Smart Parking Systems Using Machine Learning

Manvendra Pal[1], Bharti Chourasia[2]
[1,2]Department of EC, SRK University Bhopal, India
[1]manvendraei@ gmail.com, [2]bharti.chourasia27@gmail.com

* Corresponding Author: Manvendra Pal

Abstract:-*In this work, a machine learning-based intelligent parking system has been built. The purpose of this work is to give the best solution possible for users, with the goals of minimizing the amount of time spent looking for a parking spot, lowering the amount of gasoline used, and contributing to the alleviation of traffic congestion and pollution. The work that has been done here utilizes tools for machine learning and full vision in order to build a smart parking module. In this work, a CNN model is constructed from the ground up and then trained on the parking dataset. The experiment was performed on three environmental conditions i.e., rainy, sunny, and overcast. In all three conditions, rainy and sunny have achieved better accuracy. The work of the results reveals an accuracy of 96%, which exceeds other state-of-the-art methods by a significant margin.*
Keyword *– Automated System, Smart Car Parking, Machine Learning, Deep Learning.*

I. Introduction

According to the information provided by the Malaysian Ministry of Transportation, roads are used to transport more than sixty percent of all goods and eighty-five percent of all passenger traffic in India. However, the existing transportation infrastructure and parking facilities are not sufficient enough to support the increasing number of vehicles on the road. As a result, issues such as clogged roads and a lack of available parking spaces will unavoidably arise. The problem is made much more difficult by the fact that the roadways in Asia are a great deal more congested than those in Western countries [1]. Many different steps have been done in the direction of solving the traffic issues that have been occurring. The work focuses on the car park management system that was presented, which is the smart parking system, despite the fact that the issue can be solved using a variety of other approaches. As part of this research project, a smart parking system for vehicles was built and tested. The needs of a particular application or project, as well as the placement of the application or project within the smart machine learning domain, both have an impact on the design of a smart system [3]. There have been quite a few project-based smart architectures established, such as SENSEI, SPITFIR, in order to meet the particular requirements of such projects [4]. The variety of purposes for which an smart system may be constructed has resulted in the creation of a variety of smart designs, each of which utilizes a unique set of components and protocols.

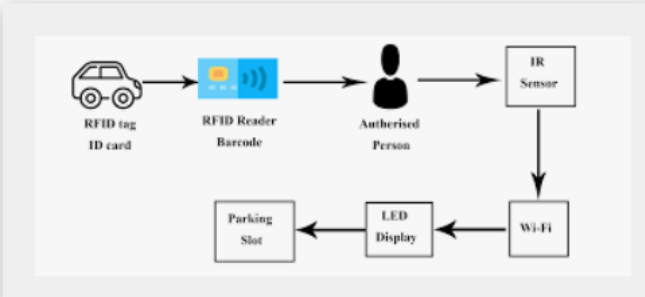

Fig 1: Machine Learning based smart parking system

The history of public parking in the United States has to be understood more fully before and after both the world wars, specifically the First World War and the Second World War. The intelligent parking system that is mostly used in Europe, the United States of America, and Japan is one that was designed with the inclusion of cutting-edge technology as well as research from a wide variety of academic fields. It is intended that by deploying it in the parking lot, it would eliminate the difficulties described above that are experienced by customers while they are parking their cars in the lot. ITS are being developed in order to find solutions to these difficulties. PGI systems provide vehicles with information regarding parking availability, price information, and in some circumstances navigation information by utilizing on-roadway or off-roadway sensors, controllers, and transmitters. In certain situations, this information also includes pricing details. The PGI system and the transit-based parking system are very similar to one another. The main difference between the two is that the transit-based parking system enables commuters to make efficient use of Park-and-Ride facilities so that they can switch from driving to taking public transportation with the assistance of parking and transportation information. Utilizing PGI systems, drivers are able to make reservations to ensure parking places for themselves and avoid competing with other cars for available parking spots. In addition, parking resource use, parking income, and overall traffic jams may all improve as a result of the implementation of PRS systems. An electro-

mechanical system, known as an automated parking system, is used to automate the parking procedure. This system takes the car away from the driver at the entrance of the parking lot and parks it in the place that has been designated for it.

