CNN-Based Smart Parking System

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Abstract—Due to the increased number of cars, outdoor parking is one of the critical problems. Moreover, the management of the parking system is also considered a difficult task. Humans, on the other hand, were acclimated to efficiently parking their automobiles by providing them with the precise location of parking in advance of their arrival. As a result of human inefficiency, it was unsuccessful and ultimately increased the compliance cost. As a result of the development of the notion of the Internet of Things. A lot of systems were installed regarding smart parking systems that are decreasing the cost but also contain a huge impact on the reduction of emissions from cars. While it is possible to integrate Internet of Things (IoT) devices into automobiles, such an approach will necessitates the deployment of additional infrastructure, which will raise the cost, and also it is not feasible within current infrastructure configurations. Then there's the fact that CCTV technology is widely available and also small enough to fit into any parking area without being noticeable. In this paper, Convolution Neural Network (CNN) based smart parking system is designed and implemented. The CNN is used to detect vacant and occupied parking spaces through CCTV cameras and provide feedback to the passengers. Furthermore, the proposed approach is using CNR and PKLot datasets for ensuring the effectiveness of the model. This was developed to solve the issues of time, cost, and accuracy with the existing systems. As a result, the proposed model provides excellent results in terms of accuracy. Moreover, it is cost-effective and saves time.

Keywords—CNN, CNR and PKlot, IoT, CCTV, IoT devices

1 Introduction

As the level of technology has increased, the concept of the internet of things has gained attention from researchers. Therefore, the systems are replaced with smart devices. These smart devices can analyze and process information so smart decisions can be made. The advancement of IoT has impacted all fields of life and also smoothened various processes like irrigation, drainage, and smart cities. From this, one of the important applications of IoT is a smart parking system [1]. Through this system, the passengers can park their cars smartly without human labor efforts. From this, various approaches are used that are moving toward smart parking systems and providing information to the drivers. Therefore, it will become possible for them to park their cars efficiently and increase the efficiency of the parking system [2]. Smart parking systems also help drivers by giving them information through smart devices like smartphones and tablets [3].

Furthermore, it is considered one of the main concerns of the urban transportation system because on-street parking is limited. Therefore, when parking space is limited then it will become difficult for the person to find out the exact parking space. For solving this, there is a need for such a system that will provide vacant space in the parking lot information to the passenger. By using this information, the users can easily park their car, and at the same time, they will save time and cost. Moreover, in peak hours, one common phenomenon is used called cruising for parking. This phenomenon is applied in areas where the population level is high and requires a reliable parking system. Furthermore, there are a lot of advantages to a smart parking system. Some of them are allowing smooth traffic flow on the roads and also increasing the efficiency of the parking system. The main concept of the parking system is executed by using various approaches [4].

In the existing parking system, the main issues that concern are accuracy and cost [5]. The fact is that many sensor-based systems are using IoT technology for collecting information about parking and providing info related to slots available. Moreover, implementing such systems in existing places will implicit construction work and increases the cost of installing sensors. The cost of the sensors is about 200-400 dollars [6]. For this reason, there is a need for factual and concise abstract that is based on the CNN in parking systems [7]. It means that if vision-based detectors are used in parking systems, then it will be cost-effective [8]. Its installation is also simple and requires no shutdowns. Each visual node of the system consists of a camera and one transmitter that is monitoring tons of vehicles. This parking system will decrease the cost [9].

Moreover, it is used for various purposes too like surveillance. It shows that the visual nodes contain no physically engaged element and they require zero maintenance [10].

Despite all of these advantages, visual systems are not still used in the industry. The major problem includes various parameters affecting it like camera resolution, light intensity, and bad weather. Due to this, the current research is related to CNN technology [11].

CNN is a type of deep learning where an algorithm is used on visual data like images. It works by the principle of all putting weights on the properties of image considering its features and can be categorized by it, therefore, it become convenient algorithm for classification problems. Similar to other deep learning models CNN contains multiple layers, input layer, output layer, and many hidden layers present between these two layers lay. Because of the multi-layer feature in the CNN processing it provide higher efficiency than other traditional algorithms [12]. Additionally, Hybrid CNN with LSTM models are also widely used in different fields but applied also in smart Parking systems [30]. Sentiment analysis to predict positivity and negativity of a given subject is still a common method in NLP tasks but it may be applied in smart parking systems [31].

This paper presents a CNN-based smart parking system to overcome the problems associated with the existing parking system. The CNN is used to detect empty and filled parking spots. Therefore, the reliability of the system will be tested with the use of large labeled open access dataset. Moreover, for evaluating the practicality of the approach, a whole system will be developed [13]. Additionally, a pipeline process to facilitate applying this system in the real world is presented [14]. This paper contains four sections. The first section includes the background and related work of this research. The second one shows the required methodology used for conducting this research. The third section will discuss the required results of the research in detail. The last section will discuss the conclusion and future work on this technology [37].

