An Elaborative Study of Smart Parking Systems

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***Abstract*—Observing the current scenario, categorizing the issues faced by drivers in large cities around the world, we come across two major issues-parking space shortages and traffic congestion. With increase in population, the demands for vehicles are increasing day-by-day. Due to the same, unavailability or mismanagement of available parking spaces, heavy traffic in crowded cities is obvious. Looking upon the ways to solve these issues, we may look to increase the parking spaces or efficiently utilize and manage the available parking space. And for obvious reasons the latter is efficient. For proper utilization of resources available, we need to develop an intelligent and efficient way so that there is no wastage of time, cost and fuel. Specifically about parking, need of safe and smart parking system is vital.**

Keywords - Deep Learning, CNN, RCNN, YOLO, Smart Parking System(SPS), CNRPark, pklot, Internet of Things (IoT).

I. INTRODUCTION

People nowadays face the issue of finding empty or vacant slots for vehicle parking. For this, they spend nearly 6-8 minutes. This is the reason which causes the major traffic in the big cities. For that, there are many facilities and techniques available in the market to reduce the tension of finding a vacant parking lot. Deep learning [12] is one concept of data or image processing that helps in this area. In Deep Learning various algorithms are used such as CNN, RCNN, MASKRCNN, YOLO, etc. [16]. A smart parking system is the need of smart cities so that the common problems will be eliminated from society. Smart Management allows the smooth flow of traffic management and time management.

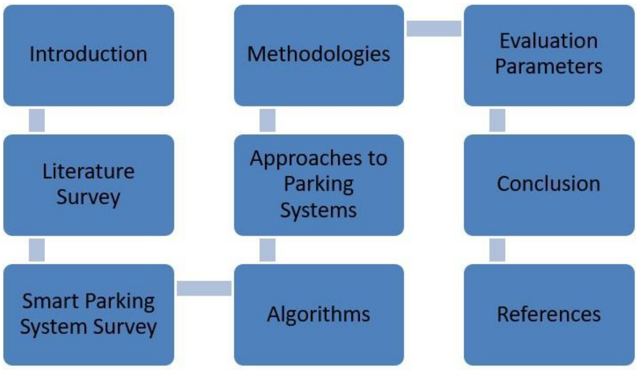

Figure 1. Layout of the paper

As IoT and cloud-based smart systems have gained mo- mentum these days, smart cities have gained new recognition and are the primary focus nowadays. The only motive of smart cities is to improve the management system in the city, enhance the effectiveness, and improving the quality of life. Also, this includes a systematic traffic management system. As of now the urban and highly populated cities like Mumbai, Delhi, Pune, etc. face this problem of parking management. Around 30% of vehicles manually search for the vacant parking lot and it cost them nearly 8 minutes and causesfuel wastage and air population.

II. LITERATURE SURVEY

According to research in [1], authors have mentioned waysto detect parking slots by applying Deep Learning techniques especially CNN which will be helpful to solve the issues that need a high level of abstraction for example vision.The authors have used the dataset CNRPark which contains pictures of parking lot with help of smart cameras. The created dataset is then made available for the community to study and develop some fresh techniques in respective areas of interest. A study done in [2] shows the development of two RNN architectures LSTM and GRU mainly used for accurate fore- casting of available parking slots in urban areas. As a result,GRU architecture achieves the best results as compared to the LSTM. Also, calendar and weather plays a role to improve the results for detecting the parking slot with a tiny numberof sensors.

Analysis done in [3] gives a detailed comparison of 5 unique machine learning models. Those are Multilayer Perceptron (MLP), Decision tree, KNN, and Ensemble Learning (EL) , Random Forest. Precision, Accuracy, Recall, and F1-score areused as performance metrics for each approach. From thedetailed analysis, it is observed that the Decision tree shows the optimal results for the prediction of available parking slots. Research in [4] proposes that License Plate Recognition System has a key role to play in the Smart parking system. To detect the Number of vehicles, deep learning on a bare metal cloud-based environment was used with LPRS. The proposedCNN determines cluttered background features which makes it more vigorous to challenging conditions.

To give a better solution to avoid traffic, the authors of [5] have proposed a methodology that uses Artificial Neural Networks (ANN). After a detailed analysis of deep learning algorithms, the method of Mask R-CNN has been implemented which results in an accuracy of 92.33.

According to research in [6], real-time data is processed for the detection of available parking slots. By studying nearly 16 cases, a vehicle localization system is proposed for both online and offline processes which include training of CNNas well as capturing of LTE downlink.

Research paper [7] to develop an IoT-based service. Basically, they tend to design an intelligent system that is capable of predicting the occupancy of parking space in the few hours of application. To optimize the flow of cars in a particulararea, a deep learning-based technique is used to forecast the parking slot occupancy in order to reduce the searching time for parking. The technique is an ensemble one. The proposed method provides outstanding results which are better that widely used strategy of the mean and single predictors which provides inherent and robust predictions.

