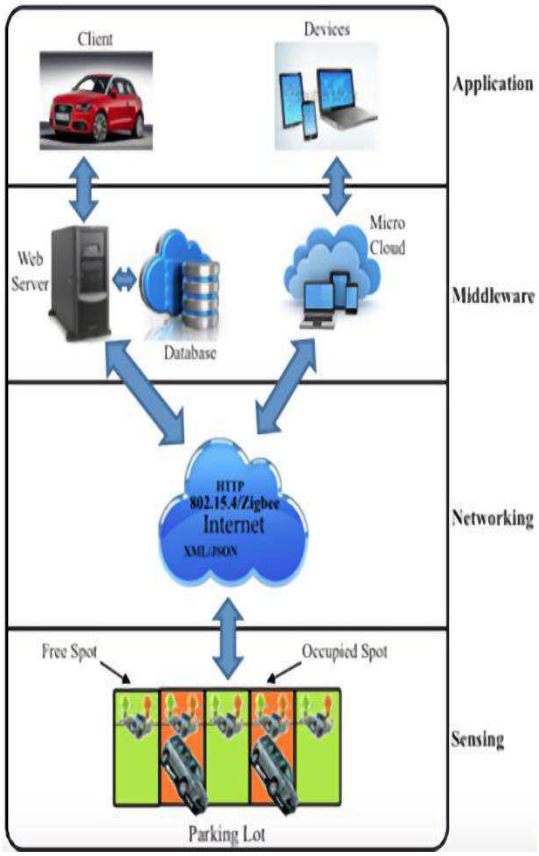
Figure 2. (a) This graph tells us the trend of currently functioning automated parking systems across the globe. (b) Parking accumulation and D/C ratio curve for P1from the experiments conducted in [14] showing the time and accumulation of vehicles.

3

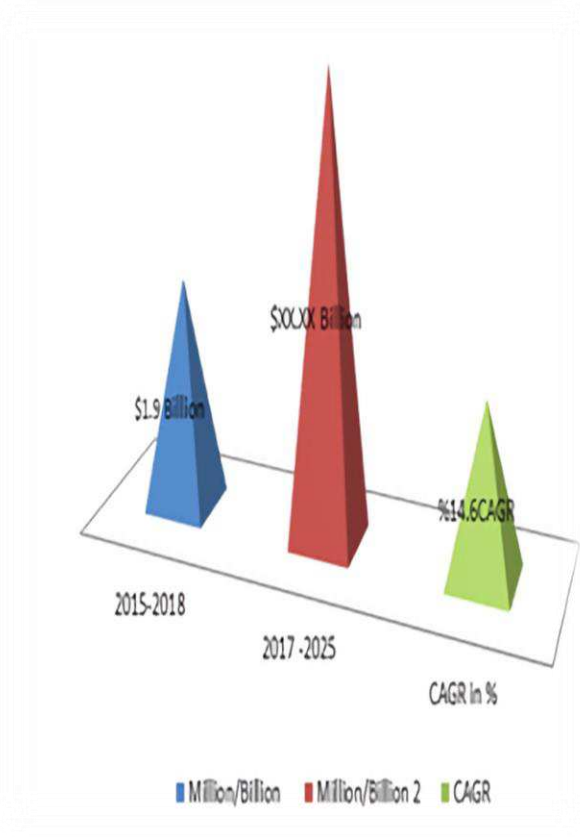
4. SOLUTION ARCHITECTURE

Parking management describes ways for making better use of parking resources. To evaluate feasible parking management solutions, the first step toward effective parking management is to identify the source of parking difficulties affecting residents, business owners, and visitors to determine feasible parking management solutions. The solution aims to provide an effective way of solving the need for smart parking[15]. Combining technologies like Machine Learning, CNN, OpenCV, and ReactJS we hope to a functional app that will notify the requesting users if there is a free parking space near their area.

The footage from the CCTV cameras of parking lots can also help identify the parking and display the parking to the user of the app. The users will be able to prepare themselves beforehand by searching for parking spots in certain areas- thus saving themselves a lot of searching time. The app will also allow the users to keep an eye on their vehicle from a remote location using the camera footage. Thus, the entire system will provide a simple yet effective solution for smart parking combined with the app, sensors find the camera.