2 Related work

The researchers had worked on the parking systems in the past. From this, the first system introduced by them is regarding parking guidance and information. According to this, required efforts are made to improve the PGI system. These efforts are categorized by different categories and they are Detection, presentation, and optimization [14]. For providing information regarding vacant spaces in the parking system, a lot of sensors are used. For single-stall detection, ultrasonic sensors are used. Camera visual accessibility and edge processing units encouraged researchers to implement visual feedback systems to detect vacant spaces [16] [17]. For conducting this research, a large number of datasets are collected, images are taken from parking lots, and also learning algorithms are applied for detecting vacant spaces [18]. Furthermore, variable message sign was considered a traditional habit for showing to drivers vacant parking lots. These guidance signs are placed in vital locations like intersections and streets to show free spaces to drivers in the nearby parking. One of the important drawbacks of this approach is the lack of obtaining data about vacant spaces. On the other hand, the presentation method is leveraging the web to distribute their data. From this, the industrialized example of this approach is the street line [19] [20]. For vacant parking spaces, some researchers also introduced optimization methods that provide drivers information about empty parking lots based on three methods, that is pre-defined and customer-defined methods like the nearest available lot [21] [22]. Moreover, some researchers had also worked on the convolutional neural networks. For this purpose, some handcrafted feature combinations like SIFT, BRISK, and ORB are used to detect and recognize tasks. So, Visual PGI is being used to bring a lot of new research findings to a lot of different things. There have been some big changes in computer vision recently, though [23]. Deep learning and other things have been shown to work. It has increased the traditional state-of-the-art system. Due to the introduction of deep learning, object recognition is improved and also contains some accurate models [23]. For this purpose, a convolutional neural network is an advanced form of a regular artificial neural network. The main difference between them is related to both convolutional and pooling layers in CNN models [4]. Therefore, the values in the hidden layers in the CNN are considered linear transformation of the previous parameters with ANN. According to this, the required value is regarding a three-dimensional filter that contains information about the previous layer. It shows that the pooling layer of CNN is the largest spatial response filter that is showing the largest values in a specific region. The main problem of this research is that it lacks vision modes in it [15].

From these two innovative layers, CNN is more advanced technology than ANN, and deeply learned filters in convolutional layers are present. From these facts, the size of the filter is not commensurate with the spatial size of the feature map [25]. On the other hand, it is shrinking the search space for every layer of the system. Moreover, it can be noted that the pooling layers are involved in reducing the spatial size of its input through assumption. These assumptions are related to the close features of the image that is representing true for all images [22]. On the other hand, it is also making the system less sensitive to the supplied image's translation. From these there are numerous networks that have been developed and trained on a sizable dataset for image recognition applications. And only small percentages of datasets are successful [11].

CNN have recently demonstrated excellent performance in the field of computer vision. Zhang W. et al. (2019) considered CNN Mini Parking Model and the VGG Extended Model. Testing is carried out to assess the timing and recognition precision. The proposed Mini Parking CNN Model performs admirably and aids users in precisely and successfully locating vacant parking places. [27]. According to research in [28], authors have introduced two systems for classifying parking lots. After converting the colored image to grayscale and then to black/white, the first technique uses the mean. It is categorized as occupied if the mean is higher than a specific threshold; otherwise, it is empty. On the Cnrall database, this approach reported a 90 percent accuracy rate, which overcome the traditional methods and has no training time. A deep learning neural network of 11 layers, trained and tested on the same database, is the second method, which relies on deep learning. When evaluated on the same database and trained on Cnrall, it had a 93 percent accuracy rate. A camera-based smart parking system is offered by the authors of [29]. They suggested a low-complexity deep neural network (DNN) architecture-based computer vision-based smart parking lot occupancy detection system. The PKLot-Val dataset was used by the authors, and the PKLot-Test and SWUPark datasets were used to evaluate the model's performance [38]. A reduced-complexity deep neural network model is used in a smart camera system that uses a Raspberry Pi 3 coupled to a camera to find open locations. In the context of this research, this method achieved 88 percent accuracy over the PKLot-Test dataset after extensive hyper parameter tuning and stochastic gradient descent (SGD) optimization [39].

