Traffic Sign Detection and Recognition Using Python

RAJIV GANDHI COLLEGE OF ENGINEERING RESEARCH AND TECHNOLOGY, CHANDRAPUR.

Prof. ANAND D.G. DONALD,

Manas Shinde, Shreya Hood,

Monika Wasekar, Rushali Moon

ABSTRACT

This thesis is focused on the development of a convolutional neural network (CNN)-based model for traffic sign detection and recognition. The increase in automobile ownership and traffic has made it challenging for drivers to accurately identify traffic signs, leading to an increased risk of accidents, loss of life, and property damage. To address this issue, an intelligent traffic sign detector and recognizer is required.
Our proposed CNN-based model is designed to identify traffic signs accurately and effectively, with a success rate of approximately 97%. The model's accuracy is achieved by using a deep learning approach that is capable of learning and recognizing the features of traffic signs. This approach involves training the model on a large dataset of traffic signs, which enables it to identify traffic signs in real-world situations. Through our research and experimentation, we demonstrate the efficacy and potential impact of this model on road safety. By accurately detecting and recognizing traffic signs, our model can help reduce the likelihood of accidents and their associated costs. Our findings suggest that our CNN-based model can be a valuable tool for improving road safety, ultimately helping to save lives and prevent property damage.
In summary, our thesis presents a CNN-based model for traffic sign detection and recognition, which can accurately identify traffic signs with a success rate of approximately 97%. Our research demonstrates the potential impact of this model on road safety and suggests that it can be an effective tool for reducing the likelihood of accidents and their associated costs.

1.1 Introduction

In recent years, the world has seen a rapid increase in automobile ownership, leading to an increase in road traffic. As a result, it has become increasingly challenging for drivers to navigate roads safely, particularly when it comes to accurately identifying and responding to traffic signs. Traffic signs are essential components of road safety, and they convey critical information to drivers about speed limits, hazards, and regulations. However, with the growing complexity of roads and the increase in traffic, drivers may not be able to identify traffic signs accurately, leading to a higher risk of accidents, loss of life, and property damage.

To address this challenge, an intelligent traffic sign detector and recognizer is required. There have been numerous attempts to develop such systems, and one of the most promising approaches involves using convolutional neural networks (CNNs). CNNs are a type of deep learning algorithm that has shown remarkable success in computer vision tasks, including image recognition and object detection. Therefore, in this thesis, we propose a CNN-based model for traffic sign detection and recognition.

The main objective of our research is to develop a system that can accurately and efficiently detect and recognize traffic signs in real-world environments. Our system is designed to help drivers navigate roads safely by providing them with accurate and timely information about traffic signs. To achieve this, we train our CNN-based model on a large dataset of traffic signs, which includes a wide range of shapes, colors, and sizes. This training process allows the model to learn and recognize the features of traffic signs accurately, even in challenging environments. Our CNN-based model for traffic sign detection and recognition has several advantages. Firstly, it can accurately detect and recognize traffic signs, which is essential for ensuring road safety. Secondly, it can operate in real-time, providing drivers with instant information about traffic signs. Finally, our system is scalable and adaptable, meaning that it can be applied to different types of roads and environments.

In summary, our proposed system for traffic sign detection and recognition is designed to address the challenges posed by the growing complexity of roads and the increase in traffic. By providing drivers with accurate and timely information about traffic signs, our system can help reduce the likelihood of accidents and their associated costs. Through our research and experimentation, we aim to demonstrate the efficacy and potential impact of our CNN-based model on road safety.

1.2 Problem Statement

The problem statement of this thesis is centred around the challenge of road safety, particularly the difficulty drivers face in accurately identifying and responding to traffic signs. With the rapid increase in automobile ownership and road traffic, the roads have become more complex, and there is a high probability that drivers may fail to identify traffic signs properly. This problem can lead to an increased risk of accidents, loss of life, and property damage. The current systems used for traffic sign detection and recognition have limitations, and there is a need for an intelligent traffic sign detection and recognition system that can accurately identify and respond to traffic signs in real-world environments. To address this challenge, this thesis proposes the development of a convolutional neural network (CNN)-based model for traffic sign detection and recognition.