3. Parking System potential



4. Expenditure of Applications

Figure 3. Shows the potential market growth for automated parking systems from [16] which proves that our proposed solution also has a positive potential in the commercial markets

Figure 4. Shows the comparison of expenditure different Applications.

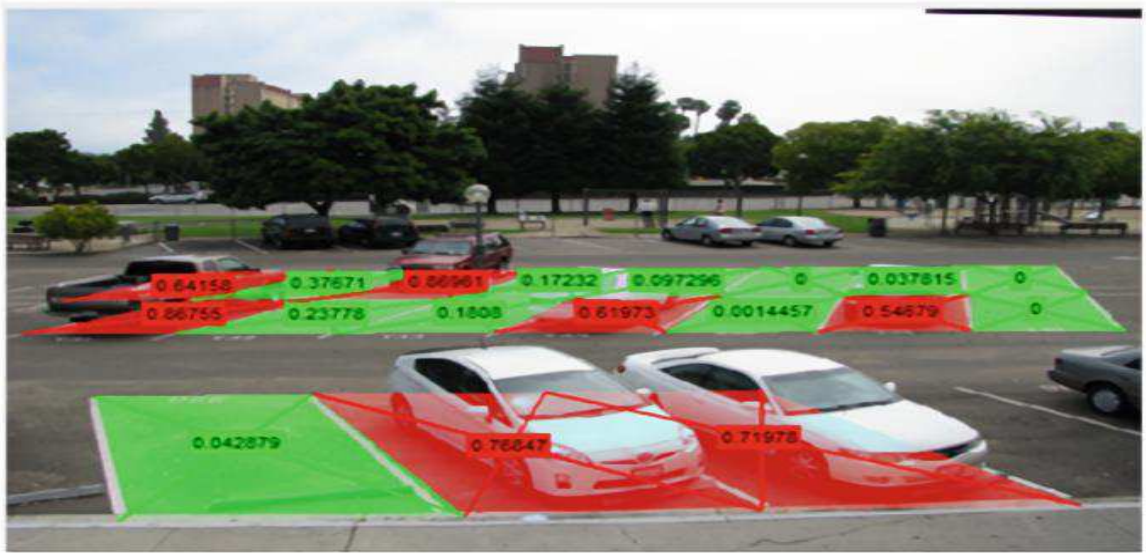


Figure 5. shows how Delibatlov et al. used a Support Vector Machine to integrate human-defined areas using security cameras using vehicle identification.

5. RELATED WORK

All these research papers analyze the different methods proposed for smart parking. We've explored various techniques and technologies like Computer vision and sensors. A smart parking environment has been described in paper [17] via a thorough and careful categorization of its capabilities and issue areas. With the rise in urban population, traffic congestion, and land scarcity, smart parking has become a key problem to work on, not only from a research standpoint but also from a business one.

After a detailed analysis of both pros and cons of these technologies in multidisciplinary fields and analyzing the economic and technical issues, the paper proposes an ecosystem of smart parking. The different Intelligent Parking Services accessible for parking assistance and facility management, and the economics of such efforts, are examined in Paper [18]. Various systems that offer intelligent parking services are explored in this article. These technologies may alleviate parking issues caused by the lack of a dependable, efficient, and contemporary parking system. Other contemporary methods, such as Intelligent Systems, wireless sensor-based, GPS-based, Vehicular communication-based, and Vision-based, may help to solve parking problems.

The paper also proposes that economic analysis of these technologies be done both qualitatively and quantitatively. Economic analysis may be used to reduce risks and increase the efficiency of investments. Economic analysis' purpose is to reduce risks and increase investment efficiency. A parking management system consisting of Arduino hardware and mobile apps is proposed in the paper [19]. There is also a smartphone application that enables users to check public parking availability and book a place. Users may book a parking space for themselves using our smartphone app.