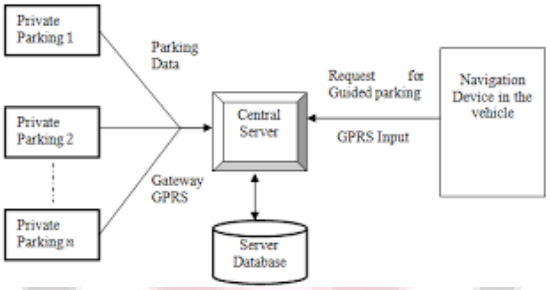

Fig 2. Parking Guidance and Information Systems

The challenge of finding parking for such automobiles is one of the main considerations that need to be taken into account in accounting. The process of acquiring parking information has utilized a wide array of car detectors of varying types[2].The inductive loop, acoustic sensor, infrared sensor, and ultrasonic sensor are the most common types of sensors utilized in these vehicle detectors. It has been suggested that the information in the car parking field be gathered utilizing a system that makes use of video camera sensor technology. However, the sensor of a video camera is susceptible to damage from inclement weather and operation throughout the night. In addition to this, it is costly and has the potential to produce a significant volume of data that may be challenging to send over a wireless network [3]. The wireless sensors are nonetheless invasive since they are either buried beneath the asphalt of each parking lot or affixed to its surface.

II. RELATED WORK

Satyanatha et al. [1] investigated the use of dehazing networks that improves the performance of parking space occupancy classifier under hazy conditions. Additionally, training procedures are proposed for dehazing networks to maximize the performance of the system on both hazy and non-hazy conditions. Experimental results indicate that there is a significant accuracy improvement of the proposed approach on the hazy parking system dataset.

Amato et al. [2] presented an approach for real-time car parking occupancy detection that uses a Convolutional Neural Network (CNN) classifier running on-board of a smart camera with limited resources. Experiments show that our technique is very effective and robust to light condition changes, presence of shadows, and partial occlusions.

Ding and Yang [3] proposed a model based on YOLO v3 network and applied to parking spaces and vehicle detection in parking lots. Based on YOLO v3, this paper adds a residual structure to extract deep vehicle parking space features, and uses four different scale feature maps for object detection.

Prova et al. [4] presented a model for make a decision of occupancy status in parking lots of a parking space. Our model is based on deep Neural Network. As we need to only take binary decision either occupied and not occupied, our CNN architecture is robust enough to take decision on real time on embedded device.

P.Mangwani et al. [5] provide an ML-based guide for the user to monitor and reserve the parking space for the car. Additionally, it offers an efficient solution for monitoring and managing free parking spaces..

The municipal authorities requested that Charles Wasswa et al. [7] create and execute a system that would include a parking fee payment method, parking permit management, parking analytics and parking occupancy prediction. The project was divided into three stages.

An intelligent parking system that may be used both indoors and outdoors has been developed by Andrew.M et al.[8]. Particle filtering is utilized, together with a foundation in Bluetooth low energy (BLE) beacons, to further enhance the accuracy of the system.

Y.Pankiv et al.[9] The developed system performs an analysis of a specific location and the statistical data associated with that location (for instance, population, the share of car ownership, location availability, characteristics of work, and so on), and then provides the user with recommendations regarding the correct number of vehicles spaces in a specific area.

T.Kalic et al. [10] present an approach that is able to rapidly send park information to clients located in different regions of the city. In order to do this, the sensors installed in the parking lot gates send data to a database that is built on the cloud and stores the data there.

III. Proposed Methodology

Nowadays, most of the research works have focused attention on Convolution Neural Network (CNN) due to its power for efficient classification as well as enhanced accuracy. One of the major properties of the convolution network is that it is not a fully connected network like in previous layers every node is connected. The negative coefficient is replaced by zero value in this activation function, representing local characteristics of the input image. fully-connected layer: this layer is typically used as a final layer in the network. it usually is used for sorting when an array of elements m (where m is a number of image categories) which include the image probabilities of a particular category are needed for the required

production. The proposed ML-based automated parking lot identification model is designed as illustrated in fig 3. The working step of the model is described as below in algorithm 1.

