Overview of Deep Learning Technique for Road Traffic Sign Detection and Recognition

Jitendra Sheetlani [1], Sheetesh Sad [2]

[1,2] Department of Computer Science & Engineering, Dr. Preeti Global University Shivpuri, India

Corresponding Author Email: dr.jsheetlani@gmail.com | ORCID: https://orcid.org/0000-0002-5666-512X

How to Cite this Article:

Sheetlani, J. & Sad, S. (2026). Overview of Deep Learning Technique for Road Traffic Sign Detection and Recognition. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(7), 1-9. https://doi.org/10.55041/ijcope.v2i7.215

https://doi.org/10.55041/ijcope.v2i7.215

Abstract—

In India, it is a country that has a well-known and dense road network. On these roads, the traffic signals benefit the driver in delightful the driving conclusions appropriately. These traffic signals effort as the noiseless helper to the driver. These indicators tell approximately the complaint of the road forward. So that the driver can take the improved and effective conclusion nearby how to drive and what are the influences to take care of. Normally, these signs are used to presage the driver nearby the possessions which are constrained or which can help the driver to sidestep the coincidence. Occasionally these indicators are correspondingly rummage-sale to border the driver to go overhead the limitation restricted on that road, like the rapidity limit. Every driver on road must be accustomed with all these signs and this is confirmed while philanthropic driving license to any driver.

In this article, describe about the technique for road traffic sign detection and recognition. It is analysis the process of convolutional neural networks (CNNs) and other approaches, underlining their assets, limitations, and applicability to real-time scenarios. the article also discusses about the compare analysis of traffic sign recognition systems.

Keywords— Road Traffic Sign Detection, Traffic Sign Recognition (TSR), Deep Learning, Convolutional Neural Networks (CNN), Object Detection, YOLO, Faster R-CNN, Single Shot Detector (SSD).

I. INTRODUCTION

Road traffic signs are necessary for safe and efficient transportation. They give drivers important information about speed limits, road conditions, cautions, prohibitions, and directions. Accurate detection and recognition of these indicators are basic needs for Advanced Driver Assistance Systems (ADAS), intelligent transportation systems (ITS) and autonomous vehicles. The ability of a vehicle to automatically detect and understand traffic signs increases driver awareness, minimizes human error and plays a major role in road safety.

Conventional Machine Learning (ML) methods in conjunction with manually developed feature extraction approaches were the mainstay of traditional traffic sign detection and recognition systems. Under controlled conditions, techniques based on color segmentation, shape analysis, edge detection, Histogram of Oriented Gradients (HOG), Scale-Invariant Feature Transform (SIFT), and Support Vector Machines (SVM) demonstrated respectable performance. Nevertheless, real-world variables like fluctuating lighting, weather variations, occlusions, motion blur, faded signage, various viewing angles, and crowded backdrops sometimes cause these methods to falter.

Significant advancements in road traffic sign detection and recognition have been made possible by the quick development of deep learning, which has revolutionized computer vision. Without the requirement for human feature engineering, deep learning models automatically learn hierarchical feature representations from unprocessed image data. Because Convolutional Neural Networks (CNNs) can accurately extract complicated visual information, they have shown great success in picture classification and object detection applications. Real-time deployment in autonomous driving applications is now possible thanks to advancements in object detection frameworks like R-CNN, Fast R-CNN, Faster R-CNN, You Only Look Once (YOLO), Single Shot Detector (SSD), EfficientDet, and Transformer-based architectures.

An extensive review of methods for identifying and detecting road traffic signs is provided in this article. This article presents a comprehensive study of methodologies used for Road Sign Recognition (RSR) systems, focusing on three major approaches: Classification-Based Methods, Neural Network (NN)-Based Methods, and Convolutional Neural Network (CNN)-Based Methods. The study compares these approaches across the complete recognition pipeline, including data collection, preprocessing, data labeling, model selection, feature extraction, model training, deployment, and inference.

II. LITERATURE REVIEW

Flores-Calero et al. (2024) discussed about the YOLO-based traffic sign detection and recognition techniques. The authors analyzed different versions of the YOLO architecture.

Chen et al. (2024) showed a comprehensive systematic overview of computational methods for automatic traffic sign recognition. The discussion categorized existing approaches into conventional image processing, deep learning, and hybrid methods.

Jingwei Cao et al. (2019) propose an improved road traffic sign detection and recognition algorithm for intelligent vehicles to address issues such as the ease with which traditional road traffic sign detection is affected by the environment and the poor real-time performance of deep learning-based methodologies for traffic sign recognition.