The issues that may occur while using a smart parking system, and the remedies, have been outlined, providing a suitable platform for all users. With the introduction of smart parking systems, people struggling with daily activities will have a better quality of

life. In future works, the paper intends to expand on allowing Smart Parking by providing improved real-time monitoring and management of available parking spaces, which will result in substantial income creation.

This article [20] analyses the most often used kinds of each component and emphasizes use patterns throughout the analysis period, as well as reviewing various works connected to the implementation of smart parking systems. Every section analysis and discusses use trends in terms of sensors, protocols, as well as software solutions[21]. This article establishes a list of complementary characteristics from the kind of components which should be considered when building a smart parking system, in addition to use patterns.

Four specific characteristics should be examined in terms of technical benefits, according to the research: invasiveness, simplicity of installation, sensors per slot, and detecting autonomy. Sensors used to retrieve data in smart parking systems must gather data in real-time and automatically [22]. The emphasis of the study was on smart parking solutions that could be utilised both on and off the street. Furthermore, we want to conduct a comparative study of the efficacy of LPWAN vs. LR-WPAN on Intelligent Parking to provide a formal approach for selecting a sensor based on its technical characteristics and the goal sought.

Various kinds of smart parking systems are discussed in the article. Various algorithms offer different benefits for the systems created; it was discovered. PCA is frequently used to solve the issue of illumination variation in recorded pictures, while SVM is capable of dealing with occlusion. However, more modern methods that use Bayesian probability, such as Huang et al. (2008), are robust enough to address both the occlusion and illumination invariance problems.

A study of all the sensing technologies used during detecting cars, which is one the most essential components of the parking management system, may be used to evaluate the benefits and drawbacks of each sensor technology. The effectiveness of the parking management system in relieving the traffic issue that develops, particularly in urban areas where traffic congestion and inadequate parking spots are evident, can be seen in the many instances of its application given.

In conclusion, majorly the papers have dealt with two factors technical difficulties and economic impact. In most of the five research papers we have observed, sensors, mobile apps, and vision-based solutions have become most efficient. The various advantages of sensors seem to outweigh their disadvantages reasonably enough. Although these have not dealt with exact implementations of these technologies, we are not very far from employing such technologies in our daily lives one day.

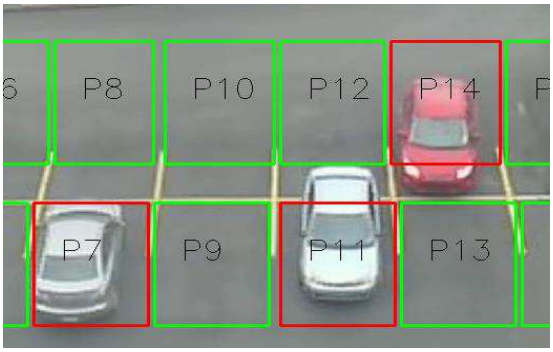
6. OBJECTIVES

The primary aim of this paper is to propose a feasible method of reducing the time, fuel, and space wastage that happens due to the lack of efficient parking methodologies. The conventional methods of parking included employing one security to look over parking lots and most spaces don’t even have assigned parking spots. This leads to massive

congestions in public spaces making traveling tough for pedestrians and vehicles alike. To tackle this issue, we are proposing a smart parking system using technologies like Machine Learning and OpenCV to provide efficient parking spaces.

More effective utilization of available parking spaces can be done by reducing the amount of time you spend looking for a parking spot. By identifying the source of parking difficulties that affect residents, business owners, and visitors to establish feasible parking management solutions. Instead of manually spending hours finding a suitable parking spot for their vehicle, users can use the proposed solution to find parking spots efficiently without having to waste time and fuel[23].

We aim to create a functioning app that will tell requesting users if a free parking space is available near their location, resulting in a more sustainable and effective parking solution utilizing mobile applications for digital payments.



7(a) 7(b)

Figure 7.a. The proposed solution is imagined to function in the way portrayed
Fig. 7.b. This picture depicts a type of output that will count the spaces directly.

7. WORKFLOW OF THE CNN MODEL

The proposed method utilizes the concepts of Python libraries of YAML, NumPy, math, etc, along with the Machine Learning concepts of OpenCV and Color Detection. The CNN model and OpenCV model will be used in combination to identify every parking space and segregate them into categories of occupied and non-occupied.