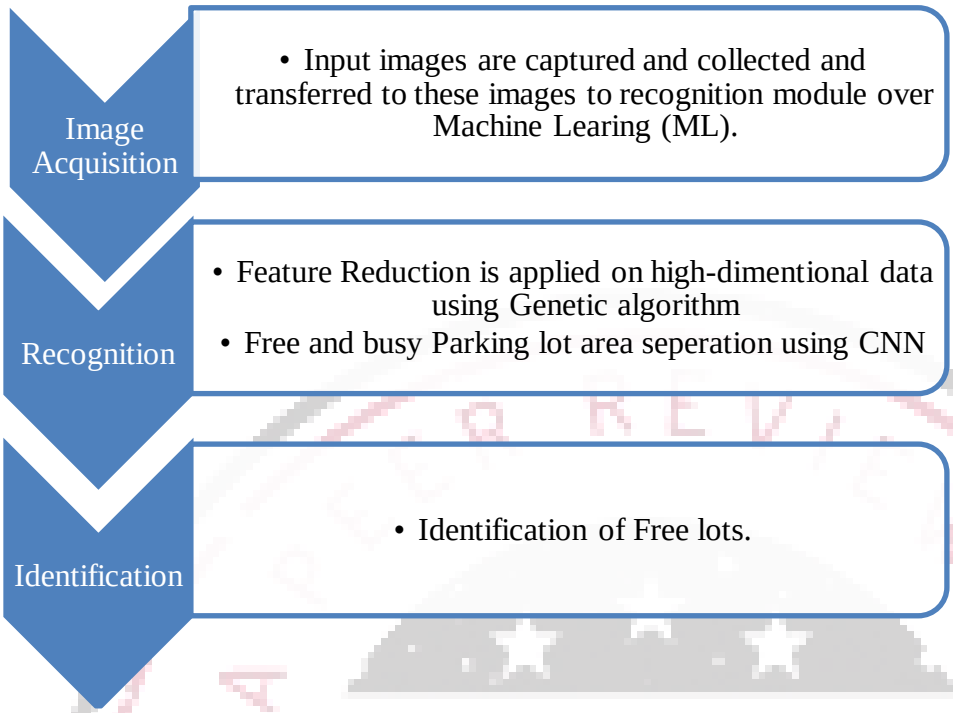

Fig 3: Working Flow of Parking Lot Detection

IV. Result and Discussion

The simulation scenario is created and simulated for performance evaluation of proposed algorithm.

Performance Parameters

Accuracy: It is one of the most important parameters for determining the classifier's performance. It denotes the total number of accurately categorized free or occupied parking lots. The mathematical expression of accuracy is given in eqn (1):

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)} \quad (1)$$

Precision: It's calculated as the ratio of properly identified free or occupied parking lots class to the total number of classes, and it's given by:

$$\text{Precision} = \text{TP}/(\text{TP} + \text{FP}) \quad (2)$$

Recall: Recall is the ratio of true positive (TP) to them sum of false negative and true positive.

$$\text{Recall} = \text{TP}/(\text{TP} + \text{FN}) \quad (3)$$

F-Measure: The F-Measure is the result of harmonic mean of precision and recall rates.

$$\text{F-Measure} = 2 * [(\text{precision} * \text{recall}) / (\text{precision} + \text{recall})] \quad (4)$$

Result Analysis

The proposed network is designed for automated parking lot detection from images. The input image patch size is 150×150 that is used to train the model. In this work, images of carpark dataset is used for training purpose. For testing the trained model, carpark datasets are used. For residual learning, loss function is used to train the model. The training is done for the 100 epochs. For simulation modeling google colab is used to train the model under GPU environment to train the model. Some sample of tested images are presented below:

