Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 2 (2024)

Integrated Deep Learning Solution and Fuzzy Logic for Accurate Vehicle Detection and Classification

HariharaganeshM,Himanshu (Asst. professor),Saurabh Premlal Tembhurne (Asst.professor)
dept. of computer science andengineering, Lovely Professionaluniversity Phagwara, Punjab

Abstract:-Vehicle detection plays an important role in the smart transportation system. It also played a significant role in various aspects like Traffic monitoring and management, Autonomous vehicles and Robotics, Surveillance and Security, advanced driver Assistance systems, Fleet Management, and Asset tracking. Also plays a critical role in various aspects of modern life, contributing to traffic efficiency, safety, security, and automation. The primary objective of this project is to examine the development and implementation of neural network models to predict vehicle models and detect vehicles within images.A number of typical network models have been applied in this training and classification experiments such as CNN (Convolutional Neural Network features), Classification model, and Fuzzy logic. This model will try to classify the vehicle with more accuracy.

Keywords: Convolution neural network, Fuzzy logic, Adam optimizer, Automation

1. Introduction

In these contemporary days, vehicle usage has increased drastically, leading to growing concerns about safety, traffic, etc. To address and solve this issue urban road tracking, traffic cameras, and safety systems were developed as more powerful which was automated, and intelligent and it also gave the information. Vehicle model classification is a crucial aspect in this field, and the key is to find the effective extract and describe the type of the vehicle, establish a robust classification model, and handle the real-time processing to find the large-scale images[4]. However, the real world or already existing problems do not cope with the influence of various factors, it did not classify the vehicle more accurately because of affecting environmental factors limiting their applicability. To address the issue a more precise way of identification and classification model was proposed. This model will study and learn the model with more number of vehicle model principles and liable label features[2].

The car is identified and classified in this study using a deep learning model called Convolutional Neural Network (CNN). A model called a convolutional neural network uses numerous layers of convolutional layers and filters to extract data from images. Each convolutional layer is linked to the activation function, and it is the convolutional layer that does the extraction. Those activation functions will introduce the nonlinearity in the data. Reducing the input's dimension through layer pooling in the CNN architecture will aid in lowering the model's complexity. The last layer, a dense layer, is in charge of determining how much each piece of data contributes to the final result[14].

The architecture is integrated with a fuzzy model to accurately classify the vehicle model. Fuzzy logic is in charge of multivalued logic, which addresses imprecision and uncertainty. The CNN's output is sent to the fuzzy layer. The classified feature map will be transformed into fuzzy sets via the fuzzification layer. All sets with a membership function defining the extent to which each element belongs to the set are called fuzzy sets.

Next, the accuracy metrics are computed for the fuzzy model's output, which will be used to illustrate the model's performance. Metrics such as the F1 score, precision, recall, specificity, and confusion matrix were employed to evaluate the model's predictive performance. Following that, the output is examined to verify the model's output.

2. Literature Review

Many methods for the detection and categorization of vehicles using different deep-learning models have been proposed in recent years. Convolutional neural networks, or CNNs, are the models of choice for image-based categorization according to numerous experts. After multiple iterations, the CNN model will attempt to extract features from the images; these iterations will correspond to the original image. Convolutional neural networks, or CNNs, are useful in a variety of domains where picture classification is important. This field was the focus of many researchers, and some references were

References	Publication Year	Algorithm	Summary	Future work
1	2021 IEEE	CNN, Softmax Activation	In this paper, the author used the shallow Convolutional Neural Network to extract the feature from the images that was generated from the input. After the CNN the Softmax Activation is used to classify them.	In future, with more number of input datasets and inclusion of multiple models will increase the accuracy of detection.
2	2018 IEEE	CNN	In this paper, the author aim to create a improved deep learning method of vehicle type detection from surveillance images and the author proposed the system based on the CNN.	The validation of the proposed system of this paper was worked fine with the public datasets however we can maintain the accuracy and work on improving it.
3	2019 IEEE	R-CNN R-FCN	In this paper, the author compares the five different mainstream model of deep learning for detecting vehicle through input images, namely faster model R-FCN, R-CNN, SSD, RetinaNet, YOLOv3 on the basis of the KITTI Datasets and analyse the obtained result.	In this paper, the author's main challenge is that balancing the real-time performance and accuracy. He says that the in-depth research is needed to solving this challenge.
4	2021	CNN	The author try to build the analysis of the traditional Haar-like vehicle recognition algorithm, a vehicle recognition algorithm based on a convolutional neural network with fused edge features (FE-CNN) is proposed.	For complex natural environment the algorithm's accuracy is still unstable. In the future, an in-depth will be conducted to improve the algorithm's speed, precision, and stability,
5	2021	CNN R-CNN	The author assess the performance of three state-of-the-art CNN algorithms, namely Faster R-CNN, which is the	As future work, the author intend to extend their accuracy to the newly released Efficient