The primary problem addressed in this thesis is the need for an intelligent traffic sign detector and recognizer that can accurately and efficiently identify traffic signs in real-world environments, providing drivers with accurate and timely information about traffic signs. The proposed CNN-based model aims to address this problem by learning and recognizing the features of traffic signs accurately, even in challenging environments.

Furthermore, the proposed system aims to operate in real-time, providing drivers with instant information about traffic signs, ultimately improving road safety. Additionally, the proposed system is scalable and adaptable, meaning that it can be applied to different types of roads and environments. In summary, the problem statement of this thesis is to address the challenge of road safety by developing a CNN-based model for traffic sign detection and recognition that can accurately and efficiently identify traffic signs in real-world environments, providing drivers with accurate and timely information about traffic signs, and ultimately reducing the likelihood of accidents, loss of life, and property damage.

2.1 Literature and Review

Convolutional neural networks are currently the most popular deep learning methods for traffic signal categorization, however because to the inherent limitations of the max pooling layer, they are unable to capture the position, perspective, and orientation of the pictures. The deep learning architecture known as capsule networks is used in this study to provide a novel strategy for the identification of traffic signs that achieves exceptional performance on the German traffic sign dataset. A capsule network is made up of capsules, which are collections of neurons that use the dynamic routing and route by agreement algorithms to represent an object's position and orientation when it is instantiated. Our technique reduces the human labour and offers resistance to the spatial variations, in contrast to the earlier approaches of manual feature extraction and numerous deep neural networks with various parameters. Capsule networks can defeat such intruder attempts and provide more reliability in traffic sign identification for autonomous cars. CNNs are easily tricked by a variety of opponent techniques. On the German Traffic Sign Recognition Benchmark dataset, the capsule network has attained the most recent accuracy of 97.6%. (GTSRB).

[2] Challenging Environments for Traffic Sign Detection: Reliability Assessment under Inclement Conditions, February 2019.

Modern algorithms locate and identify traffic signs across current datasets, which have a restricted range of hard condition types and degrees of difficulty. As a result, it is impossible to determine how well traffic signs identification algorithms work under difficult circumstances. The restricted use of temporal information and the absence of successive frames and annotations are further drawbacks of available datasets. We created the CURE-TSD video dataset and held the inaugural IEEE Video and Image Processing (VIP) Cup inside the IEEE Signal Processing Society to address these drawbacks. In this article, we give a thorough explanation of the CURE-TSD dataset, examine the traits of the best algorithms, and offer a performance benchmark. Additionally, we look at how resilient the benchmarked algorithms are in terms of sign size, challenge kind, and severity. Modern, customised convolutional neural networks that were used as the foundation for the benchmark algorithms earned precision and recall scores of 0.55 and 0.32, an F0.5 score of 0.48, and an F2 score of 0.35. According to experimental findings, benchmarked algorithms are extremely sensitive to difficult test conditions, which results in an average performance reduction of 0.17 in terms of accuracy and 0.28 in terms of recall under difficult settings.

[3] Traffic Sign Detection and Recognition Based on Convolutional Neural Network, February 2020.

