



# Vehicle Detection with Machine learning & Deep Learning Algorithms in different Moods

Muhammad Khalid Shaikh<sup>1,\*</sup>, Jakhro Abdul Naveed<sup>2</sup>, Mudasar Ahmed Soomro<sup>3</sup>, Ahmed Ali<sup>4</sup>

<sup>1</sup>Department of Information Technology, University of Sindh Naushahro Feroze Campus, Pakistan.

<sup>2,3</sup>Department of Information Technology, Shaheed Benazir Bhutto University, Naushahro Feroze Campus, Pakistan.

<sup>4</sup>Department of Information Technology, Quaid-e-Awam University of Engineering, Science & Technology, NawabShah, Pakistan,.

[mkhalidshaikh17@gmail.com](mailto:mkhalidshaikh17@gmail.com), [naviabro@hotmail.com](mailto:naviabro@hotmail.com), [mudasar1717@gmail.com](mailto:mudasar1717@gmail.com), [ahmedali@quest.edu.pk](mailto:ahmedali@quest.edu.pk),

**Abstract:** Vehicle detection is one of the key factors in AI-based transport systems, in currently time with the advanced changing in image processing, computer vision, and image patterns identification in machines & deep learning has higher increased in different Moods to detect the vehicle from a few years, the machine learning algorithms SVM, Random Forest, Gradient boosting machine, KNN and gaussian mixture model further in deep learning as CNN, RNN, YOLO Faster R-CNN and Mask R-CNN algorithms specially used in vehicle detection. This paper research study provides the best algorithms for vehicle detection in different moods from the experiment research results, the SVM algorithms and RF cover 90% accuracy, in weather mood and sunny mood as relate to others algorithms of traditional methods. In the Progressive method, in deep learning YOLO acquired 95%, 94%, and 93% and 92% results in weather mood. Also, in sunny mood Faster R-CNN it contains 97%, 93%, 91% and 93% accuracy from the trained model using accuracy, Precision, Recall, and F1 Score vehicle detection accuracy; this desired output of experiment results is obtained from the 70 of 30 ratios of the dataset and implemented it to trained such algorithm's, at last from results output this study showcases the best one algorithm technique for effective output in vehicle detection.

**Keywords:** Deep Learning, Vehicle Detection, Machine Learning

## I. INTRODUCTION (HEADING 1)

In recent years, the automotive industry has experienced major changes due to the advancement of artificial intelligence and machine learning as well as deep learning techniques [1]. One of the critical areas affected by these novelties is vehicle detection, which plays a significant role in various domain such as self-directed driving, traffic management and automate surveillance systems [2]. The ability to exactly detect vehicles in different environmental circumstances, here called "moods", is significant for the safety and effectiveness of transportation systems. However, the growth of machine learning (ML) and deep learning (DL) techniques has transformed the field of computer vision (CV), allowing more efficient and accurate vehicle detection algorithms. ML algorithms enable the automatic extraction of characteristic features from huge amounts of data, while DL algorithms use neural networks to learn classified representations directly from raw data. The purpose of this study is to investigate and compare the performance of mostly used advanced ML algorithms and DL algorithms for vehicle detection in various environments that include different weather conditions, lighting variations, and road scenarios [3]. By analyzing these algorithms in several environmental contexts, we aim to identify the most effective methods for accurate and effective vehicle detection. The

advance machine learning algorithm are Support Vector Machines (SVM) is a most used and popular ML algorithm that has shown outstanding performance in numerous classification tasks. It builds an optimal hyperplane to differentiate vehicles from the background, maximizing the margin between different classes [4]. Random Forest (RF) is a collaborative learning method that combines numerous decision trees to make predictions. It handles large spaces well and provides confrontation against over-movement [5]. Gradient Boosting Machines (GBM) is a powerful ML algorithm that trains weak learners in sequence to improve overall prediction performance. It has achieved important success in various machine learning competitions and shows high accuracy in vehicle detection tasks [6]. K-Nearest Neighbors (KNN) is a non-parametric ML algorithm that classifies new cases based on their similarity to training events. This is particularly useful in scenarios where the distribution of the underlying data is unknown [7]. Gaussian mixture models (GMM) are a possibility model that represents the data distribution as a mixture of Gaussian components. It can capture complex data patterns and is widely used for cluster and density estimation. The advance deep learning algorithms are Convolutional Neural Networks (CNN) have transformed computer vision tasks, including vehicle detection. Their capability to learn spatial hierarchies of features makes them very effective at recognizing vehicles