			most popular region-based algorithm	detector and larger datasets of a input images.
6	2018 Science Direct	CNN, Faster RCNN, RPN	In this paper, the author applied the Faster RCNN, improved the RPN networks, Convolutional Neural Network of deep learning on object classification algorithm	In this article the author only classified for three types of car. In future he may increase the number of classifications.
7	2020 IEEE	R-CNN, Normalization, COST Function	In this paper, the vehicle detection by Faster R-CNN algorithm is tested and optimized by the method of model pruning and quantization	The future work of the author is that accuracy of the algorithm needs to be further improved.
8	2002 IEEE	CNN	Here the author tries to build the analysis of the traditional vehicle recognition algorithm based on a convolutional neural network is proposed.	In future work, the author need to work on increasing accuracy to the newly released Efficient and larger datasets of a input images.
9	2020	SVM, R-CNN	In this author, the proposed an implementation without retraining the deep learning models for object detection under different weather conditions.	In future the author tend to more time and energy to the creation of a better correction method which is general and adaptive method than this.
10	2019	CNN	In this paper, the author proposes a vision-based vehicle detection. 57,290 high definition highway vehicle dataset instances in 11,129 images is used in this study.	According to the author the input image, the cameras where mounted to obtain the internal and external of the vehicle to classify more.
11	2022 IEEE	CNN	In this paper, overview of deep learning for perception and its decision-making process based on images and LiDAR point clouds is discussed.	Here the author proposed the ensemble learning model acts as a future direction in segmentation, and hybrid learning is stated for future research on object detection
12	2022	Faster R-CNN, single-short detector	In this paper, the author proposed a system which can detect in two steps: vehicle detection and counting. Here he labelled the vehicle in six different labelled classes for classification.	According to the author, the surveillance cameras where mounted in certain angle to get the good vehicle images to classify more.

13	2019 IEEE	CNN, R-FCN, R-CNN	In this paper, the authors proposed the integration additional prediction layers into conventional Yolo-v3 using spatial pyramid pooling to complement the detection accuracy of the vehicle in large scale.	As future work, the author intend to extend their accuracy to the newly released Efficient detector and larger datasets of a input images.
14	2019 MDPI	Random Forest (RF), Support Vector Machine (SVM)	In this paper, the author used the realistic dataset to test and evaluate the proposed vehicle make and model Recognition system (VMMR).	In future the author says that . Dimensionality reduction techniques can be used to reduce this number. Deep learning models can be explored more with larger datasets.
15	2019	KNN	Here the author proposed that a set of data extracted from the front view of a vehicle is used to determine the vehicle type with higher accuracy.	In the future the author says that to attain the performance of other forms of single-class classifier on this problem.

3. Methodology

The proposed work of identifying and classification of vehicles is done through the convolutional neural network (CNN) and fuzzy system integrated in it. This system integration will help to identify and classify the model with more precise output. The CNN will try to extract the features from the images and the fuzzy system will try to identify the uncertainty and imprecision in the data. Below is the methodology of the study, which includes data collection and pre-processing,

