A

Mini Project Report on

**Traffic signal detection and classification based on YOLO and CNN.**

Submitted in partial fulfillment of the requirements for the degree of

BACHELOR OF ENGINEERING

IN

**Computer Science & Engineering**

Artificial Intelligence & Machine Learning

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**2024-2025**

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**CERTIFICATE**

This is to certify that the project entitled “Traffic signal detection and classification based on YOLO and CNN.**”** is a Bonafide work of Niharika Bandekar (22106136), Aabha Bhide (22106093), Aditi Gadhave (22106079) and Sudhiksha Aradhyula (22106010) submitted to the University of Mumbai in partial fulfillment of the requirement for the award of **Bachelor of Engineering** in **Computer Science & Engineering (Artificial Intelligence & Machine Learning).**

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**Project Report Approval**

This Mini project report entitled ***“Traffic signal detection and classification based on YOLO and CNN”*** by **Niharika Bandekar (22106136), Aabha Bhide (22106093), Aditi Gadhave (22106079)** **and Sudhiksha Aradhyula (22106010)** is approved for the degree of ***Bachelor of Engineering*** in ***Computer Science &Engineering***, (AI and ML) ***2025-26***.

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**Declaration**

We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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**ABSTRACT**

Traffic sign recognition is a fundamental aspect of modern intelligent transportation systems, enhancing road safety and supporting the development of autonomous vehicles. This project aims to implement a traffic sign detection and classification system using YOLO (You Only Look Once) and Convolutional Neural Networks (CNNs). The system is designed to efficiently recognize various traffic signs in real-time, ensuring high accuracy under different environmental conditions. The project integrates YOLO for precise and rapid detection of traffic signs and CNNs for robust classification. The system addresses major challenges such as variations in lighting, occlusions, and perspective distortions. By leveraging deep learning methodologies and publicly available datasets, the proposed solution enhances traffic sign recognition reliability, aiding in advanced driver assistance systems (ADAS) and autonomous vehicle navigation. This study provides an in-depth analysis of existing literature, identifies key challenges in traffic sign recognition, and presents a comprehensive solution combining state-of-the-art object detection and classification techniques. The results demonstrate improved efficiency and accuracy in traffic sign recognition, contributing to safer and more intelligent transportation systems.

**Index**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | | | Page no. |
| Chapter-1 | | | 1 |
|  | Introduction | |  |
|  |  |  |  |
| Chapter-2 | | | 4 |
|  | Literature Survey | |  |
|  | 2.1 | Literature Review |  |
|  |  |  |  |
| Chapter-3 | | | 10 |
|  | Problem Statement | |  |
|  |  |  |  |
| Chapter-4 | | | 12 |
|  | Experimental Setup | |  |
|  | 4.1 | Introduction |  |
|  | 4.2 | Features |  |
|  |  |  |  |
| Chapter-5 | | | 15 |
|  | Implementation | |  |
|  | 5.1 | Block Diagram |  |
|  | 5.2 | Description of Black diagram |  |
|  | 5.3 | Implementation |  |
|  |  |  |  |
| Chapter-6 | | | 21 |
|  | Conclusion | |  |
|  | 6.1 | Conclusion |  |
|  | 6.2 | Future Scope |  |
| References | | | 22 |
|  |  |  |  |

**CHAPTER 1 INTRODUCTION**

* **INTRODUCTION**

Traffic sign recognition is a crucial component of intelligent transportation systems, contributing to road safety and autonomous vehicle navigation. With the increasing deployment of advanced driver assistance systems (ADAS) and self-driving vehicles, real-time and accurate detection of traffic signs is essential. This project focuses on detecting and classifying traffic signs using YOLO (You Only Look Once) and Convolutional Neural Networks (CNNs), ensuring high efficiency and precision in real-world scenarios.

Traffic sign recognition involves two key processes: detection and classification. The detection phase locates the traffic signs in an image or video stream, while the classification phase assigns the correct category to the detected sign. YOLO, a deep learning-based object detection algorithm, is used for efficient real-time detection, while CNNs enable accurate classification of signs into predefined categories.

The proposed system aims to enhance the safety and reliability of automated driving systems by recognizing a wide variety of traffic signs under different environmental conditions, such as varying lighting, occlusion, and perspective distortions.

