A Survey On Deep Learning Approaches For Vehicle And Number Plate Detection

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Abstract: In the modern world, the data is captured on multiscale and multiplatform where the data captured provides a way to understand and analyze different domains. In all the analysis of real-time data which is time crucial helps evaluate and respond quickly one such application is in terms of transportation field whereas the vehicles on road are increasing day by day this is the need to map, understand and analyze the data generated from them this analysis could be in the form of security, finding of stolen vehicles, toll booth, etc. Vehicle detection and recognition system can provide a general approach for providing traffic analysis which could be a type of clutter of vehicles, an area where the traffic is more or more issues. As the data generated and analyzed is in real-time and due to the tremendous increase in the capability of computation power, we use a machine learning approach for processing this data. Due to the use of high-Powered graphical processing units, parallel computing and ease of resources and availability of systems the approach are feasible. This paper provides an overview of multiple pattern classification and detection methods in the literature. The overview of the paper is accompanied along with the comparisons of algorithms along with various datasets. Here the goal is to provide an idea for several methods with different data and to find the various approaches of the methods also to give a perspective of different approaches used for the detection of vehicles using different scenarios.

Keywords: Machine Learning, Vehicle Detection, Convolutional Neural Network, Yolo, Pattern Recognition.

1. INTRODUCTION:

In our modern-day to day life, the use of information to provide insights and meaning to the data has grown on a large scale this generation of insights happens with different approaches where machine learning is one of it where the data is generalized from various sets of examples. One of the approaches used is the use of ANN (Artificial Neural Network) which tries to mimic the biological counterparts one of the approaches in it is the CNN (Convolutional Neural Network) where it works on mimicking computer vision to identify, detect and classify the objects or entities in the given field of view. Here the approaches land with the generalization of samples by performing N layer processing on the data. CNN also has various approaches to look forward one such is YOLO (You look only once), this approach as being highly accurate and able to outperform multiple approaches along with its characteristics of real-time analysis of data makes it suitable for various different applications such as real-time vehicle detection. As vehicles are increasing there is also a need to maintain and record and analyze the health of the transportation system. Thus, analyzing the vehicles or road can give various key points in making adjustments to improve the efficiency of traffic, maintain the flow, securing people form non-rule followers. This paper gives an overview of various different approaches present in the vehicle detection system. In this paper, we will see various approaches used by different authors its results.

2. RELATED WORK

Vehicle Recognition

As the need for processing the data is increased authors have approached the task with multiple and diverse ways.

In case of detecting patterns in the vehicles, the approaches utilized by different authors give a glimpse of scalability, performance, and reliability of available methods one such method is the use of RPN (Regional Proposal Network) which helps enables the extraction of features of the object using the convolutional network which in turn uses region proposals. [4] Kaiming He et al, with the use of region proposals tried to predict the object's confidence scores and bounds. Here while doing training of the region proposal network to generate regions of interest the features and required dimensions are extracted which are then given to fast convolution neural network for the purpose of detection. From the different methods, two different modules are computed and merged then using a single convolutional network the classification of multiple vehicle types of the vehicle is performed within a given frame. Authors [9] Hong Bao et al, with selective approach performs the task of detection of vehicles using Regional fast convolutional neural network the work is based on pre-processing the data and tune the network for optimized results, with the use of multi-features such as structure, size, shape classification and detection of objects are performed with the use of selective approach the performance is derived in terms of accuracy. One of impactful approach is the use of Ad boost method for the detection of vehicles and its type here the author [10] Yu Xue et al, where the using the Ada boost method training for the model is performed one of the issues during this is time taken to train the model which is more as compared to others thus to overcome the hurdle the use of Rapid learning algorithm is used for training purpose. In the rapid algorithm, the use of Haar on grayscale like feature pool image by rotation is used for Haar regional prototype like for representing the appearance of the vehicle after which with the use of weak classifiers the classification is performed using the class label. Lastly, an incremental rapid learning algorithm is utilized for increasing the performance of detecting the vehicles. To detect multiple objects within the given set of data authors [13] Santosh Divvala et al, used an approach known as yolo (you look only once) here the method of classification works by splitting the objects as a regression problem where the frame of the input data is split and separated as n*n grids and as detection of the object is done the segregation is performed by determining the class probabilities for each predicted objects. Authors [5] Debi Prasad Dogra et al, worked with a different approach for reaching a goal of detecting moving objects, they used Dirichlet Process Mixture Model where for the need of identification the inferencing of the components is done which helps identify the object it is done by mapping