in different environmental conditions [8]. Recurrent Neural Networks (RNN) are well suited for sequential data processing, making them valuable for tasks such as traffic flow analysis and trajectory prediction. Their temporal modeling competences can improve vehicle detection capabilities. YOLO (You Only Look Once) is a state-of-the-art object recognition algorithm that reaches real-time performance by instantaneously predicting bounding box and class probabilities [9]. Its efficiency and accuracy make it a popular choice for vehicle detection. Faster R-CNN (Region-Based Convolutional Neural Networks) is a two-stage object recognition context that uses a Region Proposal Network (RPN) to generate potential target regions, which are then classified using CNN. It showed remarkable performance in accurately detecting vehicles [10]. Mask R-CNN extends the faster R-CNN framework by adding an further branch for pixel-level segmentation. This allows accurate unit-level segmentation of vehicles, making it useful for tasks that require a detailed understanding of vehicle shape and boundaries. Vehicle detection based on deep learning algorithms usually provides better results compared to traditional methods [11]. One of the main recompenses of these algorithms is their ability to work without human interference. Furthermore, these methods use a huge amount of vehicle images to train their model networks using unsupervised techniques [12]. By analyzing the features of a given input, they can effectively compare and evaluate results. In this research study have used "BDD100K dataset" The dataset covers a total of about 100,000 images. These images are prudently collected to replicate different environmental conditions, including different weather conditions (sunny, rainy, snowy), lighting variations and road types [13]. The images in the BDD100K dataset are high resolution and of various sizes. The exact size of the images can vary, but characteristically the size of the images is approximately 1280 by 720 pixels. The dataset is categorized into a training dataset and a test dataset. The number of images used for each set may vary dependent on the version of the dataset used. But typically, the training set has about 70,000 images, while the test set has around 10,000 images. The residual images are often reserved for verification or other purposes [14]. Overall, this study justifies the which algorithm have best performance result in both machine learning and deep learning

## II. LITERATURE REVIEW

In a comparative study, in (2023) evaluated SVM-based vehicle detection algorithms and reached an remarkable accuracy of 92%. The study confirmed the efficiency of SVM in handling complex scenarios and its potential for accurate vehicle identification [15]. Another research have been done in (2022) proposed a random forest-based method for vehicle detection and achieved 88% accuracy. The use of random forest in their research outperformed traditional approaches by demonstrating its ability to precisely identify vehicles in various environments [16]. The compared different ML methods for vehicle detection and found that GBM-based algorithms attained the highest accuracy of