Research paper [8] aims to increase the efficiency; to adapt transform a 3-space input path for the displacement of various vehicles of a convolutional spatial transformer network. To learn the vigorous and contrastive feature descriptor, Authors have proposed a Siamese architecture which assists in reducing effects caused due to image collision. The proposed network was developed to address the practical issues in outdoor environment which helped to gather information about space status of parking lots.

Authors in [9] have provided a smart parking application using a deep learning framework. As a solution system that utilizes the DL and image processing concepts to deal with the out passing of information process in the deciding systemsis proposed. The system successfully identifies the parking process through output images.

A deep classification of smart parking systems based on parking lot occupancy detection is made in [10]. The authors have proposed two methods, one deep learning neural net- work. It includes 11 layers and the other depends on the mean. As a result, the deep learning network along with alexnet hasa high result.

It [11] involves object detection in a parking lot. For that initially creates a dataset of images and also a dataset of the empty parking lot called the template of the parking lot. Then the dataset is trained using Convolutional Neural Network and its features and classified with the help of a Binary SVM classifier and tested with the template of the parking lot and generates the empty space in the parking area.

Here [12] Deep Extreme Learning Method (DELM) is used as an algorithm to process the image-based data and find the vacant parking space. Here few processes are involved such as Data acquisition, Pre-processing, Application layer Prediction,and performance.

In this paper[13] the dataset of cropped images of the parking spots is collected and then with the use of the convolutional neural network we find whether spot is vacant or not by comparing the images. Here we used some system related programming to create and store some files such as .json, lable.txt, .caffemodel, and deploy .protocol in the user system.

The author in [14] has explained that the thermal camera can be used to detect objects in any climatic condition and also it is utilized in cases of security reasons to recognize overheated instruments. According to this method, it is used to detect vehicles when they are moving giving out heat at tyres, engines, or lights. So basically, the frame to frame dataset of the images was passed to the 5-fold cross-validation process where Deep learning detectors like Yolo-v, Yoloconv, GoogleNet, ResNet18, ResNet50 are used to evaluate the test dataset providing the results of vehicle detection and generating the parking slot.

[15] proposed Real-Time system which is Cloud-Based. Since it is a system for Smart Cities, for obvious reasons, it should be an Intelligent one. In this paper, to develop a secure and reliable cloud-based intelligent car parking system, integrated on-site data is collection is efficient. It is used with wireless sensors. It helps in realtime and streaming data analytics on data which is collected from IoT which is investigated to check the availability of parking lots dynamically.

For Real-Time and Accurate Parking Measurement, the authors in [16] suggested a Video based Deep Learning approach. Utilizing the current developments in deep convolutional neural networks (DCNNs) and a unique filter for vehicle tracking, they get together information across various picture frames ina very sequence of video to get rid of produced noise by detection failures and occlusions. It helps to design real-time video system. Noticeably, it should be accurate. The developedsystem is made keeping in mind the smart cities applications and future Internet of Things (IoT). The fast average interval per frame denoted that in real-world deployment the system will be feasible in financial terms.

In [17], Deep Long Short Memory Network is employed designed for Smart Parking System based on IoT. In this paper, car parking availability prediction architecture is provided which is sensor based along with RNN. Also long short term memory model approach is used to develop a framework sup- porting a deep long short term memory network that predicts the car parking zone by using multiple technologies like sensornetworks, Internet of Things (IoT) and cloud technology. By observing the efficiency and accuracy of the mentioned method on day-wise car parking slot availability we will notice that variation in prediction is incredibly low on week days.

Researchers in [18] implemented the SPS Model based on TensorFlow with Internet of Things (IoT). They have used Google Cloud IoT Core for cloud-based architecture. They have mentioned an Android application that can help to search and book the close or nearby available parking slot. Along with it, they also ran Convolutional Neural Network (CNN) algorithm with usage of TensorFlow which highlights amazing accuracy

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in the detection of a license number plate. Also, with navigation bot developed with the help of TensorFlow, they have mentioned this bot utilizing Deep Reinforcement Learn- ing (RL). However, it does not examine the social events as well as occlusion conditions.

[19] proposed "An Edge Based Smart Parking Solution Using Camera Networks and Deep Learning". The proposed method deploys cameras having zoom-lens which captures numbers from license plate with the help of motorized heads by detecting the vehicles while their entries or exits from parking lot. Specifically, to monitor the large parking lot via custom-designed deep neural network, wide-angle fish-eyelens cameras are used which helps to design more affordable, adaptable parking system. However, accuracy is compromised to some extent.