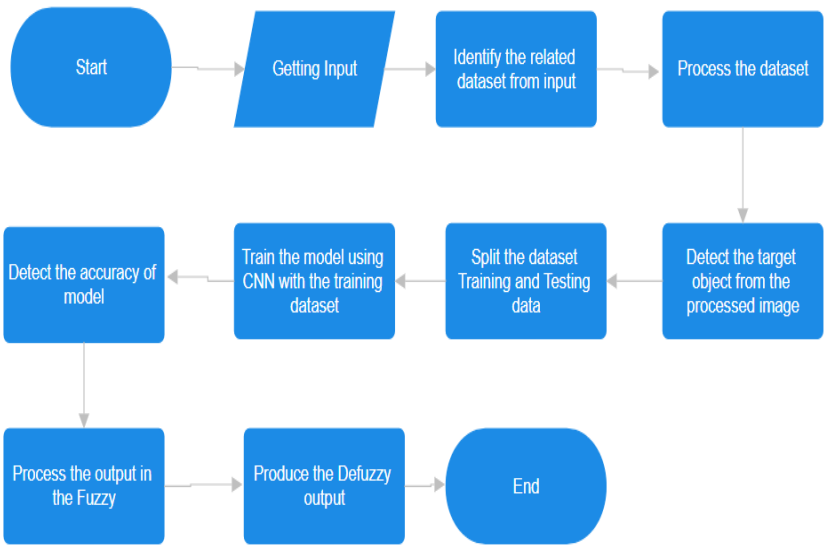

Fig 1:- Explain the workflow of the CNN model and Fuzzy system integration

3.1. Data collection and pre-processing

[3]Obtain another dataset of annotated photos with different kinds of cars taken from different angles and in diverse environments. A variety of vehicle types, including ambulances, cars, trucks, autos, buses, and more, are included in the dataset. The process of identifying and fixing erroneous or corrupt records from a dataset is known as pre-processing. The forms and size of the photos are incorrect. To ensure uninterrupted model operation, it should be adjusted to the same size and dimensions. The dataset is normalized in order to standardize the feature values within it. [8]The dataset will be brought into a similar scale through normalizing, convolutional neural network (CNN) and the Fuzzy system. The output is measured with the metrices like F1 score, accuracy, precision, recall.

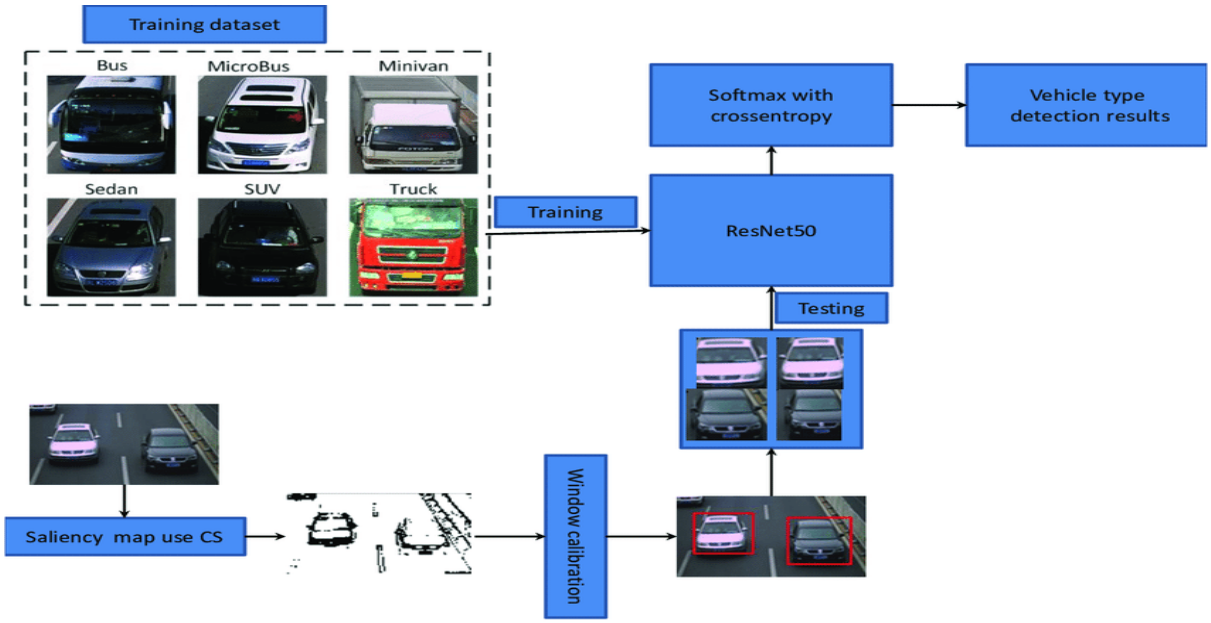

Fig2:-Vehicle prediction model"https://www.researchgate.net/figure/Diagram-of-vehicle-type-detection-based-on-CS-and-deep-learning_fig2_329795358"

3.2 Convolution neural network

In vehicle detection, the Convolution neural network (CNN) plays an important role. The pre-processed dataset is passed as a input for the CNN model. In this study, CNN is used to extract the features from the images and it will classify them accordingly[1]. Like in common CNN, here in the problem, all three layers below were used.