the pixels that are present and then they are clustered using the optical flow and position approach. Authors [15] Pedro D. Suárez et al, performs the counting and tracking of vehicles this is done using a bounding box approach where each of the objects is been given a unique identification number for purpose of detection of objects. There are multiple different techniques available for the need of detecting patterns on vehicles one such is the use of support vector machine which works on a binary classifier approach where it either detects an object or it doesn't. One other method is the use of faster convolutional neural network which tries to reduce the limitations of other convolutional neural networks it does it by using regional proposal networks where the sections of the data is been divided into regions and it is then passed for recognition purpose here the use of regions are made in such a way is that the performance of the system is not hampered and near real-time analysis for the data can be done.

Number Plate Detection

Number Plate Detection revolves around the capability of the methods to generate and extract the features related to digits and the number plate associated with it. Here is one of the approaches authors [14] Bogdan Tomoyuki Nassu et al, using a non-intrusive detection system the type of the vehicle is detected, there are various components used for the purpose of measuring the system type, here vehicles are detected along with text detection is done for recognizing the text of a number plate. Using this system certain features are tracked and selected on a license plate and these tracked features are used across multiple frames and any rectification for the tracked features is done using the convolutional network. In yolo the convolutional neural network performs the classification, along with the class probabilities and visualizing the object with a bounding box with one evaluation step. Due to its advantage of one-pass processing of data the network is optimized for performance thus the same can be used for detection of vehicles and number plate detection. To identify the movement of the vehicle and at the same time detect the license plate authors [8] Adel M. Alimi et AL, used convolutional network is used where the method works in tandem with the different layers of the network to obtain the required features for detection and classification of the object. In one approach authors [2] Shruti Gujral et al, with the use of K star algorithm vehicle type and the number plate is detected here k star method uses instance-based algorithm to check for the values that are missing and also perform smoothing of the constraints available. One of different approaches used by authors [1] Surya Prakash Sharma et Al, is the use of OCR (Optical Character Recognition) the name itself denotes that it performs the recognition of characters present on a given frame here it reads the number plate values available with character recognizer which is pre-trained for the different character types. Authors [11] S. P. Narote et al, using artificial neural network and genetic programming performed the detection of number plate where the classes of the objects are identified with the use of support vector machine. The survey of the different approaches provided by authors gave a glimpse of various unique methods for the recognition of objects here there are some approaches where the use of non- intrusive has been observed whereas others use intrusive method which consists of hardware as well as software for recognition of patterns in vehicles also it is observed not many systems provide a complete system where not only the recognition of type of vehicle but also the number plate is provided.

The summary of the various methods can be given below: -

TABLE – I

SUMMARIZATION OF SEVERAL METHODS FOR VEHICLE DETECTION

Method/Dataset	Accuracy Achieved	Output Achieved	Summary	Future Scope
Method: R-CNN (Regional Convolutional Neural Network) [9] Dataset: KITTI, BUU-T2Y	86%	Recognition of various objects from vehicle category	Using R-CNN the drawbacks for recognition of objects are reduced and accuracy, performance is increased.	To make an end to end structure and real-time.
Method: CNN (Convolutional Neural Network) [3] Dataset: low-quality traffic data	94.72%	Vehicle Type Classification	Using CNN feature extraction classification of vehicles is done.	
Method: Faster R-CNN [4] Dataset: COCO, VGG-16	76 %	Recognition of various objects from the vehicle category.	Using faster R-CNN the drawbacks for recognition of objects are reduced and accuracy, performance is increased.	To make an end to end system and achieve more performance for processing.
Method: Dirichlet		Classification of	Using DPMM	To improve for better