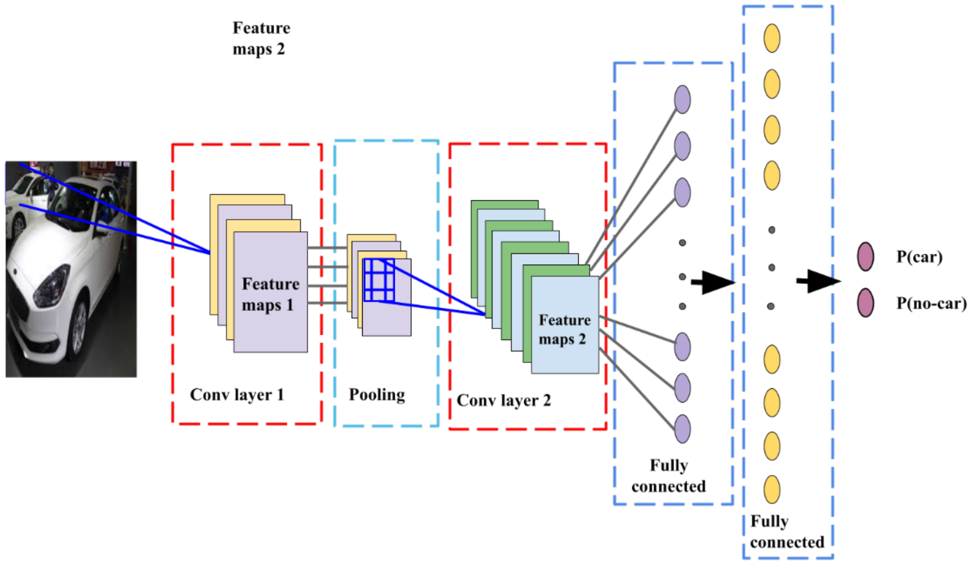

Fig. 1. General overview of the deep neural network by using convolutional and pooling layer

3 CNN

Convolutional Neural Networks (CNNs) have become an effective tool for computer vision and image identification applications. In order to effectively categorize photos into multiple categories, CNNs are built to automatically learn hierarchical representations of characteristics in input images [33]-[34].

Layers of different kinds, including as convolutional layers, pooling layers, and fully-connected layers, frequently make up the architecture of a CNN. The input picture is subjected to a series of filters, or kernels, using convolutional layers. These kernels glide across the image and carry out a dot product with the pixel values in each window. A feature map that depicts the activation of that filter at each location in the input picture is produced by this technique. The spatial dimensions of the feature maps are reduced using pooling layers, and the final output classification is produced by fully linked layers using the preceding layer's output that has been flattened [35].

CNNs have been demonstrated to perform at the cutting edge on a number of computer vision tasks, including object identification, detection, and segmentation. They have also been used in other fields, such audio analysis and natural language processing. Moreover, more complicated CNN designs like ResNet and DenseNet, which can learn more effective and reliable representations of features, have been developed as a result of recent advancements in deep learning [36].

CNNs do, however, have certain drawbacks, including a high computational cost and the requirement for a substantial amount of labeled training data. Also, it might be difficult to comprehend the learnt features in CNNs since they sometimes include intricate combinations of pixel values that may not have a clear semantic meaning.

In conclusion, CNNs have transformed computer vision and provide great potential for a variety of applications. We may anticipate future advancements in CNN performance and interpretability, as well as its application to new domains and applications, as deep learning research advances.

4 Method

The proposed system of this research contains three important parts. The first part has consisted of visual nodes that are cameras, and local wireless links connect them to the server network and the internet. The second part is the server. The whole server contains a detection module, database, event handler, and web service. From this, the server is involved in collecting images through visual nodes and then them to the detection module, which will gather data and output, and store it in the necessary database. After this, the whole system provides a web service for front-end apps so that real data from a database may be accessed. The front end that displays parking lot vacancies to users is the third component [22]. The main components of the system include visual nodes, servers, a detection module, and datasets. All of these components are important in the experiment of the parking lot smart system [40].

4.1 Visual nodes

According to this, high-resolution, color cameras are used as visual nodes for this project. Moreover, another choice like microwave radar is also used. When it comes to parking management, cameras are the most cost-effective and scalable choice because they require little maintenance, are inexpensive, and are simple to scale. One disadvantage of utilizing it, though, is that the raw photos that it produces are not very good quality, which is a shame. These images are quite sensitive to the weather, and their appearance changes as the weather changes, as illustrated in the example below. Therefore, some camera parameters and points of view will be mentioned in detail. In-camera parameters, there is camera intrinsic parameter, imaging frequency, image size, and low-level filtering. All of these parameters are present drastically between each manufacturer and camera model. Moreover, the point of view of the camera is affected when it is installed. On the other hand, restricting the camera to some specification is practically possible. For this purpose, the parking owners present at the various location has to decide the main camera type that is according to their spending plan. Furthermore, the point of view of the camera depends on the parking structure as well as its installation [26]. Therefore, the required constraints selected for our visual nodes are given below

- Visually block all stalls of interest to the camera.
- The output from the camera must be delivered upon request of the server.

All of these expectations are also achievable in practice. From this, the visibility of stalls can be used for various other purposes like surveillance systems. On the other hand, the second constraint is regarding the standard and applied for all digital cameras in which embedded flash memory is present that is taking images according to request. For this, publicly available IP cameras will be installed in parking lots for conducting this experiment [19].