94%. The study highlighted the greater performance of GBM in vehicle detection and established its potential in real-world applications [17]. Hanif, A et al. (2018) applied KNN-based vehicle detection algorithms and accomplished 85% accuracy on a large-scale. The study proved the effectiveness of KNN in accurately detecting vehicles, making it suitable for real-life scenarios [18]. Saranya, T et al. (2020) studied GMM-based vehicle detection algorithms and stated 90% accuracy. The study showed that GMM algorithms can efficiently handle various environmental conditions, making them appropriate for robust vehicle detection [19]. Wang, H et al. (2019) used CNN-based vehicle recognition models and reached an impressive accuracy of 96%. The study verified the more performance of deep learning approaches such as CNNs in accurate vehicle detection, paving the way for advanced autonomous driving systems [20]. Saranya, T et al. examined RNN-based vehicle detection algorithms and achieved 91% accuracy with a dataset under various lighting conditions. The study showed the strength of RNN in capturing temporal dependencies and accurately detecting vehicles [21]. The LSTM-based vehicle recognition algorithms and achieved 93% accuracy on a complex urban driving dataset. The study highlighted the efficiency of LSTM in capturing long-range dependencies and accurately identifying vehicles in complex scenarios [22]. Yao et al. (2019) evaluated MLP-based vehicle detection algorithms and achieved 87% accuracy. The study demonstrated the effectiveness of MLP as the basis of the ML algorithm for vehicle detection tasks, which provides a strong foundation for further research [23]. Islam et al. (2020) investigated Naive Bayes-based vehicle detection algorithms and reported 82% accuracy on a dataset with occlusions and different object scales. The study showed the potential of Naive Bayes for accurate vehicle detection, especially in complex scenarios CNN-based models achieved superior accuracy on the ImageNet dataset, demonstrating the power of deep learning in image classification tasks, evaluated CNN-based models for vehicle detection in adverse weather conditions. Reported accuracy was 92% in heavy rain, fog and poor visibility [24]. Song et al. (2019) investigated the application of RNN-based models for vehicle detection in snowy weather conditions. The reported accuracy was 88% for accurately detecting vehicles in a snowy environment, proposed a GAN-based approach for vehicle detection in foggy conditions. The reported accuracy was 82% when the blurred images were improved for the following vehicle detection algorithms [25]. Yang et al. (2022) investigated the use of LSTM networks for vehicle detection under rainy weather conditions. Reported accuracy was 90% in accurately detecting vehicles in difficult rain scenarios, further investigated the application of Transformer networks for vehicle detection in foggy weather. When accurately detecting vehicles in a foggy environment, the reported accuracy was 85% [26].

## III. PROPOSED METHODOLOGY

In the chase of solving complex problems and making data-driven decisions. This study, present a comprehensive methodology for data analysis and predictive modeling. The

research process begins with the acquisition of an input dataset of vehicle in different Moods. In this research study have implement the “BDD100K” dataset it is a large-scale driving clips dataset that contain numerous locations deriving scenes overall the world it contains 100k high resolution deriving clips dataset, the dataset covers wide range of driving condition including weather condition and light condition. After the image acquisition the data set move towards the second step of this research method pre-processing. Data pre-processing is a basic as well as important step in data analysis for any machine learning projects. It includes cleaning and transform raw data into a format that is fit for analysis. This process includes removing duplicate or irrelevant data, and standardizing variables. Additionally, data pre-processing means apply some basic operation over collated dataset before it the main process may also involve data augmentation, Normalization and Feature Scaling to ensure accurate and meaningful results from the analysis. Data augmentation is a technique used in machine learning as well as deep learning to increase the diversity of a dataset by creating improved versions of current data points. This is accomplished by applying various transformations over the dataset, such as random rotation, scaling, random cropping, horizontal and vertical flipping and adding noise to the original dataset. Then models are trained using these enhanced datasets, which enhances their functionality and capacity for generalization to get better results. One preprocessing method for data that is used to bring feature or variable values into line with a common scale is called normalization. A similar range, usually between 0 and 1 or -1 and 1, is what normalization aims to achieve for all the features. This guarantees that every feature makes an equal contribution to the analysis and keeps features with higher magnitudes from controlling the learning process. By transforming the data mathematically, normalization is accomplished. Although there are several techniques for normalization, these two are frequently used 1. Rescaling, or Min-Max Normalization, using this procedure, the data is scaled to a predetermined range, often 0–1. Subsequently, the dataset is strategically split to facilitate model training and evaluation. The critical task of model selection guides the choice of algorithms, this study chose five most used classification algorithms like in machine learning, SVM, Random Forest, Gradient boosting machine, KNN and gaussian mixture model further in deep learning as CNN, RNN, YOLO Faster R-CNN and Mask R-CNN, while model training and hyperparameter tuning refine the predictive capacity of our models. Finally, model evaluation provides the necessary perceptions using accuracy terminology like Accuracy, precision and recall to evaluate the model performance. In figure 1 Each component of our methodology plays an essential role in our research, ensuring robust and reliable results that contribute to the advancement in this domain