- Convolution layer
- Pooling layer
- Fully connected layer

In CNN, the model will undergo the training process with the various images and try to get the difference of features from it and it will classify the images with the extracted classification. Likewise, here is the image which we need to pass the image of the vehicle which is to be classified as the input. The classification model will try to classify the image by undergoing different types of features which was extracted. For that, we need to convert the images into the data. The image is basically three-dimensional data, where in every pixel it will contain the intensity or the contribution that was provided to the images. For e.g., if a pixel has a high value (255,255,255) then the contribution of the pixel is high in the image.

The Convolution layer in the Convolution neural network (CNN) is responsible for the extraction of different features from the distinguishing vehicle images. The features will include the size of the vehicle, color, headlight size, shape of the head, etc..,. Basically, it will identify the contours in the image[5]. Contours means the curve or shape that joins all the boundaries and edges in the image. The convolution layer has many layers of filters which were applied to the input images so that each layer will give different varieties of features. The

output of each filter was called a feature map, which holds the strength or contribution of that pixel on that image.

The pooling layers of a Convolution neural network (CNN) for a vehicle model classification are responsible for reducing the dimension of the obtained feature maps of the feature from the output of the convolution layer. In pooling there are some methods to identify and extract the features,

- Max pooling
- Average pooling

With the help of the pooling methods, the model will get the highly contributed area of each area of the input, so that it will effectively reduce the size of the feature map. In the pooling layer, it extracts some useful features from the extracted feature map which will highly contribute to the classification.

For the final classification of the model, the vehicle model classification in a Convolution neural network (CNN) is Fully connected layers, which are responsible for the final output classification or prediction of the vehicle. As a rule, they will come after the pooling layers, which will take the input as the extracted feature maps of the pooling layer. Here they connect all of the neurons in one layer to all of the neurons in the next layer.[12] These fully connected layers will take the reduced feature map from the pooling layers and it will combine and it will undergo many probability distributions to find the possibility of a vehicle. Then the model with the highest probability will be chosen as the final classification[13].

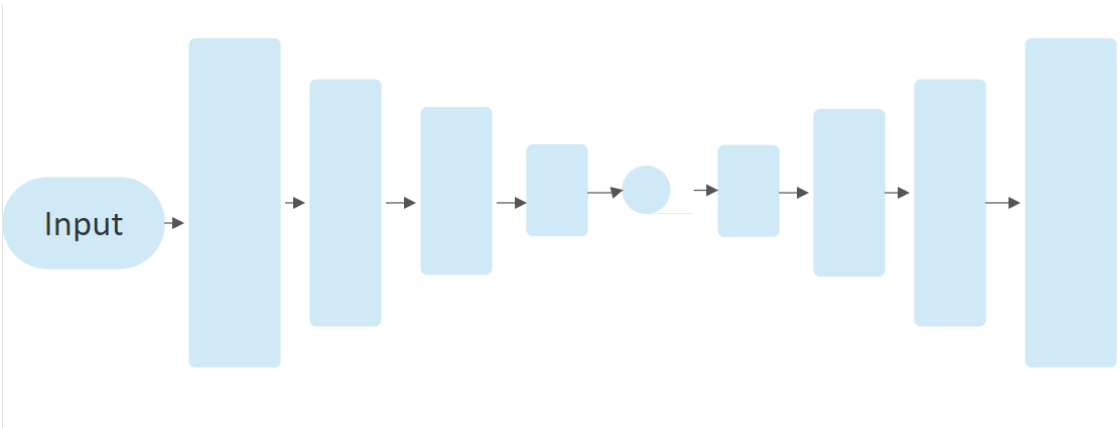

Fig 3:- Basic Structure of the Convolution Neural Network.