The CNN model was trained on similar CCTV footage and learned how to identify objects such as cars in parking spaces. The model was pre-trained on Microsoft Azure Cognitive Services Vision library. The Amazon Computer Vision services provide effective tools to easily employ OpenCV and Computer Vision properties on datasets without much hassle and this has proved efficient in our result generation. We have utilized this pre-trained model on top of our training for improved accuracy of results in this proposed solution. The pictures from CCTV footage will be used to calculate the number of free slots and occupied spaces in real-time[24]. The thus calculated values will be displayed real-time in the Flask API which is connected to the Machine Learning backend of the proposed solution. Thus the users will be able to access the real-time data without much hassle. We are in the development of the frontend for the app using React JS, Flutter, etc. This will aid in making the app accessible for customers in a much more efficient way.

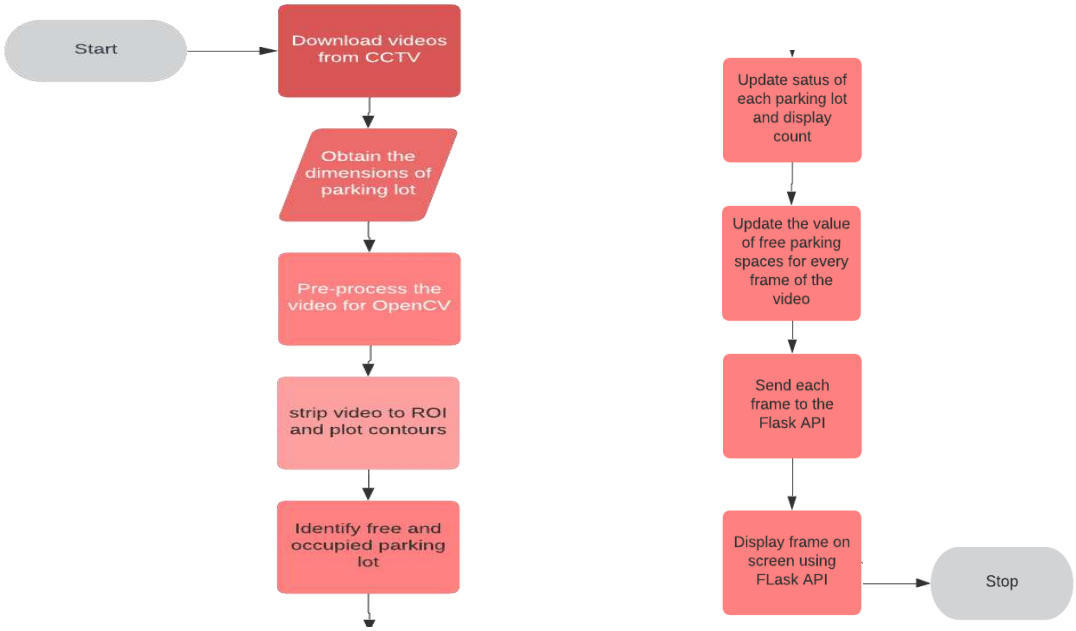


Fig. 8. The image depicts the workflow of the model developed for the proposed solution

8. ALGORITHM OF THE MODEL

1. Get the parking dimensions of the given parking lot from the owners
2. Obtain the live CCTV footage from the parking lot
3. Extract the video using OpenCV in the backend
4. Identify the frame of the video and make it grayscale
5. Subtract additional layers and remove excessive exposure or disturbances
6. Strip the video to its ROI form for better detection
7. Run the trained model's prediction on the video
8. Identify the dimensions using OpenCV and plot the contours of parking spaces
9. Mark the spaces with parked cars with red contours and the free ones with green contours
10. Measure this count and the count from the trained model
11. On identifying a change in status (of parking), update contours and count accordingly.
12. Send the count status of the parking and contours in real-time using OpenCV to the Flask API.
13. Connect the model to a Flask API and display the values in real-time in the localhost.