4.2 Server

The required server has to fulfill four important responsibilities. The first important responsibility is that the server must host the database, so that this system uses a relational database is used in this system. The required database will store separate tables regarding parking lots and The table's elements all display stalls. Moreover, every stall has four required fields. The first field is about stall number It is the only match in the parking lot. The second one is bounding box coordinates for stall. With the help of an administrator, these coordinates are entered into a GUI. The third field is about image blob. It will take the picture of the stall that has been cut from the live video stream. Additionally, the server will update it at various predetermined intervals. The last field is regarding status. The status is a binary value that is showing information regarding empty or filled spaces. It is updated via the server from the outcome of the detecting technique [22].

Furthermore, The following duty involves gathering camera data. Through a local network and the internet, these cameras are linked to the server. Furthermore, local communication protocol will be utilized if cameras are not using the HTTP protocol. Therefore, required responses will be taken from HTTP. Furthermore, There is no need to if the cameras are connected to the internet. install a visual node close to the server[15].

The third responsibility is regarding serving a web service. It maintains a bridge with the front end of the system. Its main job is to find out what's going on with each parking lot. After this, all information is taken from the visual nodes and moved toward the detection module with bounding boxes [11].

4.3 Detection module

This component is in charge of showing information regarding the parking space's state of occupancy by providing an image of the stall. For this CNN will be used. It contains The input data is subject to little restrictions, which places great load on the detecting system. As long as the technique is robust enough, it is critical to do it right the first time. As a result, it is critical to select the most appropriate training method and the most appropriate network. Another point to mention is that the network has been designed in compliance with VGGNet-F. Each convolutional layer in this network is preceded by a rectified relu activation function and a pooling layer, and the network as a whole has five convolutional layers. Also, it contains fully connected layers [11].

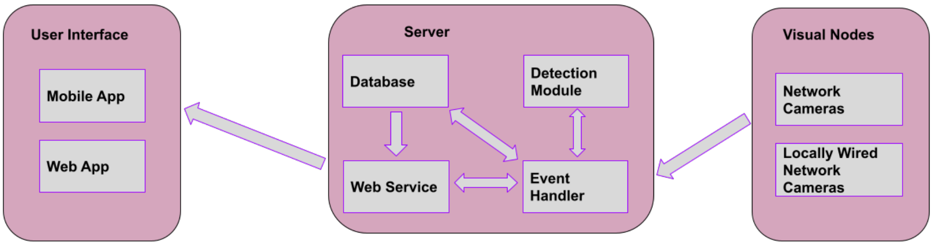

Fig. 2. System Architecture

Here, the system's considered necessary architecture is shown. It has three parts: the graphical user, the server, and the aesthetic nodes, which are all parts of the whole[41].

4.4 Datasets

PKLot is providing us with the information we require. We'll go collect it from the parking lot area, no problem. Furthermore, the results of this investigation will be revealed through the use of this information. The dataset consists of various images taken from CCTV cameras and then sent to the server and arranged in the dataset of the system. All of these images will be analysed properly to show the occupancy level in the parking area. Table 1. describes the da0taset and train/test split:

Table 1. Dataset summary

Total Samples	Training	Testing
12,417 images	80% (9933 samples)	20% (2448 samples)

4.5 Model development

Two models are developed to conduct our experiment a Model based on AlexNet model and mAlexNet model with different datasets to proof model effectiveness. The used model with the system is AlexNet-based model. The model consists of 5 Conv2D layers to train the data Table 2. shows a summary of the model layers.

Table 2. Model Summary

Layer	Parameter	Value
Conv2D	Kernal size	11
	Stride	4
	Padding	2
	Activation	Relu
MaxPool2D	Kernel Size	3
	Stride	2
Conv2D	Kernal Size	5
	Padding	2

Layer	Parameter	Value
	Activation	Relu
MaxPool2D	Kernal Size	3
	Stride	2
Conv2D	Kernal Size	3
	Padding	1
	Activation	Relu
Conv2D	Kernel Size	3
	Padding	1
	Activation	Relu
Conv2D	Kernal Size	3
	Padding	1
	Activation	Relu
MaxPool2D	Kernal Size	3
	Stride	2
Dropout	Liniar	256*6*6,4096
	Activation	Relu
Dropout	Linear	4096,4096
	Activation	Relu
	Linear	4096, Number of Classes

The input to the model is pre-processed normalized images of parking lots from the dataset. The classification for each image is either empty or occupied. Then the levels of occupied parking lots are calculated based on the total classification report. In this experiments two different dataset are tested to validate the effectiveness of the model (as mentioned earlier).