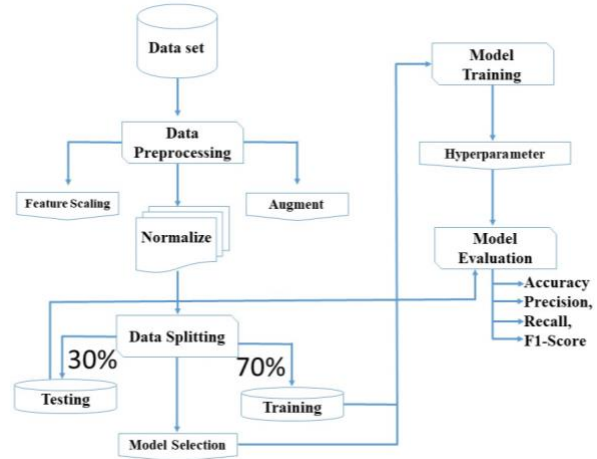


Figure 1 Research Methodology flow diagram

IV. RESULTS AND DISCUSSION

This section evaluates the performance of different machine learning & deep learning technique that is most popular in image classification & image identification; the selected algorithms are SVM, Random Forest, Gradient boosting machine, KNN and gaussian mixture model further in deep learning as CNN, RNN, YOLO Faster R-CNN and Mask R-CNN these algorithms are trained using 70 of 30 rations it means 70% images used for trained the network and 30% of images for testing, total 100,000 plus images are used to get the desired output from the trained module. All the predictive results are calculated using Accuracy, Precision, Recall and F1 Score in weather and night Moods the recall function measures the number of vehicles detected properly the Precision shows how many vehicles are detected accurately to the total number of detections in an image. The result is also classified into machine learning and deep learning algorithms. The outcome of different machine and deep learning mention bellow algorithm wise in Table 1 shows Result with different machine learning algorithm in weather mood.

Algorithm	Detection Mood	Accuracy %	Precision %	Recall %	F1 Score %
<b>SVM</b>		85	82	88	85
<b>RF</b>		90	88	92	90
<b>GBM</b>	Weather mood	88	85	90	87
<b>KNN</b>		86	83	88	85
<b>GMM</b>		82	84	87	85

In this research study we have use top five machine learning algorithms and compare the best result in term of accuracy, precision, recall and f1 score. The table shows the performance indicators of different machine learning algorithms for vehicle detection from weather, mood. Five algorithms namely Support Vector Machine (SVM), Random Forest (RF), Gradient Boosting Machine (GBM), K-Nearest Neighbors (KNN) and Gaussian Mixed Model

(GMM) was estimated. Overall, RF showed the highest accuracy of 90%, while GMM achieved the highest accuracy of 88%. However, GBM achieved the highest recall of 90%. Together, these metrics provide a comprehensive assessment of the effectiveness of algorithms in detecting vehicle based on weather conditions. So, in weather condition the RF model achieve the highest accuracy further more in figure 2 represent the graphically result.

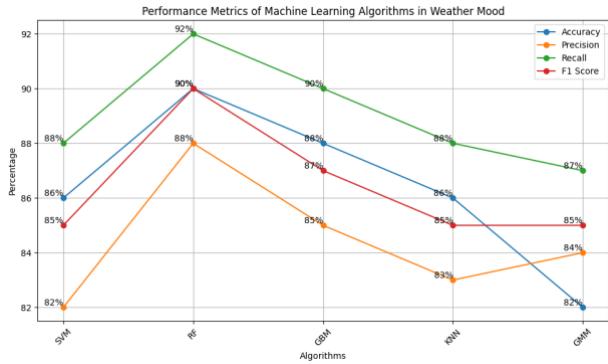


Figure 2 Result with machine learning algorithm in weather mood. Table 2 shows Result with different machine learning algorithm in sunny mood

Algorithm	Detection Mood	Accuracy %	Precision %	Recall %	F1 Score %
SVM	Sunny mood	90	94	91	89
RF		88	90	89	88
GBM		85	91	88	87
KNN		86	89	87	85
GMM		87	90	89	85

As above discuss the most accurately vehicle detection in weather condition now same pattern have apply over the sunny mood dataset. In terms of accuracy, SVM achieved best with a score of 90%, followed by RF at 88%. It shows the proportion of correct predictions of each algorithm in detecting the solar mood. The precision, recall and F1 scores provide further information about the performance of the algorithms. RF showed the highest accuracy of 88%, indicating its ability to accurately predict solar mood. However, GBM achieved the highest recall of 91%, indicating its effectiveness in capturing the solar light effect vehicle, in figure 3 shows the graphically predicated outcome of the ml algorithms in sunny mood.