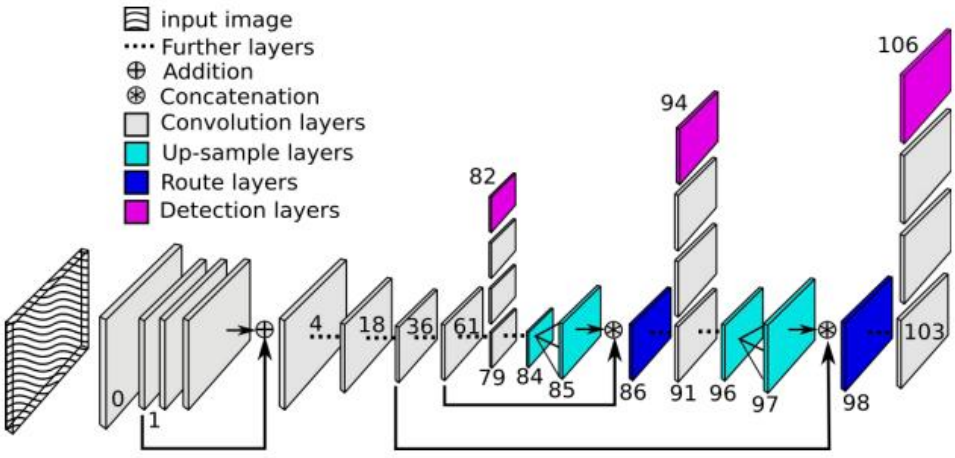

Fig 4:- M. Hassaballah, Mourad A. Kenk, Khan Muhammad, Shervin Minae in the paper "Vehicle Detection and Tracking in Adverse Weather Using a Deep Learning Framework" in IEEE 2021

In cases where the model has errors or losses, backpropagation is employed. The model's result is used to calculate the loss function. The adaptive moment estimation in backpropagation (ADAM). The cross-entropy loss function is used by the model, and backpropagation is carried out if the function is triggered. Calculating the differentiation of the output based on the output obtained with the output of the previous iteration is how backpropagation is carried out.

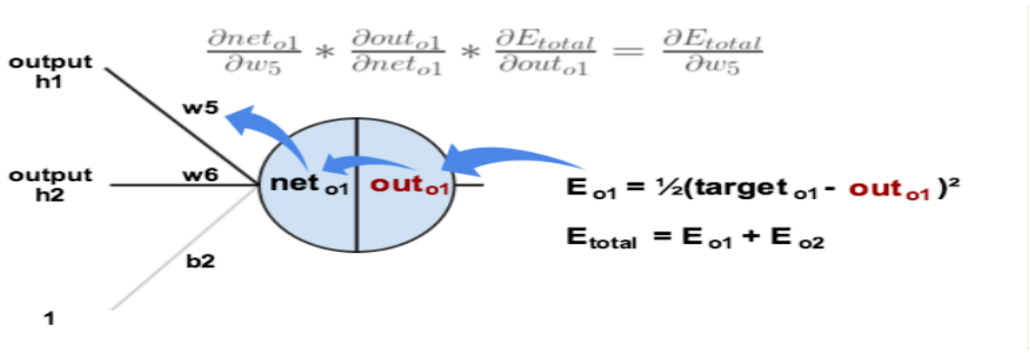

Fig5:- Backpropagation equation "https://mattmazur.com/2015/03/17/a-step-by-step-backpropagation-example/"

3.3 Fuzzy

Fuzzy is the multivalued logic that deals with the uncertainty and imprecision. It will mainly focus on the degree or value of the truth rather than going by true or false. Typical Fuzzy logic contains three layers,

- Fuzzification
- Inference
- Defuzzification

In the Fuzzification stage, the output of the fully connected layers of the Convolution neural network (CNN) is passed as an input. The Fuzzification layer will convert the classified feature map into fuzzy sets. Fuzzy sets are nothing but sets that have a membership function that defines the degree to which each element belongs to the set. For example, the output of the Convolution neural network (CNN) will provide the probability distribution of the classification. In fuzzy this could be converted into fuzzy sets by defining the membership functions that map the probability to the degrees of membership.

The inference stage of the Fuzzy model uses the fuzzy sets to make the inferences about the output. The inference layer contains many fuzzy rules. These fuzzy rules are nothing but the scaling of the probability for different ranges in the fuzzy sets. For example, Rule 1 – if the CNN output is 'low' then it was the 'A' or it was the different letters.

The defuzzification stage deals with the output of the inference stage and converts it back into the crisp values. These will be done using a defuzzification method. These are the techniques for selecting the most appropriate value from the fuzzy set.

4. Conclusion

In conclusion, for vehicle detection and classification, the combo of the Convolution neural network and the Fuzzy logic effectively classified the images with more accurate values. With the help of the CNN the model has processed the various aspects of feature maps in the videos and images, and with the help of the Fuzzy the model has processed the uncertainty in the the input data. This combination has been proved from the above output it shows more accuracy and robustness in vehicle detection, and real-time performances of vehicle detection systems, making them a valuable model for detection and classification.