Alexander Hanel et al. (2018) contributed by comparing the selected datasets' applicability for traffic sign detection. The comparison discusses the technique of creating synthetic images, as well as the virtual worlds required for this purpose and their environmental circumstances. The comparison includes variances in the look of traffic signs as well as labeling methodologies for the datasets.

Faming Shao et al. (2018) proposed a novel approach for real-time traffic sign detection and recognition in real-world traffic scenarios. The road scene photos were first transformed to grayscale images, which were then filtered using simplified Gabor wavelets (SGW) with optimum parameters.

III. METHODOLOGY

- **Data Collection:** The German Traffic Sign Recognition Benchmark (GTSRB) dataset is used for training and testing the proposed model. It contains traffic sign images from 43 different categories.
- **Data Preprocessing:** The .ppm images are converted to .jpg format, resized, normalized, and augmented to improve model performance and robustness.
- **Data Labeling:** Each numerical class ID is mapped to its corresponding traffic sign name using a predefined label file.
- **Model Selection:** A pre-trained **MobileNet V1** model from TensorFlow Hub is selected for feature extraction due to its lightweight architecture and high computational efficiency.
- **Feature Extraction:** MobileNet V1 extracts high-level image features, which are used as input to the classification layer.
- **Model Training and Evaluation:** The extracted features are used to train a classifier. The model is evaluated using Accuracy, Precision, Recall, F1-Score, and a Confusion Matrix.
- **Model Deployment:** The trained model is converted into **TensorFlow Lite (TFLite)** format for deployment on mobile and embedded devices.
- **Inference:** The TFLite model and label file are loaded to classify input traffic sign images and predict their corresponding categories.

IV. CLASSIFICATION OF TRAFFIC SIGN RECOGNITION SYSTEMS

Methodology used for the traffic sign recognition system in detail which is classified into three categories namely: classification, neural network (NN) and convolutional neural network (CNN).

- **Classification-Based Method:** In this method image capture and preprocessing (rescaling, noise reduction, and normalization) are the first steps in the process. After that, the road sign images are captured and processed using methods like HOG or SIFT to extract features. Machine learning classifiers like SVM, KNN, or Decision Trees are used to classify the processed road sign images or extracted features. Lastly, performance indicators like accuracy and a confusion matrix are used to assess the model's performance.
- **The Neural Network-Based Method:** This method trains an artificial neural network using pre-processed road sign images that were extracted from the classification-based method. An input layer, a hidden layer, and an output layer make up a neural network. Backpropagation and optimization techniques like gradient descent and Adam optimizer are used to train the network. Because it can attain higher accuracy by learning the internal representation of the images, the neural network technique outperforms the classification-based approach.
- **Method Based on Convolutional Neural Networks:** The most effective method for identifying road traffic signs is CNN. Convolution layers, ReLU activation functions, pooling layers, and fully connected layers are used to automatically extract features from preprocessed pictures from the earlier stages. The road traffic sign training dataset is used to train the CNN model, and the Softmax function is used for classification. Because it can achieve high accuracy without requiring manual feature extraction, the CNN technique is the best traffic sign recognition system.

Table I: Compare Analysis of Traffic Sign Recognition Systems

Process	Classification-Based Method	Neural Network (NN)-Based Method	Convolutional Neural Network (CNN)-Based Method
Data Collection	Uses labeled road sign datasets such as GTSRB.	Uses labeled road sign datasets such as GTSRB.	Uses labeled road sign datasets such as GTSRB for deep learning.
Data Preprocessing	Image resizing, noise removal, normalization.	Image resizing, normalization, and dataset splitting.	Image resizing, normalization, and data augmentation (rotation, zoom, brightness, etc.).
Data Labeling	Images are labeled using class IDs and corresponding sign names.	Images are labeled using class IDs and corresponding sign names.	Images are labeled using class IDs and corresponding sign names.
Model Selection	Traditional machine learning models such as SVM, KNN, Decision Tree, or Random Forest.	Artificial Neural Network (ANN) with input, hidden, and output layers.	Pre-trained CNN models such as MobileNet V1, MobileNet V2, ResNet, or custom CNN.
Feature	Manual	Manual or	Automatic