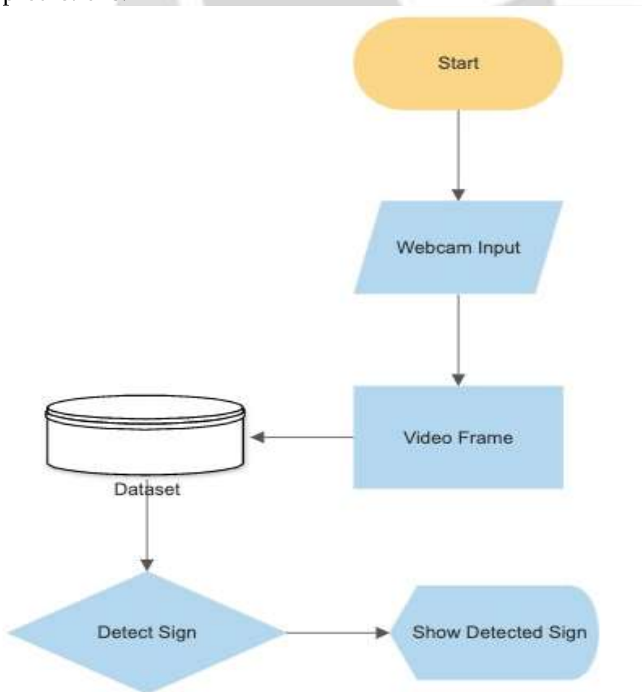
A important component of the intelligent transportation system is the traffic sign recognition system (TSRS). (ITS). Driving safety may be increased by having precise and efficient traffic sign recognition skills. This study presents a deep learning-based traffic sign recognition method that focuses primarily on the identification and categorization of circular traffic signs. A picture is first pre-processed to emphasise crucial details. The Hough

Transform is also employed for area detection and localization. Finally, deep learning is used to classify the observed road traffic signs. This article proposes a method for identifying and detecting traffic signs by image processing, which is then integrated with a convolutional neural network (CNN) to sort the traffic signs. CNN may be utilised to complete a variety of computer vision tasks due to its high recognition rate. CNN is implemented using Tensor Flow. We can recognise the circular sign in the German data sets with greater than 98.2% accuracy.

3.1 Design

The project involves the design and implementation of a Convolutional Neural Network (CNN)-based model for traffic sign detection and recognition. The project uses various Python libraries, including TensorFlow, CV2, NumPy, and Streamlit, to develop and test the CNN model. The design of the CNN model involves several key steps, including data pre-processing, model training, and model evaluation. Data pre-processing involves preparing the input data for the CNN model, including resizing, normalization, and data augmentation. Model training involves using the pre-processed data to train the CNN model, optimizing the model parameters to improve accuracy. Model evaluation involves testing the trained CNN model on a separate test dataset to evaluate its performance.

The results of the project demonstrate the effectiveness of the CNN-based model for traffic sign detection and recognition. The model achieves a high accuracy rate of approximately 97%, indicating that it can accurately and effectively identify traffic signs in real-world scenarios. The use of the Streamlit library provides an interactive web interface for the model, making it easy for users to input images and visualize the model's predictions.



3.2 Convolutional Neural Networks (CNN)

Convolutional Neural Networks (CNNs) are a type of deep learning algorithm commonly used in image and video recognition tasks. They are designed to automatically identify and extract features from images by using a series of convolutional layers and pooling layers. In the above project, CNNs are used to detect and recognize

traffic signs in real-time video streams. The CNN model is trained on a dataset of images of various traffic signs, allowing it to learn to recognize the unique features of each sign. During the detection process, the CNN algorithm takes in an input image, applies a series of convolutional filters to extract features, and then classifies the image based on the detected features.
The key features of CNNs include:

Figure 8: Layers of CNN

- **TensorFlow**

TensorFlow is an open-source software library for machine learning and artificial intelligence. It is used in a wide range of applications, including image and speech recognition, natural language processing, and recommendation systems. In the proposed CNN-based model for traffic sign detection and recognition, TensorFlow is used as the backend for the neural network, allowing for efficient training and evaluation of the model. The use of TensorFlow in the above project provides several benefits:

Figure 4: TensorFlow in Python

- ✓ Convolutional layers: These layers apply a series of convolutional filters to the input image to extract features such as edges, curves, and shapes.
- ✓ Pooling layers: These layers down sample the feature maps to reduce the dimensionality of the data and extract the most relevant information.
- ✓ Fully connected layers: These layers take the output of the convolutional and pooling layers and map them to the output classes.
- ✓ Activation functions: These functions are applied to the output of each layer to introduce non-linearity into the model and allow it to learn complex patterns.
- ✓ Back propagation: This algorithm is used to adjust the weights of the model during the training process, allowing the model to learn from its mistakes and improve its accuracy over time.