TECH STACK USED
Python 3.8, OpenCV, Flask API, Yaml Firebase- real-time database, CNN, Microsoft Azure Computer Vision Services, Microsoft Azure Cognitive Services Vision library. HTML, CSS,Jinja.

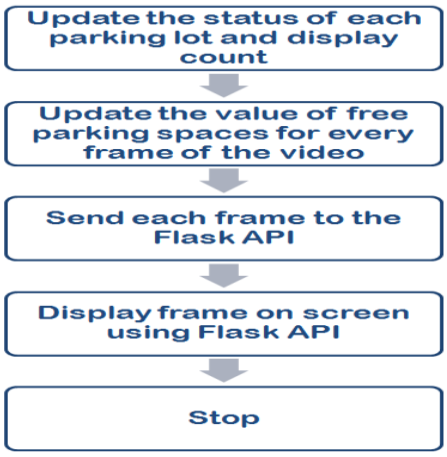


Fig.9.(a)

Fig.9.(b)

Figure 9. a. The image depicts the workflow of the model developed for the proposed solution. Fig. 9.b. This is the output image from the model developed through experimentation,

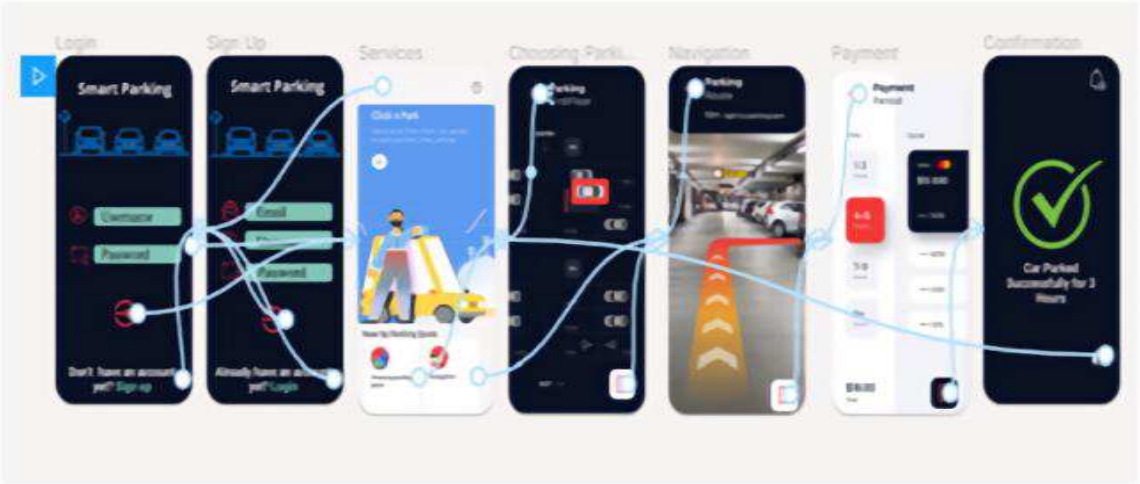


Fig.9.c. The connectivity between the multiple screens in the user app depicts the functioning of the front end of the proposed solution.

8.1 Algorithm for the User Interface

- The user logs in to the app if he already has an account.
- If the user doesn't have an account, he has to sign up.
- After logging in, the user is directed to the Services screen, where he can book parking slots or use the navigation feature.
- Then the user is required to the screen where he can choose to book a convenient parking space. Also, he cannot book a slot that is already occupied by another user.
- Then he is directed to the Navigation screen, which helps the user provide a digital pathway and helps him find his parking slot.
- Once he finds the slot and parks, he is directed to the Payment screen.
- After successful payment, he receives a confirmation from the app confirming his parking was successful.

9

8.2 Modules and Challenges

Learning and understanding how app development works to create a user-friendly interface for the application are one of the top priority challenges. Furthermore, by comprehending and examining the required hardware components for seamless hardware and software integration[25]. For this purpose, our solution is focused on connecting APIs directly which enhances data transfer in real-time more than regular hardware and software connections. Recent trends suggest that in years to come paperless payments have a bigger advantage over the conventional methods of payments[26-29]. The proposed solution is developed based on the concept of supporting contactless payments and developing a payment gateway for the app that makes payments more sophisticated for users[30-34]. Obtaining the live footage and connecting it seamlessly to the OpenCV backend also proves to be a challenge due to the probabilities of connection damages, electrical power loss, and network issues. Obtaining continuous flow of videos.