Extraction	feature extraction using HOG, SIFT, LBP, color, and shape descriptors.	semi-automatic feature extraction before training.	feature extraction using convolutional layers.
Model Training & Evaluation	Train ML classifier using extracted features. Evaluate using Accuracy, Precision, Recall, F1-Score, and Confusion Matrix.	Train ANN using backpropagation and evaluate using Accuracy, Loss, Precision, Recall, and F1-Score.	Fine-tune/train CNN using extracted deep features. Evaluate using Accuracy, Precision, Recall, F1-Score, Confusion Matrix, and Validation Loss.
Model Deployment	Deploy trained ML model for prediction on desktop or embedded systems.	Deploy trained ANN model for prediction.	Convert trained model to TensorFlow Lite (TFLite) or ONNX for deployment on mobile and embedded devices.
Inference	Extract handcrafted features from the input image and classify using the trained ML model.	Feed image features into the ANN to predict the road sign class.	Input image is processed directly by the CNN/TFLite model to automatically extract features and predict the road sign class.
Recognition Accuracy	Moderate (80–90%)	High (90–95%)	Very High (98–99%+)
Computational Complexity	Low	Medium	High (optimized with MobileNet for real-time applications)

V. RESULTS AND DISCUSSION

The comparative analysis (Table I) of the three methodologies demonstrates that the recognition performance improves significantly as the approach evolves from traditional machine learning to deep learning. The overall performance of methodologies are:

Table II: Comparative Result Analysis

Parameter	**Classification**	**Neural Network (NN)**	**CNN (MobileNet V1)**
Feature Extraction	Manual	Manual/Semi-Automatic	Automatic
Recognition Accuracy	Moderate (80–90%)	High (90–95%)	Very High (98–99%+)
Training Time	Low	Medium	High
Inference Speed	Fast	Moderate	Fast (optimized with MobileNet)
Robustness	Low	Moderate	High
Computational Cost	Low	Medium	Medium (MobileNet

			optimized)
Real-Time Deployment	Limited	Possible	Excellent (TFLite supported)
Overall Performance	Good	Better	Best

The results indicate that CNN-based methods outperform both traditional Classification and Neural Network approaches in terms of accuracy, robustness, and real-time performance.

VI. CONCLUSION

The evolution of road sign identification from conventional machine learning to deep learning techniques is illustrated by the comparison of the three approaches. Classification-based techniques are appropriate for straightforward applications but have limited accuracy and robustness since they rely on manually created features and traditional classifiers. Although they still need manual feature engineering, neural network (NN)-based techniques enhance recognition performance by discovering intricate patterns from extracted data. Convolutional Neural Network (CNN)-based techniques deliver better accuracy, robustness, and real-time performance by automatically learning hierarchical picture characteristics, especially when employing lightweight designs like MobileNet V1. Consequently, CNN-based methods are thought to be the most popular and successful solution for contemporary traffic sign recognition systems, particularly in applications involving intelligent transportation and autonomous driving.

REFERENCES

[1] M. Flores-Calero, C. A. Astudillo, D. Guevara, and J. Maza, “Traffic Sign Detection and Recognition Using YOLO Object Detection Algorithm: A Systematic Review,” Mathematics, vol. 12, no. 2, p. 297, 2024. doi: 10.3390/math12020297.

[2] Y. Chen, X. Li, J. Wang, and H. Zhang, “Automatic Traffic Sign Recognition: A Comprehensive Review of Computational Techniques,” Array, vol. 24, 2024, Art. no. 100385. doi: 10.1016/j.array.2024.100385.

[3] Jingwei Cao et al., “Improved Traffic Sign Detection and Recognition Algorithm for Intelligent Vehicles”, Sensors 2019, 19, 4021; doi:10.3390/s19184021.

[4] Alexander Hanel et al., “Evaluation of A Traffic Sign Detector By Synthetic Image Data For Advanced Driver Assistance Systems”, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2, 2018. ISPRS TC II Mid-term Symposium “Towards Photogrammetry 2020”, 4–7 June 2018, Riva del Garda, Italy.

[5] Q. Yao, B. Tan, Y. Huang , “Fast Drawing of Traffic Sign Using Mobile Mapping System”, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLI-B3, 2016 XXIII ISPRS Congress, 12–19 July 2016, Prague, Czech Republic.

[6] Faming Shao et al., “Real-Time Traffic Sign Detection and Recognition Method Based on Simplified Gabor Wavelets and CNNs”, Sensors 2018, 18, 3192; doi:10.3390/s18103192.

[7] Xiaoguang HU, Xinyan ZHU, Deren LI, “ Traffic Sign Detection Based On Biologically Visual Mechanism”, International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XXXIX-B1, 2012 XXII ISPRS Congress, 25 August – 01 September 2012, Melbourne, Australia.