The authors in [20] suggested smart parking sensors, tech- nologies, and applications for open parking lots. This study proposes a mixture of machine vision, convolutional neural network, or multi-agent systems suitable for open parking lots because of less expenditure and resistance to varied environmental conditions. As reservation is not possible in an open parking lot, it becomes difficult to facilitate the driver in the decision making process of choosing a parking lot.

In [21], a Camera-based Smart Parking System along with Low-complexity Deep Learning for Outdoor Environments is implemented. In this paper, a smart camera consisting of Rpi3 is used. Then mAlexnet accompanying an OKER Webcam model 386 is used to detect any vacant parking spaces within the car parking lots. Once a picture of the automobile parking lot is taken, every car parking lot (pre-configured) within the picture will be cropped and sent to the mAlexnet model which is deployed inside the RPi3 to work out if that parking lot is vacant or busy.

Research conducted in [22] proposed a Mobile AR-Based Interactive Smart Parking System. AR is used to improve user experience, while drives capture the video and send it to the server. Then the server compares it with predefined scenes and identifies the location of the driver. Then, the nearest parking lot is informed to the driver via a route. Foggy, dusty, and bad weather environments are considered as one of these challenges.

In [23], the authors have proposed to use RGB-D cameras to support AI-based object detection for cars. Their paper presents a mobile mapping system mounted on an electrictricycle, which allow government agencies to verify and adjust parking policies in city districts. Joining red-green-blue-depth (RGB-D) images from cheap 3D cameras with 3D object identification algorithms for extracting and mapping parked vehicles makes way for accurate levels of 3D object detection. In [24], the authors suggest using deep learning models for detecting vehicle occupation in an open parking lot with the use of thermal detection cameras. A smart parking sys- tem must be able to detect parking occupancy continuously irrespective of the heat that is emitted from vehicle. The author evaluated and compared multiple deep learning object detection algorithms such as You only look once, ResNet18 and ResNet50.

In [26], we explore a collaborative research mechanism of multiple parking lots. This model is inspired from dynamic vehicular path planning. With the help of vehicular construc- tive networks, traffic data can be collected in real-time. Based on this, the path-travel-time of the vehicle is divided into three parts to estimate separately: 1. waiting for signal lights 2. passing intersections 3. driving on straight roads. Including the consideration of parking time inside of the parking lot, the authors propose the integrated reservation mechanism which can steer all parking lots, share their real-time parking space information, and work collaboratively for incoming vehiclesto park successfully.

In [27], the authors propose that we could use genetic algorithms to optimize vehicle classification. Their focus was on classifying vehicle types into car, van and other such vehicles. They utilized DEvol, the open-source tool that uses genetic algorithm for improving number of filters and nodes. Detected vehicles were classified using convolutional neural network (CNN) along with kernels sliding the input image for extraction of convolutional layer feature. Convolutional neuralnetwork has an benefit over other ML techniques because it requires little pre-processing of input data. Genetic algorithm is a procedure use to search from various populations.

In [28], the authors did a comprehensive review of various SPS based on various aspects. A possible system is a WSN based cheap, and low energy consuming SPS. This smart parking system is created to count total cars entering and exiting from a parking area instead of detecting vehicle occupation in each single parking space. According to research stated in one of the system proposed a method named visual vehicle parking space occupancy detection with the use of deep Convolutional Neural Network.

III. METHODOLOGIES

A. IoT based Parking System

IoT is that the most trending technology of the present era. IoT uses web as a agent to interconnect the devices with each other. For this interconnected devices, unique identifier (UID) is provided to recognize them. These devices may include different kinds of devices like computational devices, digital devices and mechanical devices. This devices transfer data without any human-to-computer or human-to-human interaction. This technology works together as the first main technologies used for Smart Parking systems by developers. In IoT based SPS as internet connects all computational devices and sensors and transfers data without human intervention. Required internet connection for computational devices and sensors is provided through either wired or wireless connections.

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B. Deep Learning based parking System

DL could be a part of ML and it's function of Artificial Intelligence which behaves like a human brain while processing knowledge and making decisions. Rather than regular sensors, Deep Learning algorithms detect partially occupied, completely occupied and completely empty parking spacesin an SPS, ultimately reducing the number of sensors and other hardware things like microprocessors, cameras, PCBs etc. required by the system.

C. Machine Learning based parking system

ML Can be assumed a part of AI which has a system powerto find, improve a selected task from the available datasets used as input. A ML based Smart parking system computesthe parking zone of the provided dataset to get the status of parking zone as busy or free. Additionally, with the help of Machine Learning approach and Artificial Intelligence hand in hand the parking occupancy status of upcoming days or weeks can be predicted.