9. FUTURE WORK

For our future work, we hope to seamlessly integrate the model with sensors by adding sensors to the ML model which will improve the accuracy of the prediction manifold. By adding more learning models to the app to gather data and predict parking and stagnant vehicles traffic (or congestion rates). Deploying the Flask API into a cloud-based service to connect to the backend for real-time data connectivity. Also, connecting the Machine Learning model's Flask API to an App backend and developing connectivity between the multiple screens of the app and the backend to display real-time output.

References

1. Lin, Trista & Rivano, Herve & Le Mouël, Frédéric. (2017). A Survey of Smart Parking Solutions. IEEE Transactions on Intelligent Transportation Systems. 18. 3229 - 3253. 10.1109/TITS.2017.2685143.
2. Faheem, S.A. Mahmud, G.M. Khan, M. Rahman, H. Zafar, A Survey of Intelligent Car Parking System, Journal of Applied Research and Technology, Volume 11, Issue 5, 2013,Pages 714-726,ISSN 1665-6423, https://doi.org/10.1016/S1665-6423(13)71580-3.
3. Anusha, Arshitha M S, Anushri, Geetanjali bishtannavar, Review Paper on Smart Parking System, International Journal of Engineering Research & Technology (IJERT), Volume 7 Issue 08
4. https://www.researchgate.net/publication/336900900_Mathe matical_modelling_of_the_spatial_efficiency_of_car_parks
5. https://blog.getmyparking.com/2019/02/14/issues-with-parking-in-indian-metropolises/
6. M.Y.I. Idris, Y.Y. Leng, E.M. Tamil, N.M. Noor and Z. Razak, 2009. Car Park System: A Review of Smart Parking System and its Technology. Information Technology Journal, 8: 101-113.

10

7. https://github.com/ketanchoyal/theParker-iOS
8. https://www.happiestminds.com/Insights/smart-parking/#:~:text=Smart%20Parking%20solutions%20are%20designed,the %20smart%20parking%20service%20providers.
9. Nyambal, J., & Klein, R. (2017). Automated parking space detection using convolutional neural networks. 2017 Pattern Recognition Association of South Africa and Robotics and Mechatronics (PRASA-RobMech). doi:10.1109/Robotech.2017.826111
10. Chester, M., Fraser, A., Matute, J., Flower, C., & Pendyala, R. (2015). Parking Infrastructure: A Constraint on or Opportunity for Urban Redevelopment? A Study of Los Angeles County Parking Supply and Growth. Journal of the American Planning Association, 81(4), 268–286. doi:10.1080/01944363.2015.1092879
11. Parmar, J., Das, P., Azad, F., Dave, S. and Kumar, R., 2020. Evaluation of Parking Characteristics: A case study of Delhi. Transportation Research Procedia, 48, pp.2744-2756.
12. Diaz Ogás, M.G.; Fabregat, R.; Aciar, S. Survey of Smart Parking Systems. Appl. Sci. 2020, 10, 3872. https://doi.org/10.3390/app10113872
13. https://github.com/kambleaa007/smartparking
14. Bagula, A., Castelli, L., & Zennaro, M. (2015). On the Design of Smart Parking Networks in the Smart Cities: An Optimal Sensor Placement Model. Sensors, 15(7), 15443–15467. doi:10.3390/s150715443
15. https://github.com/luispaulot/DetectParking
16. https://www.veraciousstatisticsresearch.com/research-study/automated-parking-system-market/
17. https://github.com/HarshiniR4/Car-Parking-System-using-OpenCV
18. https://github.com/Shobhit70/SmartParkingSystem.
19. Regester, A., & Paruchuri, V. (2019). Using Computer Vision Techniques for Parking Space Detection in Aerial Imagery. Urban Water Management for Future Cities, 190–204. doi:10.1007/978-3-030-17798-0_17
20. https://github.com/eladj/detectParking
21. Delibaltov, D., Wu, W., Loce, R.P., Bernal, E.A.: Parking lot occupancy determination from lamp-post camera images. In: 2013 16th International IEEE Conference on Intelligent Transportation Systems-(ITSC), pp. 2387–2392. IEEE (2013)
22. https://github.com/GustavoDuregger/SmartParking-AI
23. Thai-Nghe, Nguyen & Nguyen, Chi-Ngon. (2014). An Approach for Building an Intelligent Parking Support System. 10.1145/2676585.2676594.
24. Bulan, O., Loce, R. P., Wu, W., Wang, Y., Bernal, E. A., & Fan, Z. (2013). Video-based real-time on-street parking occupancy detection system. Journal of Electronic Imaging, 22(4), 041109. doi:10.1117/1.jei.22.4.041109.
25. V.Megala and C.Pugazhendhi Sugumaran, "Application of PI/MWCNT Nanocomposite for AC Corona Discharge Reduction," in IEEE Transactions on Plasma Science, vol. 47, no. 1, pp. 680-687, Jan. 2019, DOI: 0.1109/TPS.2018.2877581.
26. V. Megala and C.P. Sugumaran, "Effect of Radio Interference in 765kV Zebra conductor with different bundle configurations," 2017 International Conference on Nascent Technologies in Engineering (ICNTE), Navi Mumbai, 2017, pp. 1-6, DOI: 10.1109/ICNTE.2017.7947923.[16] V. Megala and C. Pugazhendhi Sugumaran,

