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Vehicle Detection and Number Plate Reading

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ABSTRACT

This paper presents an integrated automation framework for effective real-time vehicle detection and number plate recognition is presented. For vehicle detection, a state-of- the-art object detection model YOLOv5 has been employed. Continuous tracking of vehicles has been done using DeepSORT. The ANPR system uses the Tesseract OCR engine to perform post-processing and character recognition on the cropped vehicle images. Combining all the

recognised characters from the final license plate number. Being useful for traffic management and security; the proposed technology solution is effective in number plate recognition and real-time vehicle surveillance. The ability of seamlessly coupling cutting-edge technologies demonstrated in this work makes it a useful tool to improve law enforcement operations and smooth traffic in city environments.

Keywords: Vehicle Detection, YOLOv5, DeepSORT, Average Precision (mAP)

1. OBJECTIVE

The research paper aims at introducing and evaluating an integrated automation framework for efficient vehicle detection and number plate recognition in urban contexts. This framework is aimed at solving complex challenges faced by urban traffic management as well as security surveillance through the use of modern technologies such as YOLOv5 object detection model, DeepSORT used for continuous vehicle tracking, and Tesseract OCR engine for character recognition in Automatic Number Plate Recognition (ANPR) systems. By doing this, the paper intends to show how effective and applicable the suggested framework is towards enhancing public safety, optimizing traffic flow and general urban mobility in different kinds of urban environments. Moreover, this study seeks to find out potential areas that can be refined or optimized so as to increase its impact and scalability for wider deployment in real world situations. This research article therefore seeks to support real-time vehicle surveillance technology improvement with a usability orientation on how it addresses vital challenges experienced in cities.

2. INTRODUCTION

The proliferation of vehicles and the ever-changing urban landscape underscore the urgent need for new solutions to enhance law enforcement, traffic management and security. As cities become increasingly interconnected and mobility increases, effective vehicle detection and identification systems are essential, but dynamic modern traffic conditions challenge traditional monitoring systems to be insufficient and require innovative approaches. This research aims to respond to the urgent demand for real-time vehicle tracking and license plate reading recognition using state-of-the-art technologies. Efficient traffic flow is vital in congested metropolitan environments, but growing safety concerns also require accurate vehicle tracking. By integrating advanced computer vision algorithms, includ- ing YOLOv5, DeepSORT and ANPR, this project aims to provide an automated, robust vehicle monitoring system adapted to the future needs of smart cities while meeting current requirements. Authorities require real-time vehicle identification and license plate reading capabilities to proactively solve prob- lems, enforce laws, and improve overall urban safety. Thus, this research proposes solutions in line with an increasingly connected, dynamic world while responding in a timely manner to the changing contemporary urban needs. Extensive testing will evaluate system accuracy and integration potential. The results will provide key insights into intelligent transport and security applications in emerging smart cities.

3. RESEARCH APPROACH

Our YOLOv5 model for vehicle detection and tracking is famous for its high performance in mean Average Precision (mAP) and processing rate as well as employing DeepSORT approach to ensure reliable vehicle monitoring. YOLOv5 has 3 basic sections: Backbone, Neck, Head. The CSP Network along with the Focus modules combines the Backbone to achieve effective feature extraction by using a Focus module with standard convolution for feature learning and C3 module to expand representational capacity. The SPP Block together with PANet are present in the Neck to ensure a pyramid of features that are used in comprehensive object detection that enhances contextual information integration and enables multi-scale feature capture. A Head usually adopts GIoU-loss which helps to predict precise bounding boxes since it generates detection outputs consisting of bounding boxes, confidence scores and class probabilities The YOLOv5 method has been extensively evaluated and proved suitable for vehicle detection because it offers very high accuracy and real-time capability. DeepSORT improves on SORT by including motion and appearance information via CNNs which is important for tracking vehicles over long periods of time. It manages noise in detections using Kalman filter, predicts optimal closed frames for tracked objects using this tool, deletes tracks that exceed threshold on detection time then DeepSORT is robust but not without challenges.

4. METHODOLOGY

Our vehicle detection and tracking system relies heavily on Number Plate Reading (NPR), which enables extracting relevant data from identified vehicles. The NPR pipeline involves image pre-processing, cleaning, contour detection, morphological transformations, and final recognition, converting an image of a vehicle into a readable license plate number. Initially, RGB images are converted to grayscale to save space and facilitate further processing. Gaussian blur is applied to reduce noise and improve image quality. Figure 1 illustrates proposed methodology for detecting and tracking vehicles using YOLOv5 and the DeepSORT algorithm.