5 Results and discussion

From this, the results are showing some positive results about the given system. The experimental results will be used to compare with the required system. According to this, the dataset that will be used in this experiment is followed by the training method and hyperparameters. For showing the required results, By using the approach, three sets of experiments are shown. The method is used to present experiments. Therefore, it will become possible to compare against their baseline classifier.

The first one is regarding single parking lot testing and training. According to this, the network will be trained on the subset of PUC, UFPRO4, and UFPRO5 and tested with the testing dataset. In this phase the model training will determine the effectiveness of the model using accuracy method. Furthermore, the images at this phase are clear and clean which would be easily detected by the model. Whereas in other steps sometimes the images were in different weather conditions like foggy, cloudy and rainy. However the results would represent the overall accuracy of the model.

The second one is testing of a single and several parking lots will be performed in which the network is tested on various parking lots as well as trained using the training subset. The specific experiment's goal is to determine if the network is sufficiently broad to categorize parking lots correctly. In this phase, the detection of empty lots is examined to measure the effectiveness in calculating empty lots on lower resolution images.

The third one is regarding multiple parking lot testing and training. In this, the network will be trained for all training subsets. This experiment is showing how the required network is managed with the variability for testing subsets. The results are showing that the accuracy of the model is about 97% and it is high and also satisfactory to be implemented in the parking lots [26]. Figure 3 presents brief results comparison between the proposed models on different datasets.

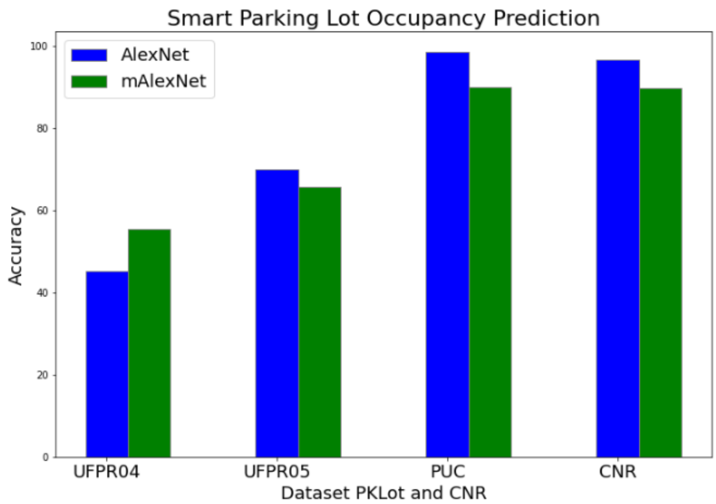

Fig. 3. Occupancy predictions comparison models on datasets

The Figure 4 is showing information from the vision mode about the parking lot. Observe that the purple borderline shows where the occupied parking spaces are in the parking lot. The yellow borderline shows where the empty parking spaces are. Moreover, the CNN method is applied to gain these results.

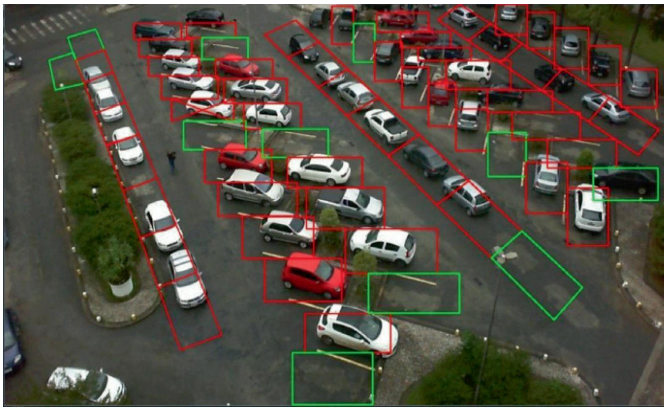

Fig. 4. CNN method applied for identifying vacant and occupied parking spaces

The Figure 5 is showing the information about the vacant spaces present in the parking lot. The main reason behind this is that the visual mode is showing a yellow border and which means that there is no car is present in the parking area. Detecting empty lots would assist to real time reporting with actual data on the available parking lots.

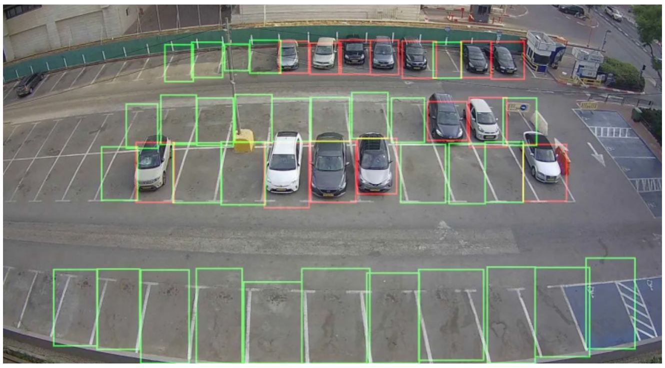

Fig. 5. Visual nodes showing vacant parking spaces

The Figure 6, there is proper information about the occupied spaces in the parking lot. The fact is that all cars are covered with a purple border. Therefore, all parking spaces are occupied. For this purpose, the top image is taken about the parking lot. With this detection a count is done in the background and subtracted from the total to easily identify the remaining number.