Traffic signs are vital components of road infrastructure, providing essential information to drivers and autonomous systems to ensure safe and efficient transportation. The ability to accurately detect and classify traffic signs in real-time is crucial for advanced driver assistance systems (ADAS) and the development of fully autonomous vehicles. Challenges such as varying environmental conditions, occlusions, and the diversity of traffic sign appearances necessitate robust and efficient recognition systems.

Objectives:

This project aims to develop a traffic sign recognition system that accurately detects and classifies various traffic signs in real-time, handles challenges such as varying lighting conditions, occlusions, and perspective distortions, integrates YOLO for efficient detection and CNNs for effective classification, enhances the safety and reliability of automated driving systems**.**

**CHAPTER 2 LITERATURE SURVEY**

**LITERATURE SURVEY**

**2.1 Literature Review**

**[1] Sichkar, Valentin N. "Real time detection and classification of traffic signs based on YOLO version 3 algorithm." *Journal Scientific and Technical Of Information Technologies, Mechanics and Optics* 127, no. 3 (2020): 418-424.”**

This paper explores using the YOLOv3 algorithm for real-time detection and classification of traffic signs, highlighting its effectiveness in autonomous driving and driver assistance systems. It demonstrates the algorithm's ability to accurately identify traffic signs under various conditions.

**[2] Khnissi, Khaled, Chiraz Ben Jabeur, and Hassene Seddik. "Implementation of a compact traffic signs recognition system using a new squeezed yolo." *International Journal of Intelligent Transportation Systems Research* 20, no. 2 (2022): 466-482.**

This paper by Khaled Khnissi, Chiraz Ben Jabeur, and Hassene Seddik presents a compact traffic sign recognition system using a new version of the YOLO (You Only Look Once) algorithm called "squeezed YOLO." This approach optimizes the YOLO model for better performance in recognizing traffic signs while reducing computational complexity, making it suitable for real-time applications in intelligent transportation systems.

**[3] Dewi, Christine, Rung-Ching Chen, Xiaoyi Jiang, and Hui Yu. "Deep convolutional neural network for enhancing traffic sign recognition developed on Yolo V4." *Multimedia Tools and Applications* 81, no. 26 (2022): 37821-37845.**

This paper by Christine Dewi, Rung-Ching Chen, Xiaoyi Jiang, and Hui Yu discusses enhancing traffic sign recognition using a deep convolutional neural network (CNN) built on YOLOv4. The study focuses on improving the accuracy and efficiency of traffic sign detection, leveraging YOLOv4's advanced capabilities in object detection combined with deep learning techniques for better recognition performance in real-world applications.

**[4]**  **Al Khafaji, Yasir Ali, and Nidhal K. El Abbadi. "Traffic Signs Detection and Recognition Using A combination of YOLO and CNN." In *2022 Iraqi International Conference on Communication and Information Technologies (IICCIT)*, pp. 328-334. IEEE, 2022.**

This paper by Yasir Ali Al Khafaji and Nidhal K. El Abbadi presents a method for traffic sign detection and recognition by combining YOLO (You Only Look Once) with Convolutional Neural Networks (CNN). This hybrid approach enhances the accuracy and efficiency of detecting and recognizing traffic signs, making it more effective for real-time applications in intelligent transportation systems. The study demonstrates how integrating YOLO with CNN improves both detection speed and classification performance.

**[5] Lin, Cheng-Jian, and Jyun-Yu Jhang. "Intelligent traffic-monitoring system based on YOLO and convolutional fuzzy neural networks." *IEEE Access* 10 (2022): 14120-14133.**

The paper by Cheng-Jian Lin and Jyun-Yu Jhang introduces an intelligent traffic-monitoring system that combines YOLO (You Only Look Once) with convolutional fuzzy neural networks (CFNN). This hybrid approach aims to enhance the accuracy and reliability of traffic monitoring, improving vehicle and traffic sign detection while incorporating fuzzy logic to handle uncertainties. The system provides real-time, efficient traffic analysis, making it suitable for smart transportation and urban management applications.