D. Cloud computing based parking system

Cloud computing is better approach for such Smart parking systems that requires high storage units and sensors with high performance. It provides a way for cloud storage whenever required and capability to process the system without any direct monitoring by the user voiding human interaction in system. Preferably cloud computing with IoT gives better approach for SPS.

E. Fog computing based parking system

Fog computing is basically a decentralized computing struc- ture that is located in between cloud and devices that producesthe data. The main aim of Fog computing is to minimize the redundancy of data.

F. Sensor Network based parking system

Information related to parking spaces in a particular areas are collected and processed in a real world by sensors so that vehicles can use available parking lots. For this the sensors used are Ultrasonic Proximity detectors and Electromagnetic parking sensors. Examples: Enhanced Data for GSM Evolution (EDGE), Constrained Application Protocol (CoAP), IPv6 over Low Power Wireless Personal Area Networks (6LoWPAN), General Packet Radio Services (GPRS), 3G/4G cellular net- works etc.

IV. ALGORITHMS

Studying all the papers mentioned above ,two best algorithms that have been proven satisfying the problem statement are MaskRCNN and YOLO-v5.

MaskRCNN- MaskRCNN- is a CNN that is a Convolutional Neural Network and is developed using Faster RCNN which is a region based CNN .Then there are two types of image segmentation (dividing a image in to multiple segments) which are semantic and instance segmentations.

YOLO-V5-YOLO v-5 is a member of YOLO V family which are basically CNN based object detectors. YOLO stands for you only look once. yolo basically divides an image in to a grid system and every grid detect object within that particular grid. Thus, they are used for real time real world object detection based on the data provided.

Both the algorithms were separately trained on two differentdatasets namely PkLot and CNRPark.

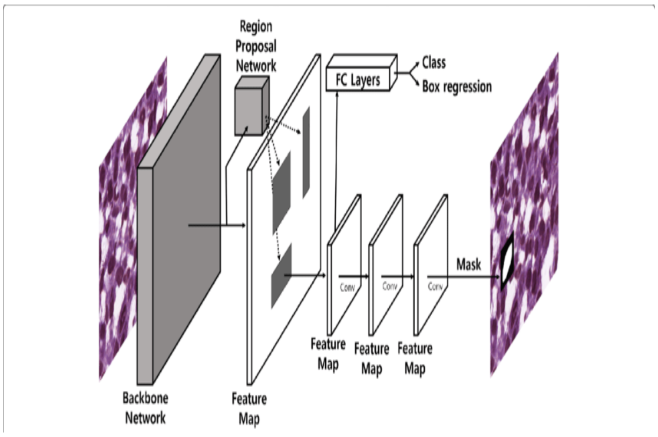

Figure 2. MaskRCNN architecture

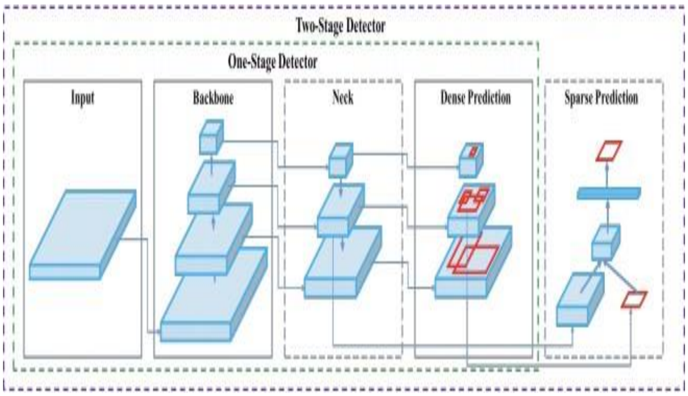

Figure 3. YOLO-V5 Architecture

V. DATASETS

The two datasets were studied, CNRPark and PKLot datasets. PKLot [25], contains nearly 12416 images of parking slots obtained from multiple parking lots which were classified based on weather conditions of which 5959 images are of busy parking spaces and remaining 6457 are of empty parking lots. CNRPark consists of 150000 labeled patches and it's downloadable but have considerably large size. Different situations of sunshine conditions which includes some obstruction because of obstacles (like trees, non parked cars or lampposts) and some partial or shadowed cars are captured by it. This permits to coach a classifier that can tell apart the

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situations that can be found in Real-time scenario. CNRPark have 81730 pictures of busy parking lots and 68270 are of empty parking lots.