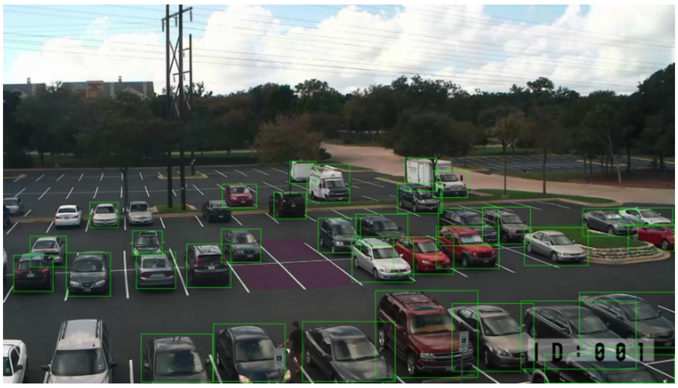

Fig. 6. The visual node showing occupied spaces in the parking lot

The Figure 7 is again showing the same information but this time the side visual node angle is selected to show the information about the parking lot. Here, the digitalized numbering of open space lots is generated based on the cars detected by the model to easily identify empty lots after the cars move and disappear from the detection.

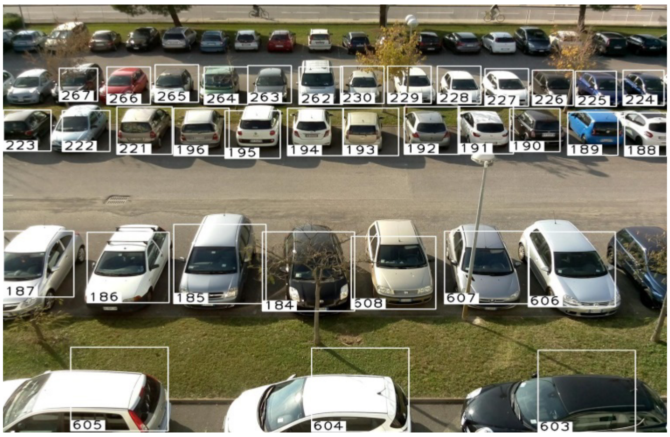

Fig. 7. The side visual node shows information about the occupied parking spaces

The potential to commercialize this solution is high; however, there are some limitations. The main limitation is the Field of View on the CCTV, for open spaces far lots won't be detected unless they become on the center of the camera view. The challenge in open spaces it would require more cameras in all positions so that each available space would be in the center of camera view.

6 Conclusion

Summing up all the discussions from above, it is concluded that the CNN network is showing positive results. For this purpose, a complete novel parking system is designed and implemented. The required system is using a convolutional neural network used for stalls and status detection in the parking lots. Moreover, the required model is designed and trained in the images taken from the PKlot dataset. From this dataset, required experiments are performed.

7 Acknowledgments

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8 References

[1] S. Valipour and E. S. a. M. J. Mennatullah Siam, "Parking-stall vacancy indicator system, based on deep convolutional neural networks," In 2016 IEEE 3rd World Forum on Internet of Things (WF-IoT), 2016. https://doi.org/10.1109/WF-IoT.2016.7845408

[2] X. Xie and S. C. G. S. a. Z. Z. Chenye Wang, "Real-time illegal parking detection system based on deep learning," In Proceedings of the 2017 International Conference on Deep Learning Technologies, 2017. https://doi.org/10.1145/3094243.3094261

[3] J. Cai and M. S. K. a. M. U. A. Jianhua Deng, "Vehicle classification based on deep convolutional neural networks model for traffic surveillance systems," In 2018 15th International Computer Conference on Wavelet Active Media Technology and Information Processing (ICCWAMTIP), 2018.

[4] Y. Guo and H. Shi, "Automatic parking system based on improved neural network algorithm and intelligent image analysis," Computational Intelligence and Neuroscience 2021, 2021. https://doi.org/10.1155/2021/4391864

[5] N. D. C. Shoup, "The High Cost of Free Parking," Chicago & Washington: Planners Press, 2005.

[6] Y.-D. Kim and S. Y. T. C. L. Y. a. D. S. Eunhyeok Park, "Compression of deep convolutional neural networks for fast and low power mobile applications.," arXiv preprint arXiv:1511.06530, 2015.