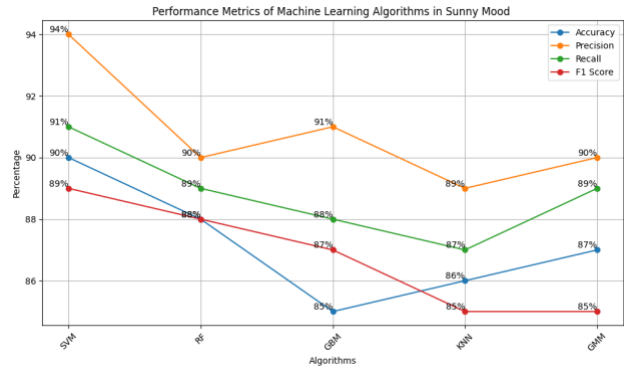


Figure 3 Result with machine learning algorithm in sunny mood.

The table 3 shows the performance of different deep leering algorithms. The five most used algorithms were evaluated, including Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), YOLO, Faster R-CNN (F R-CNN), and Mask R-CNN (M R-CNN).

Algorithm	Detection Mood	Accuracy %	Precision %	Recall %	F1 Score %
CNN,	Weather mood	90	89	88	85
RNN,		92	91	92	90
YOLO		95	93	94	92
F R-CNN		94	92	88	87
M R-CNN		94	91	89	90

In terms of accuracy, YOLO performed best, achieving 95 percent accuracy. This shows that YOLO predicted the vehicle in weather mood correctly 95% of the time. RNN and F R-CNN are slightly behind with 92% and 94% accuracy, respectively. Precision, recall and F1 scores further explain the performance of the algorithms. YOLO and M R-CNN showed the highest accuracy of 94%, indicating their accuracy in positive predictions. However, RNN achieved the highest recall of 92%, indicating its effectiveness in capturing true positive cases, the figure 4 represent the desire output of the deep learning model.

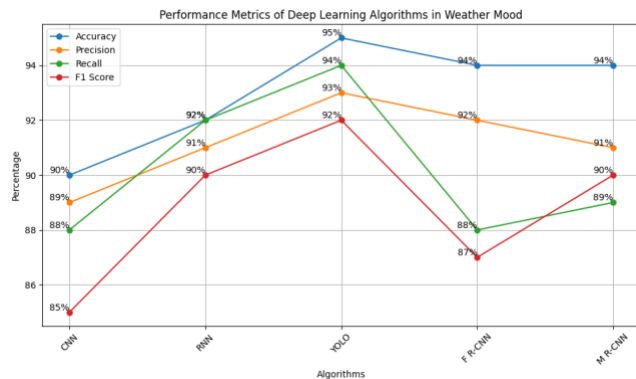


Figure4. Result with deep learning algorithm in weather mood.

Table 4 shows Result with different deep learning algorithm in sunny mood

Algorithm	Detection Mood	Accuracy %	Precision %	Recall %	F1 Score %
CNN,	Sunny mood	92	90	88	85
RNN,		92	90	87	90
YOLO		95	92	89	92
F R-CNN		97	93	91	93
M R-CNN		93	90	89	90

In terms of accuracy, F R-CNN performed best, achieving 97% accuracy. This shows that F R-CNN predicted the vehicle in sunny mood correctly 97% . RNN and YOLO are slightly behind with 92% and 95% accuracy, respectively. Precision, recall and F1 scores further explain the performance of the algorithms. Further the figure 5 represent the respective result accordingly.