Following are the main differences between the datasets used i.e. CNRPark and PKLot:

i) PKLot have images which span across the months consisting various weather conditions through out the year; in CNRPark parking spaces images are genrally squares which can not be rotated and they are not that capable to cover the parking space volume precisely or entirely, whereas in

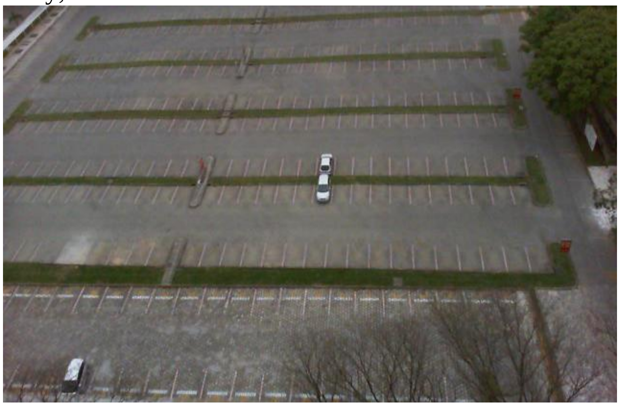

Figure 4. PKLOT DATASET

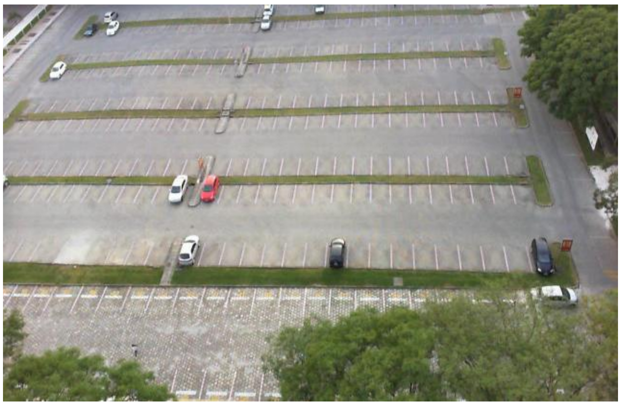

Figure 5. CNRPark DATASET

PKLot uses rotated rectangular masks to extract the images through layers of algorithm which ultimately covers the parking space quite precisley.

Figure 6. PKLOT Dataset vehicle detection

ii) CNRPark consists of widely blocked spaces they are almost covered by surrounding trees and shadows of lampposts) and such images are excluded in PKLot dataset; also, in PKLot there is inclusion of the images which arecaptured form lower geographical points which in turn results more occulsion due to presence of vehicles side by side. Studying two completely varying datasets gave us a chance to compare and validate both the algorithms by training and testing them many a times.

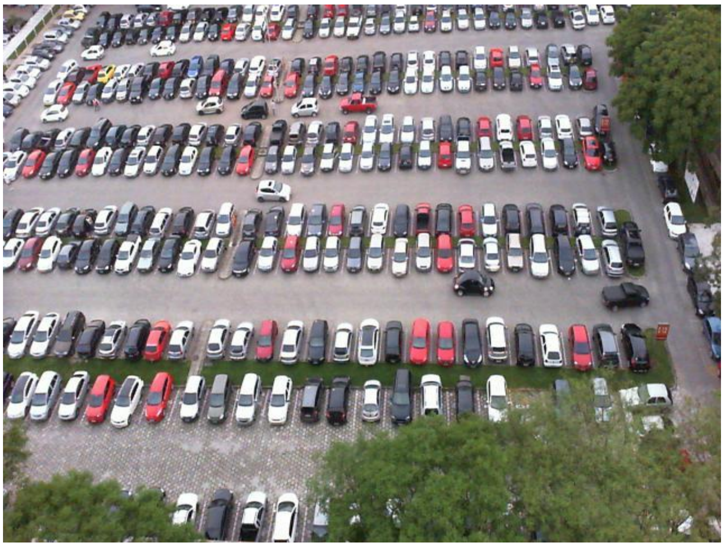

Figure 7. CNRPark Dataset vehicle detection

VI. EVALUATION PARAMETERS

After training of huge dataset on two different algorithms to check the efficiency of the algorithm to detect presence of an object (Vehicle) in provided input data(.jpg,.mp4,.csv) the four terms are used are as following ;

True Positive(TP) - correctly classified empty spaces
False Positive(FP)-incorrectly classified empty spaces
True Negative(TN) -correctly classified nonempty spaces
False Negative(FN) -incorrectly classified nonempty spaces

$$TPR = TP / P \quad .....1$$
$$TNR = TN / N \quad .....2$$
$$FPR = FP / N \quad .....3$$
$$FNR = FN / P \quad .....4$$

Where ,
P-Total positive numbers
N-Total negative numbers

VII. RESULT

In this study, Result based on two algorithms MaskRCNN and Yolo-V5 for classification of parking slots as free and occupied are obtained. For the same, we have applied this algorithms on two datasets- PKLot Dataset and CNRpark Dataset. The performance ,efficiency and evaluation is done in three parameters- Precision Score, Recall Score and F1 score. Greater the value of these parameters, more is the efficiency of the algorithm. Dataset consists of images of free as well as occupied parking slots. For training and testing purposes, dataset is split in the ratio of 8:2 i.e. 80% of images are used for training and 20% for testing. We have obtained quite precise scores and represented them in the form of tables and graphs.