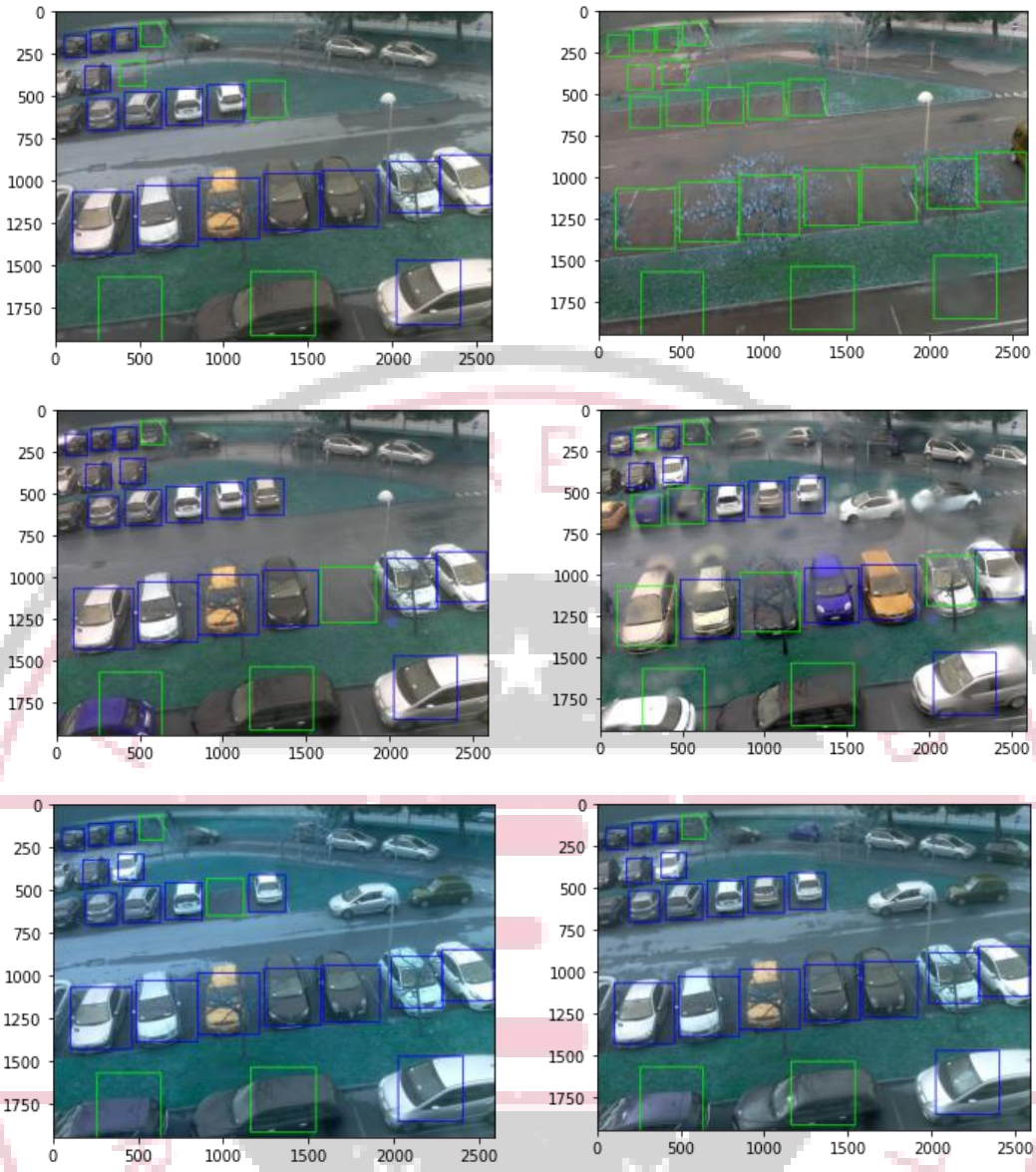

Fig 4.: Identified Car Park Regions

The training of model was performed on google colab and below, we have presented the training loss and accuracy of the model. The figure 5 shows the training loss of model for epochs 0-4. Each epoch runs in 1000 steps or iterations. Similarly, figure 6 shows training accuracy of the model. It seems that model have achieved about 98% training accuracy. The carpark dataset contains approx. 40000 images which is divided into 70:30 ratio of training and testing dataset. The testing and training performance evaluation in presented below in table 1.