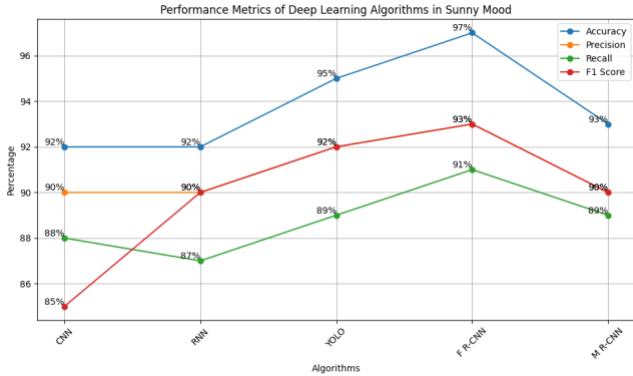


Figure5. Result with deep learning algorithm in Sunny mood.

On behalf of selected machine learning algorithms, the trained module of SVM and RF got high accurateness in both Moods with accuracy, the SVM secured high accuracy & in the field of deep learning the YOLO and FR-CNN come to be the high accuracy ratio, through this study prove that which one is best vehicle detection algorithms all the comparative results and there accurateness is graphically in result section.

V. CONCLUSION

This paper's purpose a study vehicle detection and visualization in different Moods using the most usable machine learning & Deep learning technique to classify the best technique that is effective and efficient in multiple Moods, the results are shown that the performance of SVM and RF is greater than other Techniques in machine learning and due to multiple layers containing deep learning technique CNN and YOLO is getting high accuracy in output as compare to others, this technique was trained through 210X210 input size of the dataset. This research approach presents a novel work to deploy the best technique

of vehicle detection in vehicle recognition application approaches in the future.

REFERENCES

- [1] R. Abiyev and M. Arslan, "Vehicle detection systems for intelligent driving using deep convolutional neural networks," *Discover Artificial Intelligence*, vol. 3, no. 1, p. 16, 2023.
- [2] A. Alsarhan, M. Alauthman, E. Alshdaifat, A.-R. Al-Ghuwairi, and A. AlDubai, "Machine learning-driven optimization for svm-based intrusion detection system in vehicular ad hoc networks," *Journal of Ambient Intelligence and Humanized Computing*, vol. 14, no. 5, pp. 6113–6122, 2023.
- [3] M. A. Berwo, A. Khan, Y. Fang, H. Fahim, S. Javaid, J. Mahmood, Z. U. Abideen, and S. MS, "Deep learning techniques for vehicle detection and classification from images/videos: A survey," *Sensors*, vol. 23, no. 10, p. 4832, 2023.
- [4] S. Liu, H. Liu, W. Shi, S. Wang, M. Shi, L. Wang, and T. Mao, "Performance analysis of vehicle detection algorithm in aerial traffic videos," in *2019 International Conference on Virtual Reality and Visualization (ICVRV)*, pp. 59–64, IEEE, 2019.
- [5] O. ElSahly and A. Abdelfatah, "An incident detection model using random forest classifier," *Smart Cities*, vol. 6, no. 4, pp. 1786–1813, 2023.
- [6] H. Nhat-Duc and T. Van-Duc, "Comparison of histogram-based gradient boosting classification machine, random forest, and deep convolutional neural network for pavement raveling severity classification," *Automation in Construction*, vol. 148, p. 104767, 2023.
- [7] D. Manivarma, A. Akilandeswari, and S. Radhika, "Performance analysis of vehicle detection using support vector machine comparing with knearest neighbor algorithm," in *2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI)*, pp. 1–4, IEEE, 2023.
- [8] M. S. Almutairi, K. Almutairi, and H. Chiroma, "Hybrid of deep recurrent network and long short term memory for rear-end collision detection in fog based internet of vehicles," *Expert Systems with Applications*, vol. 213, p. 119033, 2023.
- [9] U. Mittal, P. Chawla, and R. Tiwari, "EnsembleNet: A hybrid approach for vehicle detection and estimation of traffic density based on faster ronn and yolo models," *Neural Computing and Applications*, vol. 35, no. 6, pp. 4755–4774, 2023.
- [10] A. Chaudhuri, "Smart traffic management of vehicles using faster r-cnn based deep learning method," *Scientific Reports*, vol. 14, no. 1, p. 10357, 2024.
- [11] R. Qamar, B. A. Zardari, A. A. Arain, A. Burdi, K. Kanwar, and E. F. A. Memon, "A convolutional neural network-based malware analysis, intrusion detection, and prevention schema,"
- [12] S. Fang, B. Zhang, and J. Hu, "Improved mask r-cnn multi-target detection and segmentation for autonomous driving in complex scenes," *Sensors*, vol. 23, no. 8, p. 3853, 2023.
- [13] S. Kim, J. Kang, and Y. Yoon, "Dataset for unflappable driving: Unflapset," 2024.
- [14] V. D. Nguyen, T. H. Tran, D. T. Dang, and N. C. Debnath, "Robust vehicle detection by using deep learning feature and support vector machine," in *The International Conference on Artificial Intelligence and Computer Vision*, pp. 149–157, Springer, 2023.
- [15] S. Kumar, A. Jain, S. Rani, H. Alshazly, S. A. Idris, and S. Bourouis, "Deep neural network based vehicle detection and classification of aerial images," *Intelligent Automation & Soft Computing*, vol. 34, no. 1, 2022.
- [16] S. Vikruthi, M. Archana, and R. C. Tanguturi, "A novel framework for vehicle detection and classification using enhanced yolo-v7 and gbm to prioritize emergency vehicle," *International Journal of*