[7] W. Zhang, J. Yan and C. Yu, "Smart parking system based on convolutional neural network models," In 2019 6th International Conference on Information Science and Control Engineering (ICISCE), pp. 561-566, 2019. https://doi.org/10.1109/ICISCE48695.2019.00118

[8] L. Baroffio, L. and Bondi, M. and Cesana, A. E. and Redondi and M. and Tagliasacchi, "A visual sensor network for parking lot occupancy detection in smart cities," in 2015 IEEE 2nd World Forum on Internet of Things (WF-IoT), IEEE, 2015, pp. 745--750. https://doi.org/10.1109/WF-IoT.2015.7389147

[9] J. Hendryli and D. E. Herwindiati, "Automatic license plate recognition for parking system using convolutional neural networks," In 2020 International Conference on Information Management and Technology (ICIMTech), 2020.

[10] Z. Suryady, G. R. and Sinniah, S. and Haseeb, M. T. and Siddique and M. F. M. and Ezani, "Rapid development of smart parking system with cloud-based platforms," in The 5th International Conference on Information and Communication Technology for The Muslim World (ICT4M), IEEE, 2014, pp. 1--6. https://doi.org/10.1109/ICT4M.2014.7020616
[11] Z. Chen and J. L. J. Z. Y. D. W. H. a. C. L. Zijun Gao, "Parking Space Recognition Based on Deep Convolutional Neural Network," 2021.
[12] Swasthi B S, Anagha R, Arpitha S, Sanjay B S, and Harshitha K, "Parking Assist using Convolution Neural Networks," International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958 (Online), Volume-9 Issue-6, August 2020.
[13] T. Thomas and T. Bhatt., "Smart Car Parking System Using Convolutional Neural Network," In 2018 International Conference on Inventive Research in Computing Applications, 2018. https://doi.org/10.1109/ICIRCA.2018.8597227
[14] Y. Wen, X. and Yang and Y. and Xu, "Cloud-computing-based framework for multi-camera topology inference in smart city sensing system," in Proceedings of the 2010 ACM multimedia workshop on Mobile cloud media computing, 2010, pp. 65--70. https://doi.org/10.1145/1877953.1877971
[15] K. Gkolias and E. I. Vlahogianni, "Convolutional neural networks for on-street parking space detection in urban networks," IEEE Transactions on Intelligent Transportation Systems, 2018. https://doi.org/10.1109/TITS.2018.2882439
[16] Vera-Gomez, J. A. a. Quesada-Arencibia, A. a. Garc'ia, C. R. a. S. Moreno, R. a. G. Hern'andez and Fernando, "An intelligent parking management system for urban areas," Sensors, vol. 16, no. 6, p. 931, 2016. https://doi.org/10.3390/s16060931
[17] P. Agrawal, Y. P. Akash Patole and P. Kaur, "Automated Car Parking System Using Deep Convolutional Neural Networks," In ICDSMLA 2020, 2022. https://doi.org/10.1007/978-981-16-3690-5_19
[18] G. Satyanath and a. R. K. R. Jajati Keshari Sahoo, "Smart Parking Space Detection under Hazy conditions using Convolutional Neural Networks: A Novel Approach," arXiv preprint arXiv:2201.05858, 2022. https://doi.org/10.1007/s11042-022-13958-x
[19] W.-b. GONG, Zhang-song SHI and J. I. Qiang, "Non-Segmented Chinese license plate recognition algorithm based on Deep Neural Networks," In 2020 Chinese Control And Decision Conference (CCDC),, 2020. https://doi.org/10.1109/CCDC49329.2020.9163986
[20] L. a. Mainetti, L. a. Palano, L. a. Patrono, M. L. Stefanizzi and R. and Vergallo, "Integration of RFID and WSN technologies in a Smart Parking System," in 2014 22nd International Conference on Software, Telecommunications and Computer Networks (SoftCOM), IEEE, 2014, pp. 104--110. https://doi.org/10.1109/SOFTCOM.2014.7039099
[21] A. P. V. a. M. F. I. Varatharajan, "Cloud-based smart parking system using embedded sensors and sshort-rangecommunication technologies," International Journal Of Pure And Applied Mathematics, vol. 119, no. 14, 2018.
[22] Giuseppe Ciaburro, "Sound event detection in an an underground parking garage using convolutional neural network," Big Data and Cognitive Computing, 2020. https://doi.org/10.3390/bdcc4030020
[23] Y. Rahayu and F. N. and Mustapa, "A secure parking reservation system using GSM technology," International Journal of Computer and Communication Engineering, vol. 2, no. 4, p. 518, 2013. https://doi.org/10.7763/IJCCE.2013.V2.239
[24] Y. Atif, J. and Ding and M. A. and Jeusfeld, "Internet of things approach to cloud-based smart car parking," Procedia Computer Science, vol. 98, pp. 193--198, 2016. https://doi.org/10.1016/j.procs.2016.09.031
[25] J. M. Armingol, a. A. Jorge, N. and Aliane, M. and Clavijo, S. and Campos-Cordob'es, A. and de la Escalera, J. and del Ser, J. and Fern'andez, F. and Garc'ia, F. and Jim'enez and a.