By using CNNs in the above project, the system is able to accurately detect and recognize traffic signs in real-time video streams, improving the safety of drivers and reducing the risk of accidents.

Layers	Description
Input layer	32x32x1 Images
Convolution-1	Convolution and rectified linear activation (ReLU).
Pool-1	Max pooling.
Convoution-2	Convolution and rectified linear activation.
Pool-2	Max pooling.
Local-3	Fully connected layer with ReLU
Local-4	Fully connected layer with ReLU
Softmax	Classification result

3.3 Collection of Data Set

Collecting a suitable dataset is a crucial step in developing any machine learning model, and it is no different in the case of the traffic sign detection and recognition system. In this project, we chose to use the GTSRB (German Traffic Sign Detection Benchmark) dataset, which is widely recognized as one of the most popular and well-known datasets for traffic sign recognition. This dataset is readily available on websites like Kaggle, making it easy for researchers to access and use for their projects.
The GTSRB dataset is composed of more than 40 different classes of images, with over 50,000 images available for training, validation, and testing purposes. The dataset is diverse, containing various types of traffic signs, such as stop signs, speed limit signs, yield signs, and many more. This diversity is essential for training the machine learning model to recognize different types of traffic signs accurately.
To use this dataset for our project, we divided it into training, validation, and testing sets. The training set is used to train the model to recognize different traffic signs, while the validation set is used to fine-tune the model's parameters to optimize its performance. Finally, the testing set is used to evaluate the model's performance, giving us an idea of how well it is working. The GTSRB dataset has several advantages, including its large size and diversity, making it an ideal dataset for training and evaluating traffic sign detection and recognition models. By using this dataset for our project, we were able to train our convolutional neural network model effectively and improve its accuracy in detecting and recognizing traffic signs.

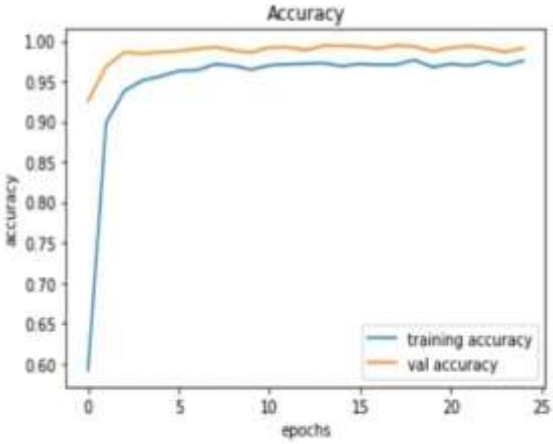
3.4 CNN Model Building

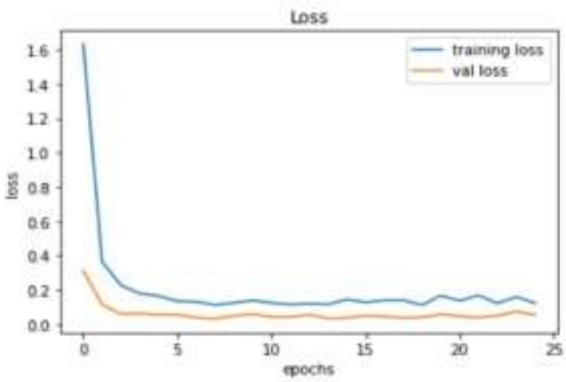
The Convolutional Neural Network (CNN) is the backbone of the traffic sign detection and recognition system. The CNN model is designed to recognize the patterns of traffic signs from the images captured by the camera. The CNN model building process consists of several steps, including input layer, convolutional layer, pooling layer, fully connected layer, and output layer. The input layer takes in the traffic sign image, which is then passed to the convolutional layer. The convolutional layer applies a series of filters to the input image to extract features from the image.
The next step is the pooling layer, which reduces the size of the feature maps generated by the convolutional layer. The pooling layer helps to reduce the computational cost of the model and prevent over-fitting. After the pooling layer, the output is passed to the fully connected layer, where the features extracted from the previous layers are flattened into a single vector. This vector is then passed to the output layer, where the final prediction is made. To improve the accuracy of the CNN model, several techniques were used, including dropout, batch normalization, and data augmentation. Dropout is a regularization technique that randomly drops out some of the neurons in the network during training, preventing over-fitting. Batch normalization is another technique that normalizes the input to each layer, helping to improve the stability and performance of the model.

