JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

TRAFFIC LIGHT DETECTION AND CLASSIFICATION USING RESNET

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Abstract : Intelligent Transportation Systems (ITS) play a crucial role in enhancing road safety and optimizing traffic management. Central to the effectiveness of these systems is the rapid and accurate detection and classification of traffic light states. This research contributes to the ongoing advancements in computer vision and machine learning within the context of ITS by presenting a novel methodology for real-time traffic light recognition. Leveraging the ResNet (Residual Networks) architecture, our approach addresses the multifaceted challenges presented by diverse environmental conditions, including adverse weather, varying illumination, and occlusions. The ResNet's deep learning capabilities enable our system to discern intricate patterns and features, showcasing its adaptability to the complexities of real-world traffic scenarios. Beyond the technical aspects, the study underscores the significance of accurate traffic light detection and classification. These processes are not merely technical necessities but hold profound implications for optimizing traffic flow, minimizing congestion, and ultimately enhancing road safety within the dynamic landscape of modern urban environments. This research contributes to the broader discourse in computer vision and machine learning, aiming to provide practical solutions for the challenges posed by real-world ITS applications. By emphasizing the importance of accurate traffic light recognition, our study seeks to propel advancements in the field, with potential implications for the development of intelligent traffic management systems that can positively impact urban mobility and safety.

Index Terms **- Traffic lights, ResNet, Deep learning, Computer vision.**

I. INTRODUCTION

Traffic lights play a pivotal role in regulating traffic flow and ensuring road safety. Automating their detection and classification using computer vision and deep learning techniques can significantly impact traffic management systems. The project aims to address the challenges associated with real-time recognition of traffic lights under varying environmental conditions, such as changes in lighting, weather, and complex urban landscapes. By leveraging ResNet, a convolutional neural network (CNN) architecture, the system intends to achieve high accuracy in identifying and categorizing different types of traffic lights, contributing to more efficient and reliable traffic control. In addressing the multifaceted challenges inherent in real-world traffic scenarios, we propose the application of the ResNet (Residual Networks) architecture, renowned for its proficiency in handling complex feature hierarchies. The ResNet framework becomes particularly pertinent in negotiating adversities such as adverse weather conditions, varying illumination, and occlusions, ensuring robust performance in diverse environmental contexts.

Intelligent Transportation Systems (ITS) have emerged as instrumental frameworks in modern urban landscapes, designed to augment road safety and optimize the fluidity of traffic networks. At the core of these systems lies the pivotal task of efficient traffic light detection and classification, serving as a cornerstone for informed decision-making in automated vehicles and adaptive traffic control mechanisms. This research endeavors to contribute to the advancements in computer vision and machine learning within the purview of ITS by introducing a novel methodology for real-time traffic light recognition.Beyond the technical intricacies, this study places a deliberate emphasis on the critical role of accurate traffic light detection and classification in the broader context of traffic management. Recognizing traffic light states swiftly and accurately is not merely a technical prerequisite but holds profound implications for optimizing traffic flow, mitigating congestion, and ultimately fostering heightened road safety within the dynamic milieu of contemporary urban environments. As we delve into the methodology and present empirical results, this research seeks to contribute to the evolving discourse in computer vision and machine learning. By illuminating the importance of precise traffic light recognition, our endeavor aims to propel advancements in the field, laying the groundwork for the development of intelligent traffic management systems poised to positively impact urban mobility and safety.

II. LITERATURE SURVEY

1. The search for previous articles in the literature has been conducted and published on IEEE Xplore, utilizing the following keywords: convolutional neural networks (CNNs), recurrent neural networks (RNNs), and deep belief networks (DBNs), with an accompanying explanation: The recognition and classification of traffic signs hold significant significance within intelligent transportation systems and autonomous vehicles. This task entails the precise and real-time identification and categorization of diverse traffic signs through the There are many different types of neural networks that can be used for traffic sign recognition and classification, including convolutional neural networks (CNNs), recurrent neural networks (RNNs), and deep belief networks (DBNs). The choice of which network to use depends on the specific requirements and constraints of the task. The field continues to evolve and advance, with new techniques and approaches being developed to address the challenges and limitations of this task.

Written by Md. Saiful Islam, Arafatun Noor Orno, Mohammad Arifuzzaman, and Md. Tamimur Rahman, the article is titled 'Traffic Sign Recognition and Classification Using Machine Learning and Deep Learning.