others, “Environmental perception for intelligent vehicles,” in Intelligent vehicles, Elsevier, 2018, pp. 23--101. https://doi.org/10.1016/B978-0-12-812800-8.00002-3
[26] P. Almeida and L. S. S. J. E. B. J. A. K. A. Oliveira, “PKLot – A robust dataset for parking lot classification,” Expert Systems with Applications, 2015. https://doi.org/10.1016/j.eswa.2015.02.009
[27] Wenjin Zhang, Jason Yan, and Cui Yu, “Smart Parking System Based on Convolutional Neural Network Models,” 2019 6th International Conference on Information Science and Control Engineering (ICISCE). https://doi.org/10.1109/ICISCE48695.2019.00118
[28] Mohamed S. Farag, M. M. Mohie El Din, H. A. El Shenbary, “Deep learning versus traditional methods for parking lots occupancy classification,” Indonesian Journal of Electrical Engineering and Computer Science Vol. 19, No. 2, August 2020, pp. 964~973 ISSN: 2502-4752. https://doi.org/10.11591/ijeecs.v19.i2.pp964-973
[29] Chantri Polprasert, Chaiyaboon Sruayiam, Prathan Pisawongprakan, and Sirapob Teravetchakarn, “A Camera-based Smart Parking System Employing Low-complexity Deep Learning for Outdoor Environments,” 2019 Seventeenth International Conference on ICT and Knowledge Engineering. https://doi.org/10.1109/ICTKE47035.2019.8966901
[30] Hung, B. T., & Chakrabarti, P. (2022). Parking Lot Occupancy Detection Using Hybrid Deep Learning CNN-LSTM Approach (pp. 501–509). https://doi.org/10.1007/978-981-16-6332-1_43
[31] Yang, G., Wu, X., & Zhang, J. (2023). A dynamic balanced quadtree for real-time streaming data. Knowledge-Based Systems, 263, 110291. https://doi.org/10.1016/j.knosys.2023.11029
[32] AminiMotlagh, M., Shahhoseini, H., & Fatehi, N. (2022). A reliable sentiment analysis for classification of tweets in social networks. Social Network Analysis and Mining, 13(1), 7. https://doi.org/10.1007/s13278-022-00998-2
[33] LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. Nature, 521(7553), 436–444. https://doi.org/10.1038/nature14539
[34] Simonyan, K., & Zisserman, A. (2014). Very Deep Convolutional Networks for Large-Scale Image Recognition.
[35] He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep Residual Learning for Image Recognition. 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 770–778. https://doi.org/10.1109/CVPR.2016.90
[36] Huang, G., Liu, Z., van der Maaten, L., & Weinberger, K. Q. (2017). Densely Connected Convolutional Networks. 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2261–2269. https://doi.org/10.1109/CVPR.2017.243
[37] N. Cavus, S. E. Mrwebi, I. Ibrahim, T. Modupeola, and A. Y. Reeves, “Internet of Things and Its Applications to Smart Campus: A Systematic Literature Review,” Int. J. Interact. Mob. Technol., vol. 16, no. 23, pp. 17–35, 2022. https://doi.org/10.3991/ijim.v16i23.36215
[38] A. Saeliw, W. Hualkasin, S. Puttinaovarat, and K. Khaimook, “Smart car parking mobile application based on RFID and IoT,” Int. J. Interact. Mob. Technol., vol. 13, no. 5, pp. 4–14, 2019. https://doi.org/10.3991/ijim.v13i05.10096
[39] J. E. Sánchez-Cano, W. X. García-Quilachamin, J. Pérez-Véliz, J. Herrera-Tapia, and K. A. Fuentes, “Review of Methods to Reduce Energy Consumption in A Smart City Based On IoT and 5G Technology,” Int. J. online Biomed. Eng., vol. 17, no. 8, pp. 4–21, 2021. https://doi.org/10.3991/ijoe.v17i08.23671
[40] C. Tang, J. Xie, Y. Zhang, D. Hu, and J. Li, “A smart exhibition system of power measurement vehicle based on the GIS and GPS techniques,” Int. J. Online Eng., vol. 10, no. 1, pp. 41–45, 2014. https://doi.org/10.3991/ijoe.v10i1.3364

[41] M. Khayyat et al., "The Simulation and Prototyping of a Density-Based Smart Traffic Control System for Learning Purposes," Int. J. online Biomed. Eng., vol. 16, no. 12, pp. 70–81, 2020. https://doi.org/10.3991/ijoe.v16i12.16849

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