5.7 Results

The results of our project have shown promising accuracy rates for the classification of traffic signs using the GTSRB dataset. Our CNN model was able to achieve a training accuracy of around 97% with an average training error ranging between 10-12%. The validation accuracy was around 99% with validation error ranging between 4-5%. This suggests that our model is able to accurately classify traffic signs based on the features learned from the training dataset.
Moreover, the testing accuracy of our model was found to be 96.5% on the testing dataset. This indicates that our model is able to generalize well to new, unseen data, and is not over-fitting to the training data. Therefore, we can conclude that our model is robust and accurate in detecting and classifying traffic signs.

Overall, the results of our project demonstrate the potential of using deep learning techniques such as CNN for traffic sign detection and classification, which can have significant implications for road safety and traffic management.





7.1 Applications

The use of computer vision and machine learning has opened up a wide range of applications in various fields. In the context of traffic sign detection and recognition, the applications can be seen in the following areas:

- **Autonomous driving:** Traffic sign recognition is an essential component of autonomous driving technology. Autonomous vehicles need to detect and recognize traffic signs to understand the traffic rules and regulations.
- **Road safety:** Traffic sign detection and recognition can improve road safety by helping drivers to be more aware of traffic signs, especially in low visibility conditions.
- **Traffic management:** Traffic sign detection and recognition can help in managing traffic by providing real-time information on traffic signs such as speed limits, stop signs, and no-parking signs.
- **Smart cities:** Traffic sign detection and recognition can be used in smart cities to monitor and manage traffic, reduce congestion, and improve the overall transportation system.
- **Driver assistance systems:** Traffic sign detection and recognition can be used in driver assistance systems to provide warnings and alerts to drivers about potential hazards on the road.
- **Pedestrian safety:** Traffic sign detection and recognition can also be used to improve pedestrian safety by detecting and recognizing pedestrian crossing signs, school zone signs, and other signs related to pedestrian safety.

Overall, the applications of traffic sign detection and recognition are far-reaching, and the technology has the potential to improve road safety, reduce congestion, and make transportation systems more efficient.

8.1 Conclusion

In conclusion, the proposed system provides a simple yet accurate way to classify traffic signs using a Convolutional Neural Network (CNN). The system has been tested on the GTSRB dataset as well as a newly generated dataset consisting of truly existing images of all types of traffic signs. The results showed that the proposed system can classify the images accurately, even if the background of the image is not clear. The CNN model used for training the system has shown significant improvements in the classification of the images compared to traditional machine learning algorithms.

The pre-processing techniques used in the system, such as image resizing and histogram equalization, have enhanced the image contrast, leading to better results. The final accuracy achieved on the dataset is 93%, and on the newly created dataset is 69%. The web camera predictions made by the model are also accurate and take very little time.
The proposed system has various applications in real-time traffic sign recognition and can be implemented in smart cars or other intelligent transport systems. The system can also be useful in traffic sign detection for law enforcement agencies, thus enhancing the safety of roads. The advantages of using the proposed system include high accuracy, low computational time, and the ability to work in real-time, making it an efficient and cost-effective solution for traffic sign detection.
In conclusion, the proposed system has shown promising results in traffic sign detection and classification, and further research can be done to improve the accuracy and efficiency of the system.