2. Low-light Traffic Objects Detection for Automated Vehicles, Xuewei Wang; Dongmei Wang; Siyuan Li; Shaohua Li; Pengtian Zeng; The low-light condition brings huge challenges to the traffic object detection, limiting its application in complex scenarios such as the round-the-clock traffic monitoring and automatic driving. To address this issue, an accurate traffic object detection method in low-light conditions is proposed. First, the dark channel prior knowledge is utilized to restore the scene radiance via the transmission map and the estimation of the atmospheric light. Meanwhile, the grayscale is adjusted by adaptive gamma transformation to further improve the brightness of the image and reduce the impact of low-light conditions. Second, a LL4PH-Net framework equipped with preset anchors and detection branches is developed to detect low-light traffic objects. The performance of the algorithm is tested on the public BDD100K dataset. Experimental results show that compared with the SOTA methods, the proposed LL4PH-Net acquires the best detection mAP, the most lightweight model and a good time efficiency. It can effectively detect traffic objects even under low-light conditions.

III. Existing Problem

In the realm of Advanced Driver Assistance Systems (ADAS) and Autonomous Vehicles (AV), the detection and recognition of traffic objects represent a critical challenge. The paper identifies four key classes of traffic objects: traffic signs, road vehicles, pedestrians, and traffic lights. Existing methods in the literature are explored, revealing the utilization of both traditional machine learning and deep learning techniques for object detection and recognition. However, these methods often lack the integration of the driver's attentional visual field, which is crucial for real-world applicability.

IV. Proposed System

The proposed system leverages the ResNet (Residual Networks) algorithm as a foundational element for traffic object detection and recognition. ResNet, known for its capacity to handle deep neural networks, plays a pivotal role in enhancing the accuracy and robustness of the system. In the detection stage, a combination of multi-scale HOG-SVM and Faster R-CNN-based models is employed to identify traffic objects within the driver's attentional visual field. The ResNet-101 network takes center stage in the subsequent recognition stage, verifying sets of generated hypotheses. This strategic integration of ResNet facilitates a more nuanced understanding of complex feature hierarchies within the visual data, ensuring a sophisticated and reliable framework for recognizing diverse traffic objects, including traffic signs, road vehicles, pedestrians, and traffic lights. Through rigorous testing on real-world data collected during drives in urban environments, the proposed system showcases its effectiveness, achieving a commendable 91% accuracy in object detections and demonstrating promising results in the object recognition stage.

V. Methodology

The research methodology involves training a deep neural network based on the ResNet architecture, utilizing a meticulously curated dataset encompassing various traffic light scenarios. The model is trained to detect the presence of traffic lights within images and categorize them into distinct states, including red, green, and yellow. Leveraging ResNet's inherent ability to handle intricate feature hierarchies, the proposed system demonstrates robust performance across a spectrum of challenging conditions, including adverse weather, varying illumination, and occlusions.

Evaluation

Extensive experiments are conducted to assess the system's effectiveness using real-world traffic scenarios. Comparative analyses with existing methods underscore the superior accuracy and robustness of the ResNet-based approach. Results showcase the model's potential for integration into intelligent transportation systems, contributing to the evolution of advanced traffic control mechanisms in smart cities.

Significance

The implementation of this project offers a substantial contribution to the development of intelligent traffic management systems, particularly in smart cities. The ResNet-based approach promises heightened accuracy and reliability, fostering safer urban mobility and laying the foundation for future advancements in intelligent transportation.

VI. Implementation

In this project we are employing ResNet50 algorithm to detect and classify type of traffic light in both images and videos. To train Resnet50 we have utilized LISA Cropped Traffic light dataset and below are the output screens.

