Large-Scale Traffic-Sign Detection and Recognition Using Deep Learning

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I. Introduction

Automatic detection and recognition of traffic signs plays a crucial role in management of the traffic-sign inventory. It provides accurate and timely way to manage traffic-sign inventory with a minimal human effort. In the computer vision community, the recognition and detection of traffic signs is a well-researched problem. A vast majority of existing approaches perform well on traffic signs needed for advanced drivers' assistance and autonomous systems. However, this represents a relatively small number of all traffic signs (around 50 categories out of several hundred) and performance on the remaining set of traffic signs, which are required to eliminate the manual labour in traffic-sign inventory management, remains an open question.

In this paper, we address the issue of detecting and recognizing a large number of traffic-sign categories suitable for automating traffic-sign inventory management. We adopt a convolutional neural network (CNN) approach, the Mask R-CNN, to address the full pipeline of detection and recognition with automatic end-to-end learning. We propose several improvements that are evaluated on the detection of traffic signs and result in an improved overall performance. This approach is applied to detection of 200 traffic-sign categories represented in our novel dataset. Results are reported on highly challenging traffic sign categories that have not yet been considered in previous works.

We provide comprehensive analysis of the deep learning method for the detection of traffic signs with large intra-category appearance variation and show below 3% error rates with the proposed approach, which is sufficient for deployment in practical applications of traffic-sign inventory management.

II. Literature Review

The literature review contextualizes the research within the broader field of computer vision and deep learning applied to traffic sign recognition. Existing approaches have shown remarkable success in identifying traffic signs for specific applications, such as autonomous vehicles. However, the scope of these approaches is limited to a relatively small subset of traffic signs, neglecting the numerous other categories crucial for complete inventory management. This study highlights the necessity of expanding the focus to encompass a larger and more diverse collection of traffic signs.

The review delves into the evolution of convolutional neural networks (CNNs) and their pivotal role in image recognition tasks. CNNs have demonstrated exceptional performance in object detection and classification, making them well-suited for the complex task of recognizing traffic signs. Moreover, the review identifies the mask R-CNN architecture as a powerful tool capable of simultaneously detecting and segmenting objects within images.

III.Objectives

The primary objective of this research is to design and implement an end-to-end system capable of autonomously detecting and recognizing a comprehensive range of traffic-sign categories. To achieve this goal, the study seeks to:

1. Adapt the mask R-CNN architecture for traffic sign detection and recognition.
2. Develop a large and diverse dataset encompassing a broad spectrum of traffic-sign categories.
3. Implement enhancements to the mask R-CNN model to address intra-category appearance variations, occlusions, and challenging lighting conditions.
4. Evaluate the system's performance on challenging traffic-sign categories not previously considered in other works.
5. Achieve a level of accuracy that is suitable for practical deployment in real-world traffic-sign inventory management applications.

IV.Limitations of the Study

It is important to acknowledge several limitations that may impact the outcomes of this research. Firstly, the accuracy of the proposed system may be affected by factors such as adverse weather conditions, vandalism, and occlusions caused by objects or other vehicles. Secondly, the system's performance heavily relies on the quality and diversity of the dataset used for training and testing. Biases present in the dataset could influence the model's generalization capabilities.

V.Conclusion

The research endeavours to advance the field of traffic-sign inventory management by presenting a comprehensive and automated solution for traffic sign detection and recognition. The adaptation of the mask R-CNN architecture, coupled with enhancements to address various challenges, has demonstrated promising results in accurately identifying traffic signs from a diverse range of categories. Achieving error rates of below 3% on challenging traffic-sign categories underscores the practical viability of the proposed approach for real-world deployment.

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