Process Mixture Model (DPMM) [5] Dataset: Manually collected traffic data	79.31%	objects (vehicles)	authors classified the object categories.	traffic management. Along with discriminative features for more specific object classification and driver discipline analysis.
Method: CNN (Convolutional Neural Network) [6] Dataset: U.S. traffic sign set images	90.82%	Classification of Traffic signal signs	Using CNN, the traffic signs are recognized.	To build an advanced driver assistance system is to achieve real-time traffic sign recognition.
Method: SURF (Speeded-Up Robust Features) [7] Dataset: Vehicle data from Vision-Based Intelligent Environment project	99.07%	Detection of the vehicle along with make and model of vehicle	Using SURF feature extraction of the make and model of the vehicle is done.	
Method: Rapid Learning Algorithm [10] Dataset: MIT CBCL, Caltech Database	95%	Recognition and classification of vehicles.	Using rapid and incremental learning technique classification of vehicles is performed.	
Method: Yolo (you look only once) [13] Dataset: UFPR ALPR	78.3%	Recognition of multiple objects.	Using YOLO architecture recognition of objects and category is performed.	Explore new approaches for CNN to optimize the detection.
Method: FCRN (Fully Convolutional Regression Network) [12] Dataset: Overhead Imagery Research Data set	93.30%	Classification of vehicles.	Using the FCRN vehicle classification of overhead imagery is done.	To focus on building a faster model to improve performance.

TABLE – II

SUMMARIZATION OF SEVERAL METHODS FOR VEHICLE NUMBER PLATE DETECTION

Method/Dataset	Accuracy Achieved	Output Achieved	Summary	Future Scope
Method: Sobel Edge Detection [1] Dataset: Vehicle Dataset (1200*1600 resolution)	90%	Vehicle Number Plate Detection	Using the K Star edge detection technique, the recognition of the vehicle number plate is performed.	Increase the performance and reduce the response time of the model along with creating an automated system.
Method: HOG, SVM [2] Dataset: Parked vehicles dataset	99%	Vehicle Number Plate Detection	Using HOG, SVM recognition of vehicle number plate is done.	To implement the system on blurred and distorted images.
Method: CNN (Convolutional Neural Network) [6] Dataset: U.S. traffic sign set images	90.82%	Classification of Traffic signal signs	Using CNN, the traffic signs are recognized.	To build an advanced driver assistance system is to achieve real-time traffic sign recognition.
Method: CNN (Convolutional Neural Network) [8] Dataset: AOLP, Caltech Database	93.80 %	Detection and recognize license plate for the vehicle	Using the CNN technique for recognizing the license plate of the vehicle.	To build a real-time system that can be portable.
Method: SSD (Single		Vehicle	Using SSD	The model would be

Shot Multibox Detector) [14] Dataset: Expressway Video	All vehicles apart from occluded images.	Detection on Expressway	technique recognition of vehicles is done.	extended to detect occluded and distant images with counting numbers of vehicles.
Method: ALPR Method [16] Dataset: Car Images	85%	Vehicle Number Plate Detection	ALPR system is applied to vehicle videos shot at parking exits	
Method: ALPR, Raspberry Pi microcontroller [17] Dataset: Vehicle Images Dataset	87.50%	Vehicle Number Plate Detection	Using ALPR and Raspberry Pi and Servo motor recognized vehicles are authorized	
Method: Neural Network [18] Dataset: Saudi Arabian vehicles	90%	Vehicle Number Plate Extraction	Using a Neural Network, the extraction of the Number plate has been done.	

3. OBSERVATION

a) Vehicle Type Classification

The survey of various approaches provides information about the different scenarios were classification and detection of vehicles is done. Here the segregation of vehicles is performed based on their attributes and feature selections the use of CNN (Convolutional Neural Network) provides us with the classification of images however for detecting multiple objects the method doesn't work. Thus, for the purpose of detecting multiple objects within a given frame, the use of different variants such as Fast R-CNN (Regional Convolutional Neural Network), Faster R-CNN (Regional Convolutional Neural Network), Yolo (you look only once) is used. Each of these has its advantages and disadvantages. As using R-CNN approaches detection of multiple objects is possible however due to the dependency of methods on multiple layers of processing the performance of the detection gets hampered also sometimes for some of the methods the data is parsed multiple times for detection purpose.