To run project double click on 'run.bat' file to get below screen

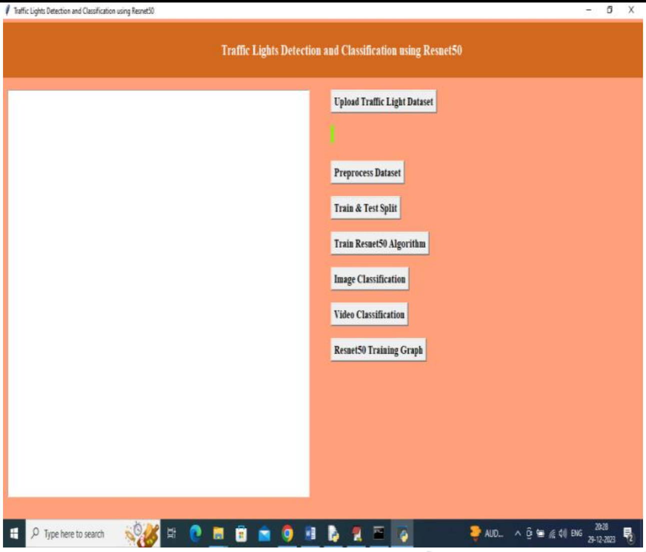


Fig 1: Opening the Page for Traffic light detection and classification

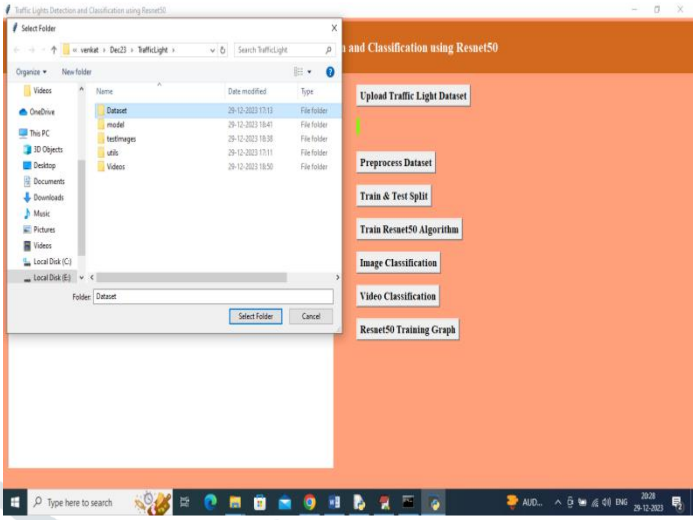


Fig 2: Uploading the Dataset

In above screen click on 'Upload Traffic Light Dataset' button to upload dataset and get below output. In above screen selecting and uploading traffic light dataset and then click on 'Select Folder' button to load dataset and get below output.

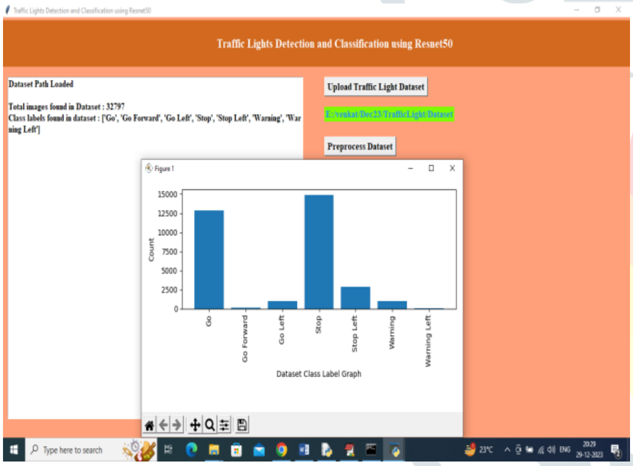


Fig 3: Loading the dataset

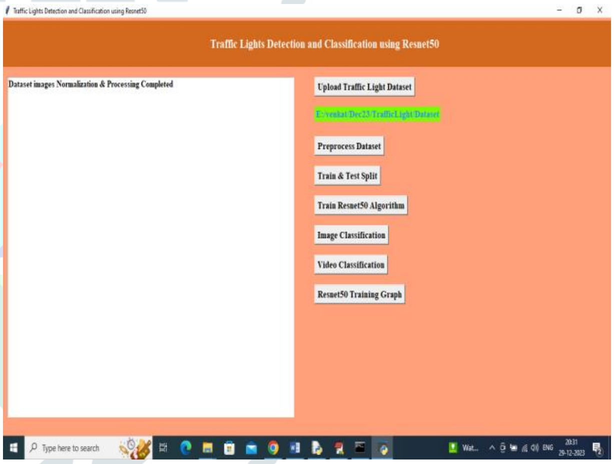


Fig 4: Dataset Preprocessing

Dataset loaded and then can see total number of images available in dataset and in graph can see different Traffic Light Names in x-axis and y-axis represents number of images available in that traffic light category and now close above graph and then click on 'Pre-process Dataset' button to normalized and shuffle images and then will get above output.

In above screen dataset process completed and now click on 'Train & Test Split' button to get below output. In a below screen using 80% dataset images for training and 20% for testing and now click on 'Train Resnet50 Algorithm' button to train Resnet50 and get below output.