"Enhancement of Corona Onset Voltage Using PI/MWCNT Nanocomposite on HV Conductor," in IEEE Transactions on Plasma Science, vol. 48, no. 4, pp. 1122-1129, April 2020, DOI: 10.1109/TPS.2020.2979843.

27. Karpagam, G.K. Sathishkumar, V. Megala, J. Lydia, N. Priya, T. Abhishek Dheeven, Solid-state switching using a wireless network in home automation, Materials Today: Proceedings,2021, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2021.02.630.
28. V. Megala, R. Karpagam, G.K. Sathishkumar, B. Gopinath, P. Marish Kumar, M. Deva Brindha, Investigation on corona performance of conductors using fabricated indoor corona cage, Materials Today: Proceedings,2020, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2020.10.682.
29. T. Naga Swathi and Dr. M.K Jayanthi (2012), VIT University, India. Survey on High-Performance Multiprocessor System on Chips. International Journal of Computer Applications 46(24):13-16, May 2012. Published by Foundation of Computer Science, New York, USA.
30. Saha, T.K., Knaus, T.N., Khosla, A. et al. A CPW-fed flexible UWB antenna for IoT applications. Microsyst Technol (2018). https://doi.org/10.1007/s00542-018-4260-031
31. Van Neste, C. W., Thomas Thundat, Ajit Khosla, Sarah Szanton, and Larry A. Nagahara. "Perspective—Maintaining the Quality of Life in Depopulating Communities:Expanding Smart Sensing via a Novel Power Supply." Journal of The Electrochemical Society 167, no. 3 (2020): 037564. https://doi.org/10.1149/1945-7111/ab729d
32. A. Khosla and B. L. Gray "Fabrication of multiwalled carbon nanotube polydimethylsiloxne nanocomposite polymer flexible microelectrodes for microfluidics and MEMS", Proc. SPIE 7642, Electroactive Polymer Actuators and Devices (EAPAD) 2010, 76421V (9 April 2010); https://doi.org/10.1117/12.847292
33. Khosla, Ajit. Micropatternable multifunctional nanocomposite polymers for flexible soft MEMS applications. Diss. Applied Science: School of Engineering Science, 2011. http://summit.sfu.ca/item/12017
34. Khosla, Ajit, and Bonnie L. Gray. "Micropatternable multifunctional nanocomposite polymers for flexible soft NEMS and MEMS applications." ECS Transactions 45.3 (2012): 477. https://doi.org/10.1149/1.3700913