**[6] Artamonov, N. S., and P. Y. Yakimov. "Towards real-time traffic sign recognition via YOLO on a mobile GPU." In *Journal of Physics: Conference Series*, vol. 1096, p. 012086. IOP Publishing, 2018.**

This paper by N. S. Artamonov and P. Y. Yakimov explores the use of YOLO (You Only Look Once) for real-time traffic sign recognition on a mobile GPU. It focuses on optimizing the YOLO algorithm for efficient deployment on mobile devices, enabling fast and accurate detection of traffic signs in real-time. This approach aims to improve traffic monitoring and driver assistance systems by leveraging mobile GPU capabilities for on-the-go processing.

**[7] Flores-Calero, Marco, César A. Astudillo, Diego Guevara, Jessica Maza, Bryan S. Lita, Bryan Defaz, Juan S. Ante, David Zabala-Blanco, and José María Armingol Moreno. "Traffic sign detection and recognition using YOLO object detection algorithm: A systematic review." *Mathematics* 12, no. 2 (2024): 297.**

This paper by Marco Flores-Calero and colleagues provides a systematic review of traffic sign detection and recognition using the YOLO (You Only Look Once) object detection algorithm. It analyses various studies and applications of YOLO in traffic sign recognition, highlighting its strengths, challenges, and performance in real-time systems. The review offers insights into how YOLO has been adapted and improved for traffic sign detection, emphasizing its potential for enhancing intelligent transportation systems.

**[8] Yu, Jing, Xiaojun Ye, and Qiang Tu. "Traffic sign detection and recognition in multi -images using a fusion model with YOLO and VGG network." *IEEE Transactions on Intelligent Transportation Systems* 23, no. 9 (2022): 16632-16642.**

This paper by Jing Yu, Xiaojun Ye, and Qiang Tu proposes a fusion model combining YOLO (You Only Look Once) and VGG (Visual Geometry Group) networks for traffic sign detection and recognition across multiple images. The approach integrates the strengths of both models: YOLO’s efficiency in real-time object detection and VGG’s deep learning capabilities for enhanced feature extraction. This fusion aims to improve the accuracy and robustness of traffic sign recognition in diverse conditions, offering a more reliable solution for intelligent transportation systems.

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| **Paper Name** | **Summary** | **Limitations** | **Adaptations** |
| "Real time detection and classification of traffic signs based on YOLO version 3 algorithm." | This paper uses YOLOv3 for real-time detection and classification of traffic signs, aiming to enhance autonomous driving and driver assistance systems. | Limited to YOLOv3's performance in varying environmental conditions. | YOLOv3 can be improved with more fusion models to handle diverse scenarios better. |
| "Implementation of a compact traffic signs recognition system using a new squeezed yolo." | Introduces a compact YOLO model optimized for traffic sign recognition with reduced computational complexity. | The model might be limited by trade-offs between compactness and accuracy. | Squeezed YOLO can be further optimized for mobile applications or embedded systems with stricter computational constraints. |
| "Deep convolutional neural network for enhancing traffic sign recognition developed on Yolo V4." | Enhances traffic sign recognition by integrating a deep convolutional neural network with YOLOv4 for better accuracy and performance. | Computationally intensive, especially for real-time applications. | Efficient hardware acceleration can make it more suitable for real-time systems. |
| "Traffic Signs Detection and Recognition Using A combination of YOLO and CNN." | Combines YOLO and CNN for better accuracy in detection. | |  |  | | --- | --- | | May struggle with varied lighting/weather conditions. | | |  | | Fine-tune models and data augmentation. |
| "Intelligent traffic-monitoring system based on YOLO and convolutional fuzzy neural networks." | Combines YOLO with fuzzy neural networks for uncertain conditions. | Increased complexity, affecting real-time processing. | Optimize or use hardware accelerators. |
| "Towards real-time traffic sign recognition via YOLO on a mobile GPU." | Optimizes YOLO for mobile GPU-based traffic sign recognition. | Limited by mobile GPU power. | Focus on lighter models for mobile devices. |
| "Traffic sign detection and recognition using YOLO object detection algorithm: A systematic review." | Review of YOLO in traffic sign detection and recognition. | No single solution for all conditions. | Integrate best practices from various studies. |
| "Traffic sign detection and recognition in multi-images using a fusion model with YOLO and VGG network." | Combines YOLO and VGG networks in a fusion model for better traffic sign recognition across multiple images. | The fusion model may require higher computational power, potentially limiting its real-time application. | Optimization through model compression or hardware acceleration could help deploy this system in real-time settings. |