\

References

[1] Dr. P.Ajitha, Jeyakumar. S, Yadhu Nandha Krishna K, Dr. A Sivasangari (2020) "VEHICLE MODEL CLASSIFICATION USING DEEP LEARNING".

[2] Jitian Wang, Han Zheng, Yue Huang, Xinghao Ding (2018)"Vehicle Type Recognition in Surveillance Images From Labeled Web-Nature Data Using Deep Transfer Learning".IEEE

[3] Hai Wang and Yijie Yu, Yingfeng Cai, Xiaobo Chen, Long Chen (2019)"Qingchao Liu A Comparative Study of Stateof-the-Art Deep Learning Algorithms for Vehicle Detection". IEEE

[4] Linrun Qiu · Dongbo Zhang, Yuan Tian, Najla Al Nabhan (2021)"Deep learning based algorithm for vehicle detection in intelligent transportation systems".

[5] Adel Ammar, Anis Koubaa, Mohanned Ahmed, Abdulrahman Saad, Bilel Benjdira (2021)"Vehicle Detection from Aerial Images Using Deep Learning: A Comparative Study".

[6] L I Suhaoa, LIN Jinzhaoa, LI Guoquana, BAI Tonga, WANG Huiqiana, PANG Yua (2018)"Vehicle type detection based on deep learning in traffic scene". Science direct.

[7] QULIN TAN, JUAN LING, JUN HU, XIAOCHUN QIN, JIPING HU (2020)"Vehicle Detection in High Resolution Satellite Remote Sensing Images Based on Deep Learning". IEEE

[8] Surendra Gupte, Osama Masoud, Robert F. K. Martin, Nikolaos P. Papanikolopoulos (2002)"Detection and Classification of Vehicles".IEEE

[9] Xiu-Zhi Chen, Chieh-Min Chan, Chao-Wei Yu, Yen-Lin Chen (2020)"A Real-Time Vehicle Detection System under Various Bad Weather Conditions Based on a Deep Learning Model without Retraining"

[10] Huansheng Song, Haoxiang Liang, Huaiyu Li, Zhe Dai, Xu Yun (2019)"Vision-based vehicle detection and counting system using deep learning in highway scenes"

[11] HRAG-HAROUT JEBAMIKYOUS, RASHA KASHEF (2022)"Autonomous Vehicles Perception (AVP) Using Deep Learning: Modeling, Assessment, and Challenges". IEEE

[12] Usha Mittal, Priyanka Chawla (2022)"Vehicle detection and traffic density estimation using ensemble of deep learning models"

[13] Kwang-Ju Kim, Pyong-Kun Kim, Yun-Su Chung, Doo-Hyun Choi (2019)"Multi-Scale Detector for Accurate Vehicle Detection in Traffic Surveillance Data". IEEE

[14] Muhammad Asif Manzoor, Yasser Morgan, Abdul Bais (2019)"Real-Time Vehicle Make and Model Recognition System".

[15] Daniel T. Munroe, Michael G. Madden (2019)"Multi-Class and Single-Class Classification Approaches to Vehicle Model Recognition from Images".

[16] T.-Y. Lin, M. Maire, S. Belongie, J. Hays, P. Perona, D. Ramanan, P. Dollar, and C. L. Zitnick, (2014) "Microsoft coco: Common objects in ´ context," in European Conference on Computer Vision. Springer.

[17] M. Everingham, L. Van Gool, C. K. Williams, J. Winn, and A. Zisserman, (2010) "The pascal visual object classes (voc) challenge," International journal of computer vision.

[18] O. Russakovsky, J. Deng, H. Su, J. Krause, S. Satheesh, S. Ma, Z. Huang, A. Karpathy, A. Khosla, M. Bernstein, et al., (2015) "Imagenet large scale visual recognition challenge," International Journal of Computer Vision.

[19] Sriashika Addala,(2020) "Vehicle Detection and Recognition". IEEE.

[20] Chandaka Babi, Y. Sai Gayatri, M. V. Sri Vishnu, Y. Amit Shreyas, (2023) "VEHICLE MODEL PREDICTION USING MACHINE AND DEEP LEARNING TECHNIQUES". Industrial Engineering Journal.

[21] A Krizhevsky, (2012) “Imagenet Classification with Deep Convolutional Neural Networks: Advances in Neural Information Processing Systems".

[22] [illegible] Zhou, (20[illegible]) “Image Based [illegible] Analysis [illegible] Neural Network: A Systematic Study”.