PKLot Dataset

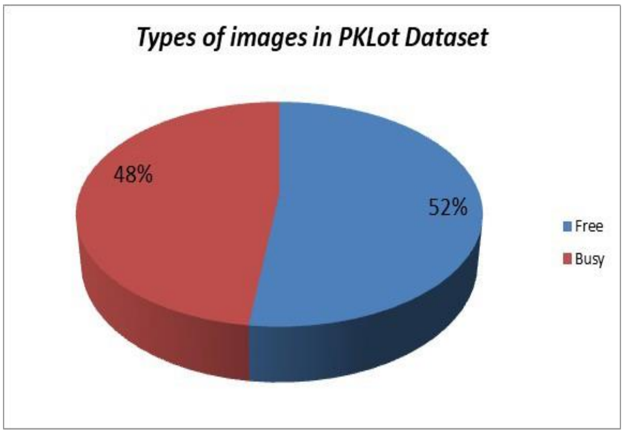

Figure 8. PKLot Dataset Info

CNRPark Dataset

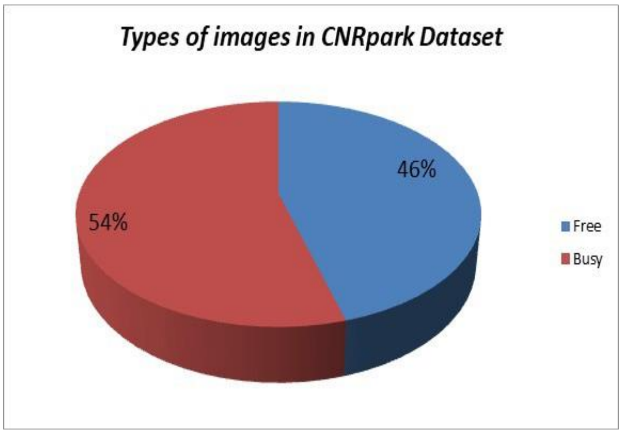

Figure 9. MarkRCNN Dataset Info

PKLot		
MATRICES	**MaskRCNN**	**YOLO-V5**
TP	5946	5815
FP	511	642
TN	5803	5861
FN	156	98

Table I . METRICS FOR PKLOT DATASET

CNRPark		
MATRICES	**MaskRCNN**	**YOLO-V5**
TP	67067	67014
FP	303	1256
TN	81532	81481
FN	198	249

Table II . METRICS FOR CNRPARK DATASET

Precision Score - It's a ratio of correctly classified empty spaces to the sum of correctly identified empty spaces and incorrectly identified empty spaces.

$$Precision = \frac{TP}{TP + FP}$$

Obtained results are shown in table III.

ALGORITHM	**DATASETS**	
	PKLot	**CNRPark**
MaskRCNN	0.9208	0.9955
YOLO-V5	0.9005	0.9816

Table III.
RESULTS FOR PRECISION PARAMETER

It is observed that in both the datasets **MaskRCNN** provides better results as compared to Yolo-V5.

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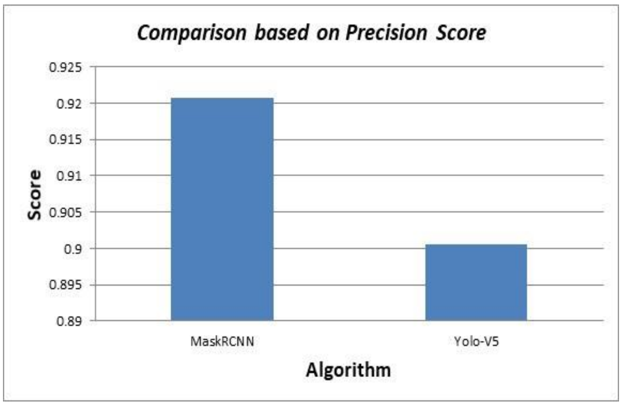

Figure 10. Comparison based on Algorithm for PKLot

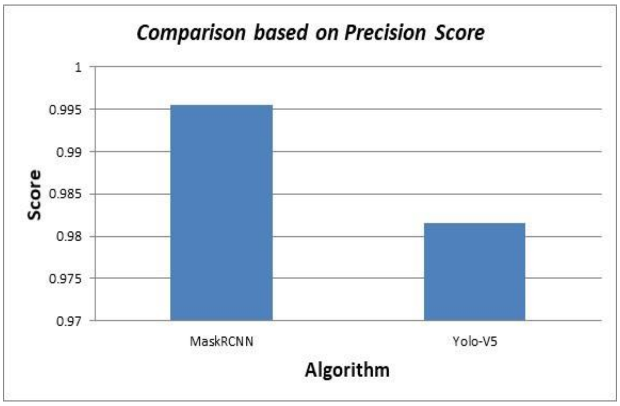

Figure 11. Comparison based on Algorithm for CNRPark

Recall Score - Applying values in the formula of of Recall score i.e. the ratio of correctly identified empty spaces to the sum of correctly identified empty spaces and incorrectly identified nonempty spaces.