**CHAPTER 3**

**PROBLEM STATEMENT**

* **PROBLEM STATEMENT**

With the increasing number of vehicles on roads, ensuring traffic safety has become a critical concern. Human drivers often fail to notice traffic signs due to distractions, weather conditions, or poor visibility. This can lead to traffic violations and accidents. Moreover, autonomous vehicles and ADAS require real-time recognition of traffic signs to operate safely and comply with road regulations, current traffic sign recognition systems face challenges such as Variability in lighting conditions (day, night, fog, etc.), occlusions caused by other vehicles, trees, or weather elements, perspective distortions due to camera angles, real-time processing constraints in embedded automotive systems. To address these issues, we propose a robust traffic sign recognition system that leverages YOLO for fast and accurate sign detection and CNN for reliable classification. Our system is designed to operate efficiently in diverse environmental conditions, ensuring high accuracy and real-time performance.

**CHAPTER 4**

**EXPERIMENTAL SETUP**

**4.1 Introduction**

Traffic signal detection and classification play a crucial role in intelligent transportation systems, aiding autonomous vehicles and advanced driver-assistance systems (ADAS). This experiment focuses on using **YOLO (You Only Look Once)** for object detection and **CNN (Convolutional Neural Networks)** for classification to achieve accurate and real-time recognition of traffic signals.

**4.2 Features**

**1. Hardware and Software Requirements**

**Hardware**

* **GPU**: NVIDIA RTX 3060 (or higher) for faster training and inference
* **CPU**: Intel i7/i9 or AMD Ryzen 7/9
* **RAM**: Minimum 16GB
* **Storage**: SSD with at least 100GB free space
* **Camera**: High-resolution camera (if real-time detection is tested)

**Software**

* **OS**: Windows 10/11, Linux (Ubuntu 20.04)
* **Programming Language**: Python 3.x
* **Libraries & Frameworks**:
* OpenCV for image processing
* TensorFlow/Keras for CNN-based classification
* PyTorch for YOLO model implementation
* YOLOv5/YOLOv8 for object detection
* NumPy, Pandas, Matplotlib for data handling and visualization

**2. Dataset**

* **Source**: Publicly available datasets like **LISA Traffic Light Dataset**, **TT100K (Tsinghua-Tencent 100K)**, or self-collected images.
* **Preprocessing**:
* **Image Annotation**: Label images using tools like **LabelImg** for YOLO format.
* **Data Augmentation**: Apply rotation, brightness adjustment, and contrast enhancement.
* **Normalization**: Scale pixel values between 0 and 1.

**3. Methodology**

**Step 1: Traffic Signal Detection using YOLO**

* **Model Selection**: YOLOv5 or YOLOv8 is chosen due to its balance between speed and accuracy.
* **Training the Model**:
* Custom dataset with labeled traffic signals.
* Input image resolution: 416x416 or 640x640.
* Optimizer: Adam or SGD.
* Loss Function: Cross-Entropy Loss for classification, Mean Squared Error for bounding box regression.
* **Inference**: Detect traffic signals in images/videos and extract the signal region.

**Step 2: Traffic Signal Classification using CNN**

* **CNN Architecture**:
* Convolutional layers to extract features.
* Max-pooling layers to reduce dimensionality.
* Fully connected layers for classification (e.g., Red, Yellow, Green signals).
* Softmax activation for multi-class classification.
* **Training**:
* Input: Cropped traffic signal images from YOLO detection.
* Output: Classified traffic signal type.
* Optimizer: Adam.
* Loss Function: Categorical Cross-Entropy.

**4. Performance Metrics**

* **YOLO Detection Performance**:
* **mAP (Mean Average Precision)**
* **IoU (Intersection over Union)**
* **FPS (Frames Per Second) for real-time performance**
* **CNN Classification Performance**:
* **Accuracy, Precision, Recall, F1-score**
* **Confusion Matrix for class-wise performance evaluation**

**5. Experimental Results and Analysis**

* Evaluate the detection and classification performance on test data.
* Compare YOLO versions (YOLOv4 vs. YOLOv5 vs. YOLOv8).
* Measure inference speed for real-time applications.
* Identify challenges such as occlusions, lighting conditions, and false positives.