b) Number plate detection

From the various techniques for the purpose of number plate detection, various authors used a method such as HOG, SVM were using binary classifiers the detection of a number plate is performed. As HOG is a histogram of gradients differentiates the data based on feature descriptors of an input data these feature descriptors denote the classifier of the information. In SVM the property of binary classification is performed for number detection. One of the approaches used for the number plate detection is an edge detection technique where the classification of the numbers is done based on edges of each number here the shape of the number denotes the class. Number plate detection is done using a convolutional neural network where the features of each class are generalized for the purpose of recognitionOut of the multiple approaches Yolo (you look only once) tries to overcome the issues bypassing the data once through the model for prediction purposes. One of the approaches where the detection of the vehicle and its number plate can be done is with yolo method A block diagram for the yolo method is given in Fig.1.

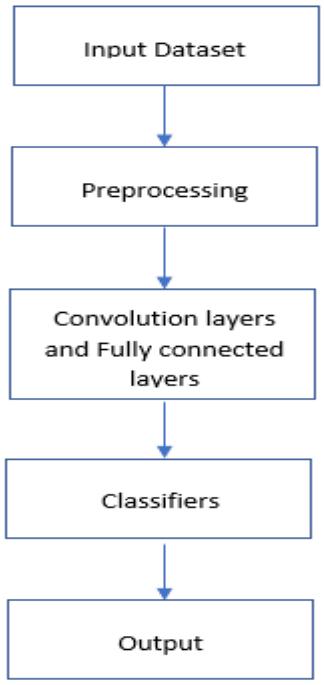

***Fig. 1**. Block Diagram for Yolo method*

The parameters used for the purpose of detection of objects within yolo are as:
their confidence values. In yolo the detection of an object is based on certain aspects they are:

(X, Y, H, W, C)

where (X, Y) is the x, y coordinates on an image.
' W' denotes the width of the object.
' H' denotes the height of the object.
' C' denotes the confidence value for the detected object.

The Class of an object and its confidence scores are given as:

$$P(\text{ObjClass}) * P(\text{Obj}) * IOU_{Truth}^{Predicted} = P(\text{Class}) * IOU_{Truth}^{Predicted} \quad \ldots\ldots (1)$$

In the yolo method, each box creates conditional probabilities for different classes which can be defined as

P (ObjClass | Object) ……. (2)

based on the object present in the grid, the probabilities are defined and conditioned. With the use of the yolo method, only a set of class probabilities are obtained per cell grid.
In the yolo method, the confidence is based on the term (IOU) Intersection over union which is given as

P(Obj) * IOU (predicted, truth) ……. (3)

In this, if no object is detected in the cell, then the score of confidence would be zero. Else the confidence score is equal to the intersection over union (IOU) for the predicted box and the ground truth.
As yolo uses bounding boxes for the purpose of detecting objects within the divided grids there is a limitation of a number of objects that can be detected. As within a grid if the object size is small the detection becomes a challenge thus to overcome such a scenario there is a need for high quality and clear images.

4. CHALLENGES/ISSUES

For the purpose of recognizing the vehicle type the challenges are the diversity of the type of vehicles of each category along with the quality of information that is used to train the model and how well balanced the dataset is to train the model. As the depth and granularity of the training increase, the data needs to be that rich as in the case of number plate detection where the number plate data needs to be precisely modeled. Some other challenges are in terms of type, color, the shape of the number plate and vehicle type were based on the different categories the variations of the features. There are also issues related to the occultation of vehicles in the given frame of relevance, whereas the vehicle in a given frame becomes smaller the model doesn't recognize it.

5. CONCLUSION

From the different approaches used for detection of the vehicle, the use of the intrinsic and non-intrinsic approach is observed where a dedicated system is being used to detect the vehicles and number plate recognition. however, the use of a non -intrinsic approach makes the use of the less dependent system and more of a software-based approach. From the survey, we are able to understand the various techniques used and its advantages and disadvantages, and the reason behind the effectiveness of various approaches. The above survey can provide one with the valuable understanding and directions for the approaches used. We have observed how different researchers using different methods outperformed others by evolving the techniques and understanding of various scenarios. Thus, with the rise of more and more computational power, machine learning algorithms will prove to be more beneficial for various classification and detection problems. From the papers discussed, there is a scope of increasing the capability and techniques for the detection of vehicles.

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