$$Recall = \frac{TP}{TP + FN}$$

Recall		
ALGORITHM	**DATASETS**	
	PKLot	**CNRPark**
MaskRCNN	0.9744	0.9970
YOLO-V5	0.9834	0.9962

Table IV. RESULTS FOR F1 MEASURE PARAMETER

We observe that in case of PKLot dataset, recall score of **Yolo-V5** is more than **MaskCNN** while it is vice-versa in case of CNRpark Dataset.

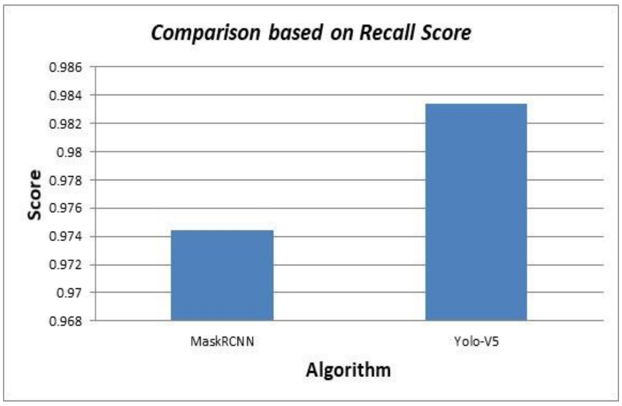

Figure 12. Recall score comparison based on Algorithm for PKLot

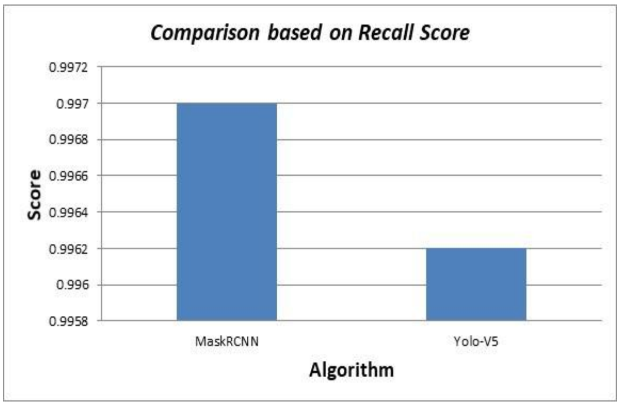

Figure 13. Recall score comparison based on Algorithm for CNRPark

F1- measure Score - It is the ratio of correctly classified empty spaces to the sum of total correctly classified empty spaces and half of sum of incorrectly identified empty spaces and incorrectly identified nonempty spaces.

$$F1Mesure = \frac{TP}{TP + \frac{1}{2}(FP + FN)}$$

F1 Mesure		
ALGORITHM	**DATASETS**	
	PKLot	**CNRPark**
MaskRCNN	0.9468	0.9962
YOLO-V5	0.9401	0.9888

Table V RESULTS FOR F1 MEASURE PARAMETER

Observing the scores it is concluded that **MaskRCNN** isefficient than Yolo-V5.

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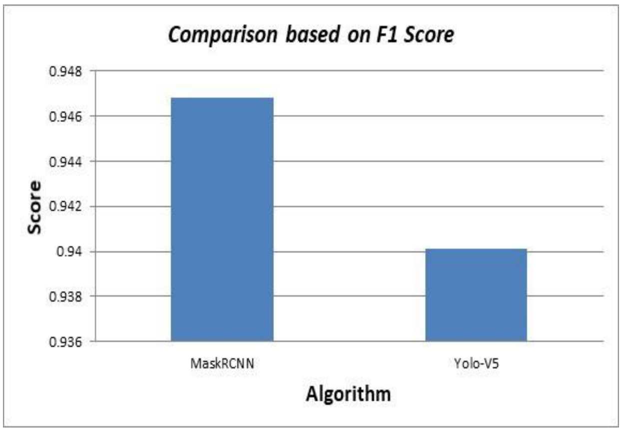