**CHAPTER 5**

**PROPOSED SYSTEM AND IMPLEMENTION**

**5.1 Block diagram of proposed system**



**5.2 Description of block diagram**

**Flow Breakdown:**

* **Dashcam Video Feed:** Captures real-time footage.
* **Frame Extraction:** Converts video into frames.
* **YOLOv8 Detection:** Identifies traffic signs in frames.
* **Detected Sign Regions:** The detected areas move to two parallel processes:
* **VGG16 Feature Extraction & Classification:** Processes and classifies traffic signs.
* **Hough Circle Transform for Speed Limit Detection:** Detects circular speed limit signs.
* **TrOCR for Speed Limit OCR:** Extracts the numerical speed value from detected speed limit signs.
* **Final Output Display:** Combines the traffic sign classifications and speed limit values for the final results.

**5.3 Implementation**



**CHAPTER 6**

**CONCLUSION**

**6.1 Conclusion**

The experiment successfully implemented **traffic signal detection and classification** using **YOLO (You Only Look Once)** for object detection and **CNN (Convolutional Neural Network)** for classification. YOLO efficiently detected traffic signals in real-time, while CNN accurately classified them into different categories (e.g., red, yellow, green). The system achieved **high accuracy** and demonstrated **fast inference speed**, making it suitable for real-world traffic monitoring and autonomous vehicle applications.

However, challenges such as **occlusions, varying lighting conditions, and blurred images** affected performance. Model accuracy could be further improved with a **larger and more diverse dataset**, better **preprocessing techniques**, and **hyperparameter tuning**.

**6.2 Future Scope**

* **Enhancing Detection Accuracy**
* Implement **YOLOv8 or YOLO-NAS** for improved detection speed and accuracy.
* Use **attention mechanisms** to focus on important image regions.
* **Integration with Advanced Models**
* Combine YOLO with **Transformer-based models (e.g., ViTs, Swin Transformers)** for better feature extraction.
* Explore **Hybrid CNN-RNN models** for improved classification under dynamic conditions.
* **Real-time Deployment**
* Optimize the model for **edge computing** (e.g., NVIDIA Jetson, Raspberry Pi) to enable real-time detection in vehicles.
* Implement **low-power AI models** for smart traffic monitoring in IoT-based systems.
* **Dataset Expansion and Augmentation**
* Collect **larger and more diverse datasets** to handle different weather, lighting, and traffic conditions.
* Use **synthetic data generation** and **GANs (Generative Adversarial Networks)** to improve model robustness.
* **Multi-Signal Detection and Recognition**
* Extend the model to detect **multiple traffic signals simultaneously** in crowded urban environments.
* Train models to recognize **blinking or special-purpose signals** used for pedestrians and emergency vehicles.
* **Integration with Autonomous Vehicles & ADAS**
* Implement the model in **autonomous driving systems** to improve decision-making.
* Integrate with **Advanced Driver-Assistance Systems (ADAS)** for real-time driver alerts.
* **Cloud-Based and 5G Integration**
* Deploy a **cloud-based model** for processing large-scale traffic data.
* Utilize **5G networks** to transmit real-time traffic data for smart city applications.

**References:**

[1] Basbug AM, Sert M (2019) Acoustic scene classification using spatial pyramid pooling with convolutional neural networks. In: proceedings 13th IEEE international conference on semantic computing, ICSC 2019. Pp 128-131

[2] M. Haloi, "Traffic sign classification using deep inception based convolutional networks", CoRR, vol. abs/1511.0, pp. 1-5, 2015.

[3]Bochkovskiy A, Wang C-Y, Mark Liao H-Y (2020) YOLOV4: optimal speed and accuracy of object detection. arXiv:2004109341 17

[4] A. Mukherjee, A. Joshi, S. Sarkar and C. Hegde, "Attribute-controlled traffic data augmentation using conditional generative models", Proc. CVPR Workshop Vis. All Seasons, pp. 83-87, 2019.

[5] W. Liu, D. Anguelov, D. Erhan, C. Szegedy, S. Reed, C.-Y. Fu, et al., "SSD: Single shot multibox detector", Proc. Eur. Conf. Comput. Vis., pp. 21-37, 2016