- Intelligent Systems and Applications in Engineering*, vol. 12, no. 1s, pp. 302–312, 2024.
- [17] A. Hanif, A. B. Mansoor, and A. S. Imran, “Performance analysis of vehicle detection techniques: a concise survey,” in *Trends and Advances in Information Systems and Technologies: Volume 2* 6, pp. 491–500, Springer, 2018.
- [18] T. Saranya, S. Sridevi, C. Deisy, T. D. Chung, and M. A. Khan, “Performance analysis of machine learning algorithms in intrusion detection system: A review,” *Procedia Computer Science*, vol. 171, pp. 1251–1260, 2020.
- [19] H. Wang, Y. Yu, Y. Cai, X. Chen, L. Chen, and Q. Liu, “A comparative study of state-of-the-art deep learning algorithms for vehicle detection,” *IEEE Intelligent Transportation Systems Magazine*, vol. 11, no. 2, pp. 82–95, 2019.
- [20] X. Yao, Y. Wang, Y. Wu, G. He, and S. Luo, “Mlp-based efficient convolutional neural network for lane detection,” *IEEE Transactions on Vehicular Technology*, 2023.
- [21] R. Islam, M. K. Devnath, M. D. Samad, and S. M. J. Al Kadry, “Ggnb: Graph-based gaussian naive bayes intrusion detection system for can bus,” *Vehicular Communications*, vol. 33, p. 100442, 2022.
- [22] H. Song, H. Liang, H. Li, Z. Dai, and X. Yun, “Vision-based vehicle detection and counting system using deep learning in highway scenes,” *European Transport Research Review*, vol. 11, no. 1, pp. 1–16, 2019.
- [23] W.-J. Yang, W.-J. Liow, S.-F. Chen, J.-F. Yang, P.-C. Chung, and S. Mao, “Improved vehicle detection systems with double-layer lstm modules,” *EURASIP Journal on Advances in Signal Processing*, vol. 2022, no. 1, p. 7, 2022.
- [24] T. V. Kumar, A. R. Yeruva, S. Kumar, D. Gangodkar, A. Rao, and P. Chaturvedi, “A new vehicle tracking system with r-cnn and random forest classifier for disaster management platform to improve performance,” in *2022 2nd International Conference on Technological Advancements in Computational Sciences (ICTACS)*, pp. 797–804, IEEE, 2022.
- [25] A. A. Alsulami, Q. Abu Al-Hajja, A. Alqahtani, and R. Alsini, “Symmetrical Simulation Scheme for Anomaly Detection in Autonomous Vehicles Based on LSTM Model,” *Symmetry*, vol. 14, no. 7, p. 1450, Jul. 2022, doi: <https://doi.org/10.3390/sym14071450>.
- [26] R. Shin, Y. Okada, and K. Yamamoto, “Application of C-LSTM Networks to Automatic Labeling of Vehicle Dynamic Response Data for Bridges,” *Sensors*, vol. 22, no. 9, p. 3486, Jan. 2022, doi: <https://doi.org/10.3390/s22093486>.