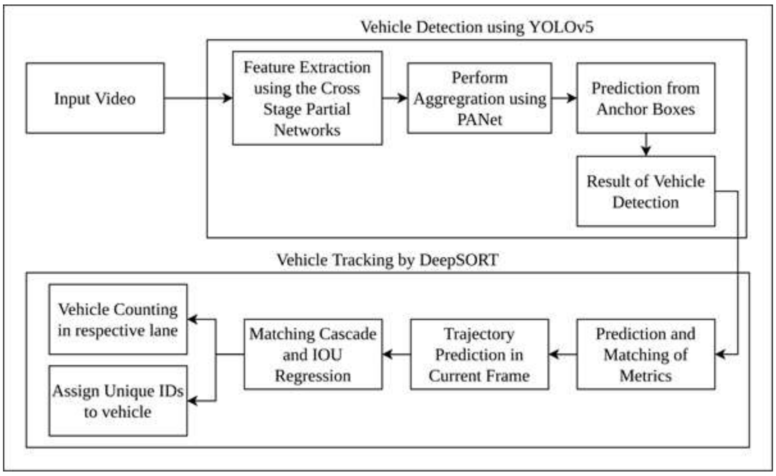

Figure 1: Proposed methodology for detecting and tracking vehicles using YOLOv5 and the DeepSORT algorithm

The cleaned image is binarized using inverted adaptive Gaussian thresholding, and Sobel edge detection is used to locate object boundaries for easier segmentation. Morphological operations such as dilatation, erosion, opening, and closing refine the image for further analysis, and contour tracing techniques are used to locate objects. In the plate recognition step, each contour is iterated over, the corresponding rectangular region is cropped, and the image contour is cleaned. The segmented characters are then passed to the Tesseract OCR engine for accurate recognition. Post-processing techniques like filtering, template matching, and spell checking enhance the accuracy and visual quality of detected characters. The process concludes with the smooth combination of detected characters to construct the final license plate number, a crucial output for the system's success in identifying and tracking vehicles.

Image pre-processing, cleaning, and other steps such as contour detection and morphological transformations are included in the Number Plate Reading (NPR) system that converts vehicle images into readable license plate numbers. At the beginning, RGB pictures get converted to grayscale to save space and enhance subsequent processes then Gaussian blur filters are applied for noise reduction. Binarization of the cleaned image uses inverted adaptive Gaussian thresholding while Sobel edge detection is used to detect boundaries of objects making it easy for one to segment them. The image is refined by it through a series of morphological operations like dilatation, erosion, opening and closing as well as locating objects using contour tracing techniques. Contours are iterated over during number plate recognition so that they can be cropped and cleaned before the segmented characters are sent off for reliable recognition through the Tesseract OCR engine. Post processing techniques which include filtering, template matching, spell checking among others improve accuracy and visual quality of detected characters. Lastly, detected characters are combined generating the final license plate number that is crucial in identifying vehicles being monitored by this system for success purposes of identification and tracking process will highly depend on it.

5. RESULT AND DISCUSSION

For its efficiency in tracking, speed estimation and vehicle detection, a combined methodology using YOLOv5 and DeepSORT was proved to be trustworthy. The fusion of real-time accuracy from YOLOv5 with dynamic tracking abilities of DeepSORT could therefore make the system strong. Thus, these praiseworthy results make bounding box-based speed estimation an essential tool in traffic management and law enforcement while proving that the integrated framework is effective for addressing current issues on urban mobility and security. Hence, as far as this research is concerned, further thorough benchmarking followed by deploying to real-world traffic systems will continue validating the solution put forth herein. Up until now however, results obtained have shown that the framework has the potential for automatic monitoring of vehicles in real- time through excellent integration of latest object detection and tracking algorithms into it. Consequently, this study offers valuable insight into developing advanced ITS specifically tailored to smart cities being established today. This framework can then estimate vehicle speeds accurately over time using such information. The proposed model improves the detection accuracy rate in videos, as evidenced by a mean average precision (mAP) of 99.45% and precision and recall rates of 0.741 and 0.987, respectively, surpassing existing methods. The training dataset achieved the model's learning process over the course of 100 epochs. Similarly, the final result of the proposed model is illustrated in Table 1.

Parameters	Precision	Recall	Average IOU	mPA@0.5
Result	0.741	0.987	95%	99.45%

Table 1: The final result of the proposed model

6. CONCLUSION

In conclusion, through suggesting a holistic framework for vehicle detection and license plate recognition, this study has addressed critical needs in traffic management, law enforcement and security. The integrated system involving YOLOv5, DeepSORT and ANPR demonstrates a well-thought effort to exploit cutting-edge technologies for immediate video surveillance. This framework's effective implementation represents a technological milestone and holds important consequences for cities that are currently experiencing increased numbers of vehicles. The system's accuracy, speediness and adaptability make it an invaluable tool for authorities striving to tackle traffic monitoring as well as regulation en- forcement or even security concerns.Intelligent transportation systems are increasingly sought after as smart cities evolve. This research also meets recent requirements while anticipating future challenges in urban transport and safety through surveillance of vehicles in real-time as well as license plate identification. Thus, successful realization of the framework should provide some hints about what lies ahead with respect to networked technologies forming part of a more secure and efficient urban fabric.

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