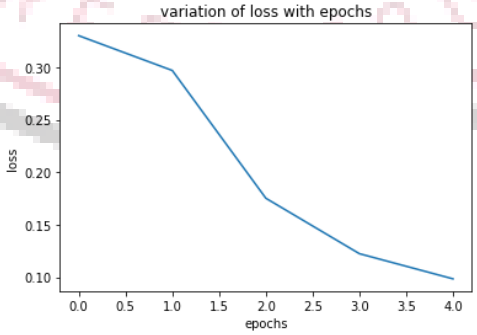

Fig 5: Training Loss

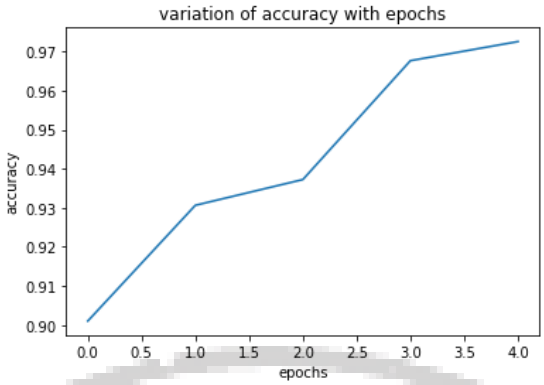

Fig 6: Training Accuracy

Table 1: Performance Evaluation on Environmental Conditions

Parameters	Sunny	Rainy	Overcast
Accuracy	97	97	97
Precision	94	93	98
Recall	98	98	75
F_Measure	96	95	83

In table 2, performance analysis is performed on environmental conditions i.e., rainy, sunny and overcast. The accuracy was achieved is 97% whereas in Sunny f_measure was highest and in rainy weather condition f_measure was achieved, i.e., 95%. Similarly, in overcast environment, 83% f_measure was achieved.

Table 2: Performance Evaluation on ALL Weather Conditions

Parameters	Test_sets					
	1	2	3	4	5	Average
Accuracy	92	100	89	100	100	96.2
Precision	93	100	93	100	100	97.2
Recall	92	100	83	100	100	95
F_Measure	92	100	86	100	100	95.6

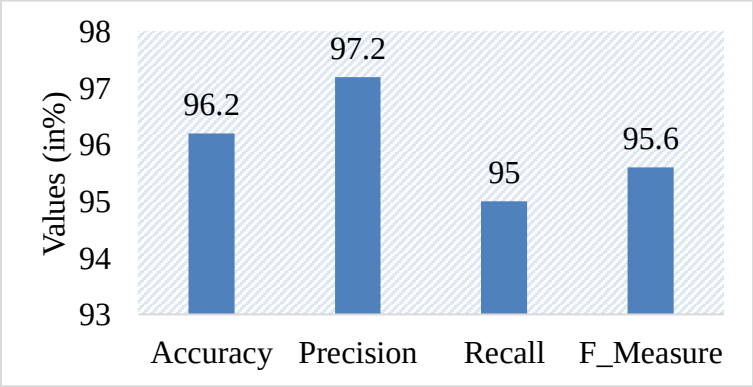

Fig 7: Performance of Designed Model

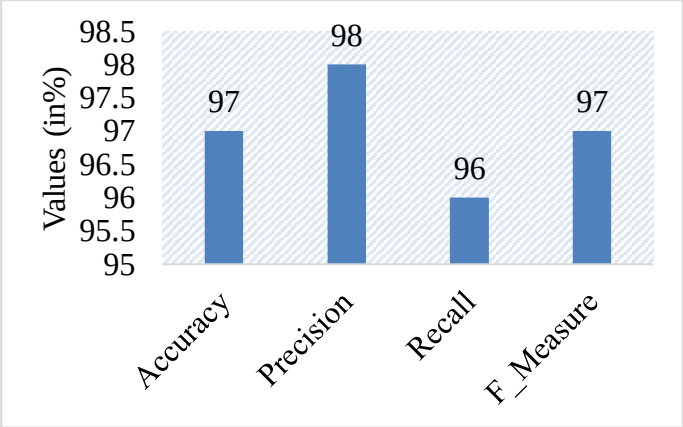

Fig 8: Performance on Some Real Images

In fig8, some real images were collected and tested and achieved accuracy of 97%.

Table 3: Comparative State-of-art

Ref	Technique used	Accuracy
[1]	CNN	93.4%
[2]	CNN	90.4%
[3]	Yolo	91.6%
[3]	Improved Yolo	93.3%
[4]	AlexNet	90.1%
	Ours	96.2%