Figure 14. F1 score Comparison based on Algorithm for PKLot

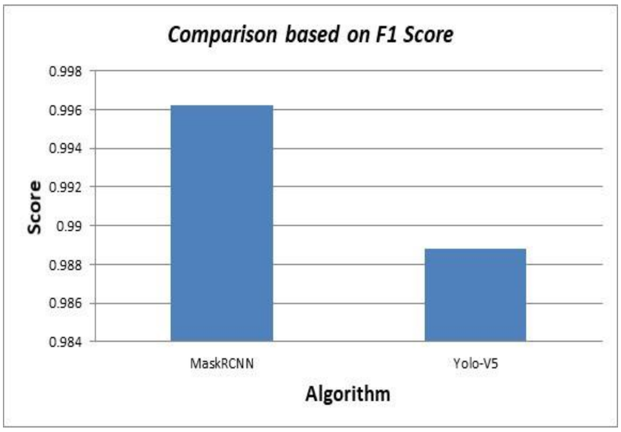

Figure 15. F1 score Comparison based on Algorithm for CNRPark

VIII. COMPARATIVE STUDY

The below graphs represent the comparative analysis of precision scores, recall scores and F1 scores with respect to datasets.

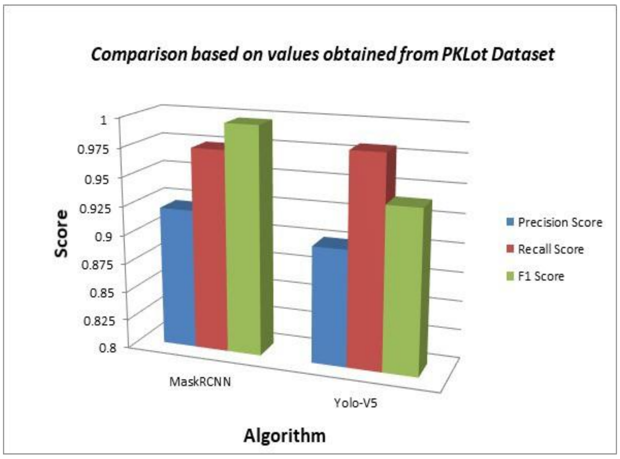

Figure 16. Overall Comparison based on Algorithm for CNRPark

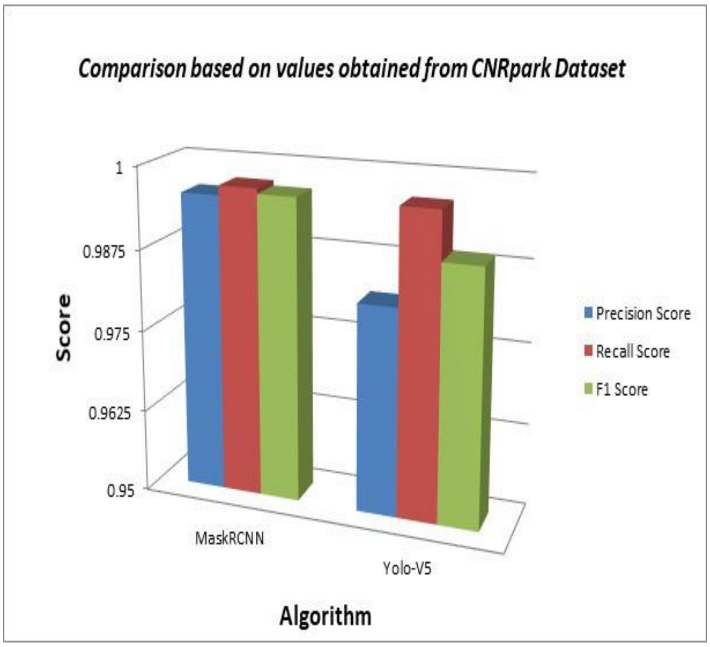

Figure 17. Overall Comparison based on Algorithm for CNRPark

It is found that out of 6 cases, in 5 cases MaskRCNN reigns supreme over Yolo-V5. Though the values seems tobe quite close but considering the best out of the mentioned, MaskRCNN leads the way.

IX. CONCLUSION

The increase in the overall population and unplanned architectures of cities are the main reasons for decreased parking spaces which is becoming backbone of irritating traffic problems. so, if there is a problem, we need a solution. Hence many researchers and tech enthusiasts have started their work to find worthy solutions in this particular area. The paper gives an elaborative comparison of available research on smart parking systems and talks about various algorithms with their results, pros, and cons. We have tried to give a quicklook at the study that we have done throughout our research. Paper provides the classification of research papers based on methodologies used .In this paper we have deployed two algorithms on two datasets and measured their performancein terms of Precision score, Recall score and F1 score . After analyzing all study it is found that the Smart parking system deployed using multiple approaches will be more efficient and have high accuracy in terms of its results. The use of IoT with deep learning algorithms and giving a touch of wireless networking to the core system i.e. object detectionand image processing will be more efficient in terms of result but somewhat not in terms of its overall cost. But with the use of IoT, sensor selection will be a major task if one wants to build the system with a low budget. still problems like deem light ,occlusion and bad climate needs to be address.

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