In the screen Resnet50 got 99% accuracy on test data and can see other metrics also and in confusion matrix graph x-axis represents "Predicted Labels" and y-axis represents True Labels and all different colour boxes in diagnol represents correct prediction count and all blue boxes represents incorrect prediction count which is 0 and now close above graph and then click on 'Image Classification' button to detect and classify traffic light from images.

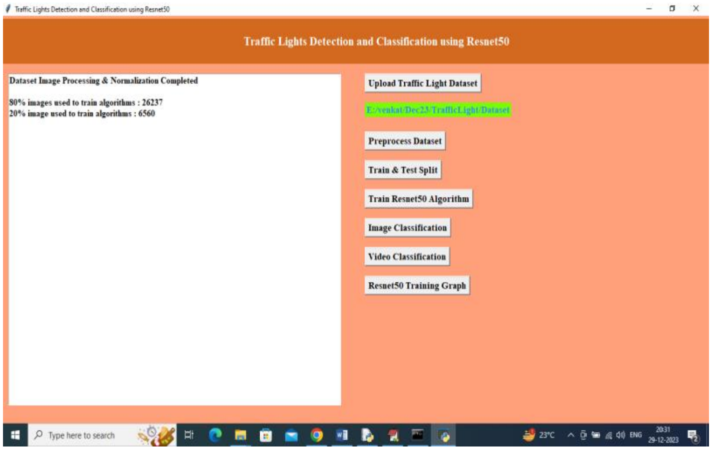


Fig 4: Splitting Train and Test Data

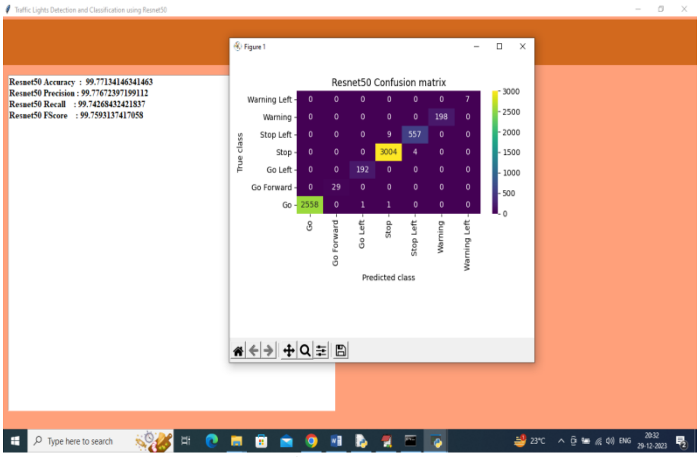


Fig 5: Confusion Matrix

In below screen selecting and uploading 'img_4.jpg' image and then click on 'Open' button to get below output.

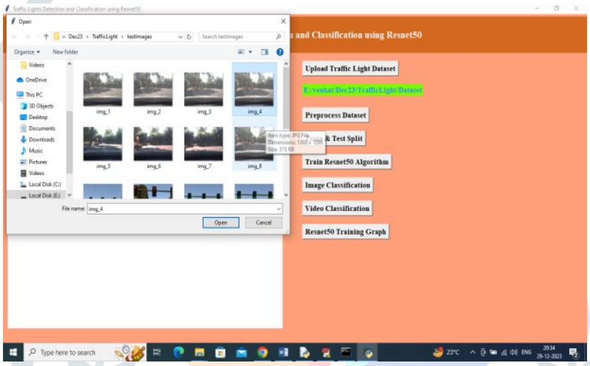
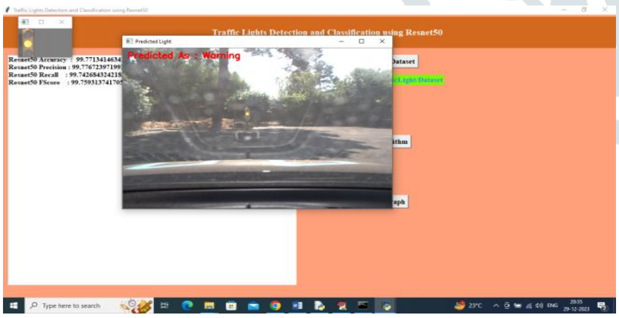


Fig 6: Selecting and uploading the image

In below screen first image represents detected traffic light and second images represents original image and in second image in red colour text can see classified Traffic light as 'Warning' and now close above image and then upload other image. In below screen can see detected and classified traffic light as 'Stop'. In above screen can see detected and classified output as 'Go'.