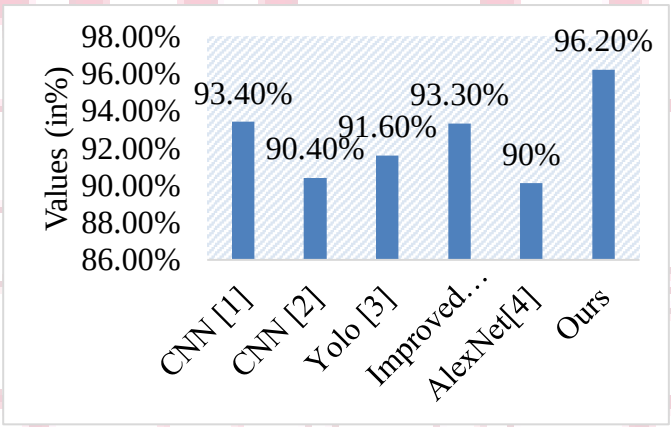

Fig 9: Comparative State-of-art

In fig 9, comparative state of art is presented with some existing research works presented on CNR Park dataset. In this out model achieved approx. 96% of accuracy and shows improvement of approx. 3% of improvement.

V. Conclusion

In this work, machine learning algorithms are used to design a automated framework to detect free parking lots through camera images. Most of the recent approach have used convolution neural network-based models to design such automated system but in most of the techniques, high-dimensional imaging data results in data imbalance issues or results high computational complexity. To reduce this, the proposed model have presented a genetic algorithm based approach that will reduce the dimension of input images and further recognition accuracy is improvised. In this work, the CNN model is designed from scratch and trained on carpark dataset. The result analysis shows an accuracy of 96% which outperforms better as compared to existing state-of-art. Our future work is to create car parking system to work as an operational platform in a smart city. There will be a high authority to get access of information managed by the car parking system center, for the relevant management and control entities, including a highway Centre, emergency Centre, traffic

control Centre, and police. The sensor after sensing the information regarding vehicle lots it will send the updated information to parking meters, which will forward this information to the information center

References

[1] Satyanath, Gaurav, Jajati Keshari Sahoo, and Rajendra Kumar Roul. "Smart Parking Space Detection under Hazy conditions using Convolutional Neural Networks: A Novel Approach." arXiv preprint arXiv:2201.05858 (2022).

[2] G. Amato, F. Carrara, F. Falchi, C. Gennaro and C. Vairo, "Car parking occupancy detection using smart camera networks and Deep Learning," 2016 IEEE Symposium on Computers and Communication (ISCC), 2016, pp. 1212-1217, doi: 10.1109/ISCC.2016.7543901.

[3] Ding, Xiangwu, and Ruidi Yang. "Vehicle and parking space detection based on improved yolo network model." Journal of Physics: Conference Series. Vol. 1325. No. 1. IOP Publishing, 2019.

[4] R. R. Prova, T. Shinha, A. B. Pew and R. M. Rahman, "A Real-Time Parking Space Occupancy Detection Using Deep Learning Model," 2022 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS), 2022, pp. 1-7, doi: 10.1109/IEMTRONICS55184.2022.9795771.

[5] A. O. Kotb, "Smart parking," Mach. Des., vol. 74, no. 9, p. 26, 2002, doi: 10.4018/978-1-7998-5326-8.ch007.

[6] D. Issrani and S. Bhattacharjee, "Smart Parking System Based on Internet of Things: A Review," Proc. - 2018 4th Int. Conf. Comput. Commun. Control Autom. ICCUBEA 2018, vol. 13, no. 12, pp. 10281–10285, 2018, doi: 10.1109/ICCUBEA.2018.8697348.

[7] R. Kanan and H. Arbess, "An IoT-Based Intelligent System for Real-Time Parking Monitoring and Automatic Billing," 2020 IEEE Int. Conf. Informatics, IoT, Enabling Technol. ICIoT 2020, pp. 622–626, 2020, doi: 10.1109/ICIoT48696.2020.9089589.

[8] C. W. Sewagudde, "The design and implementation of a smart-parking system for Helsinki Area Master's," 2016.

[9] A. Mackey, P. Spachos, and K. N. Plataniotis, "Smart Parking System Based on Bluetooth Low Energy Beacons With Particle Filtering," IEEE Syst. J., vol. 14, no. 3, pp. 3371–3382, 2020, doi: 10.1109/JSYST.2020.2968883.

[10] Y. Pankiv, N. Kunanets, O. Artemenko, N. Veretennikova, and R. Nebesnyi, "Project of an Intelligent Recommender System for Parking Vehicles in Smart Cities," in 2021 IEEE 16th International Conference on Computer Sciences and Information Technologies (CSIT), 2021, vol. 2, pp. 419–422. doi: 10.1109/CSIT52700.2021.9648687.