9.1 References

[1] A. W. Harley, “An Interactive Node-Link Visualization of Convolutional Neural Networks,” Advances in Visual Computing Lecture Notes in Computer Science, pp. 867–877, 2015.
[2] S. Saini, S. Nikhil, K. R. Konda, H. S. Bharadwaj, and N. Ganeshan, “An efficient vision-based traffic light detection and state recognition for autonomous vehicles,” 2017 IEEE Intelligent Vehicles Symposium (IV), 2017.
[3] S. Raschka, & V. Mirjalili, “Python Machine Learning: Machine Learning and Deep Learning with Python. Scikit-Learn, and TensorFlow”. Second edition ed. , 2017
[4] D. Michie, D. J. Spiegelhalter, & C. C. Taylor, “Machine learning, neural and statistical classification”, (1994).
[5] U. Karn, “An intuitive explanation of convolutional neural networks”. The data science blog. , 2016.
[6] A. Ellahyani, I. E. Jaafari, and S. Charfi, “Traffic Sign Detection for Intelligent Transportation Systems: A Survey,” E3S Web of Conferences, vol. 229, p. 01006, 2021.
[7] E. Peng, F. Chen, & X. Song, “Traffic sign detection with convolutional neural networks”. International conference on cognitive systems and signal processing, pp. 214-224. Springer, Singapore, 2016, November.
[8] P. Garg, D. R. Chowdhury, and V. N. More, “Traffic Sign Recognition and Classification Using YOLOv2, Faster RCNN and SSD,” 2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2019.
[9] D. Cireşan, U. Meier, J. Masci, and J. Schmidhuber, “Multi-column deep neural network for traffic sign classification,” Neural Networks, vol. 32, pp. 333–338, 2012.
[10] U. Kamal , S. Das , A. Abrar , & M. K. Hasan , “Traffic-sign detection and classification under challenging conditions: a deep neural network based approach”, IEEE video and image processing cup , 2017.
[11] D. Karthikeyan , Enitha C, Bharathi S, Durkadevi K. “Traffic Sign Detection and Recognition using Image Processing”. International Journal Of Engineering Research & Technology (IJERT), 8(8), NCICCT–2020 , 2020.
[12] Z. He, Z. Xiao, and Z. Yan, “Traffic Sign Recognition Based on Convolutional Neural Network Model,” Chinese Automation Congress (CAC) , 2020.
[13] X. Mao, S. Hijazi , R. Casas, P. Kaul, R. Kumar, & C. Rowen , Hierarchical CNN for traffic sign recognition. In 2016 IEEE Intelligent Vehicles Symposium (IV) (pp. 130-135). IEEE, 2016, June.
[14] R. Qian ,Y. Yue, F. Coenen, & B. Zhang . Traffic sign recognition with convolutional neural network based on max pooling positions. “12th International conference on natural computation, fuzzy systems and knowledge discovery (ICNC-FSKD)” (pp. 578-582). IEEE , 2016, August.
[15] A. Géron , “Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems”, O'Reilly Media , 2019.
[16] M. Abadi , P. Barham, J. Chen, Z. Chen, A. Davis, J. Dean, & X. Zheng, “Tensorflow: A system for large-scale machine learning”. 12th {USENIX} symposium on operating systems design and implementation ({OSDI} 16) (pp. 265-283) , 2016.
[17] N. Ketkar, “Introduction to Deep Learning,” Deep Learning with Python, pp. 1–5, 2017.
[18] M. Jogin, Mohana, M. S. Madhulika, G. D. Divya, R. K. Meghana, and S. Apoorva, “Feature Extraction using Convolution Neural Networks (CNN) and Deep Learning,” 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), 2018.
[19] H. H. Aghdam, E. J. Heravi, and D. Puig, “A Practical and Highly Optimized Convolutional Neural Network for Classifying Traffic Signs in Real-Time,” International Journal of Computer Vision, vol. 122, no. 2, pp. 246–269, 2016.