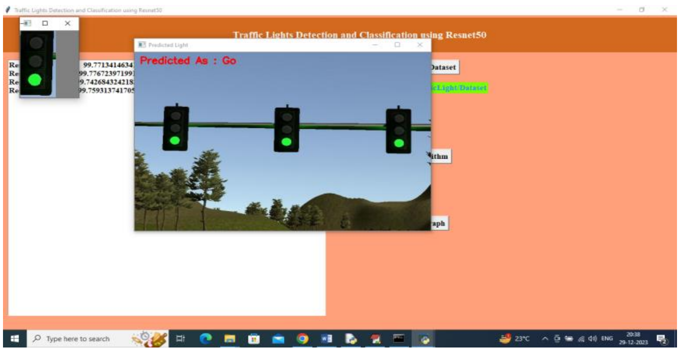


Fig 7,8,9: Traffic Light Detection and Classification in Images (Warning, Stop, Go)

Now click on 'Video Classification' button to upload video and get below output. In a below screen selecting and uploading video file and below are the detected output. In above screen from video we can see detected traffic light in small panel and in red colour text can see classified traffic light as 'Go'.

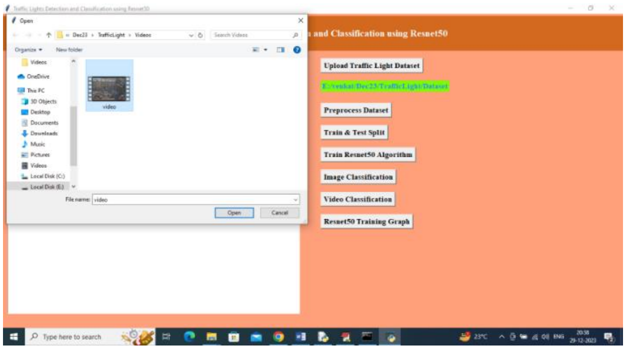


Fig 10: Uploading Video

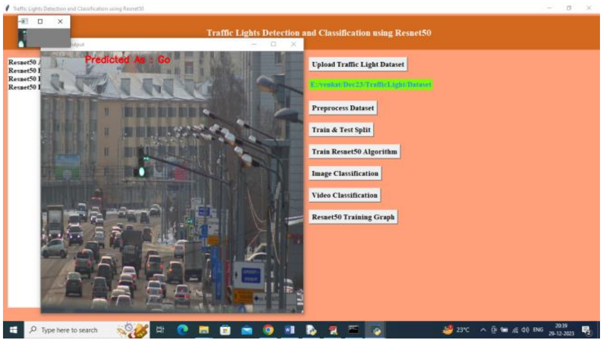


Fig 11: Output Predicted as Go

In above screen can see detected and classified traffic light as "Warning' or ready to go and now click on 'Resnet50 Training Graph' button to get below graph. In above graph x-axis represents Resnet50 training epoch and y-axis represents accuracy and loss values and in above graph can see with each increasing epoch accuracy got increased and reached closer to 1 and loss got decrease and reached closer to 0. Similarly, you can upload and test other images.

VII. Conclusion

The Traffic Lights Detection and Classification project, employing ResNet-based deep learning models, stands as a pivotal advancement in traffic management and road safety. By leveraging computer vision techniques, this project aims to accurately detect and classify traffic light signals, offering substantial contributions to intelligent transportation systems. The project's implementation of Convolutional Neural Networks, particularly ResNet, demonstrates the potential to enhance safety measures by enabling automated vehicles to interpret and respond to traffic signals effectively. Moreover, the project has implications for optimizing traffic flow and enhancing overall transportation efficiency by facilitating quick, precise analysis of traffic light data. However, challenges persist, including environmental variations and real-time processing requirements. Ongoing research endeavors focus on addressing these challenges to ensure more robust and adaptable systems. Ultimately, the outcomes of this project hold promise for integration into smart city infrastructures, autonomous vehicles, and broader traffic management systems, paving the way for safer, smarter, and more connected urban environments.

VIII. Acknowledgement

We would like to thank Dr.M.Suneetha for her valuable comments and suggestions to improve the quality of the paper. We are also grateful to Dr.K.Shirisha Reddy for helping us review our work regularly. We would also like to thank the Department of Computer Science Engineering (AI & ML), VBIT Hyderabad for providing all the help we need.

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