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AUTOVISTA: A NEXT-GEN NUMBER PLATE RECOGNITION

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ABSTRACT: Automatic Number Plate Recognition (ANPR) is an integral part of the Intelligent & Transportation Systems (ITS) field, facilitating automatic vehicle recognition via license plate detection and recognition. This project demonstrates a highly robust, affordable, & scalable ANPR system based on open-source technologies. The system combines image processing methodologies, object detection algorithms, and Optical Character Recognition (OCR) to detect & recognize vehicle number plates correctly and extract alphanumeric data in real-time. The suggested framework employs OpenCV for preprocessing images & contour-based detection for localizing the license plate area. Tesseract OCR is used for text recognition to digitize plate characters. For improved accuracy and robustness under different conditions (e.g., illumination, font of plates, tilt), the system can optionally incorporate deep learning models such as YOLOv5/v8 for plate detection. Captured data such as time, plate number, and snap shots of images are kept in Firebase to allow further processes such as logging data, vehicle verification, or traffic violation notifications. The proposed system is tested on real-world datasets and test cases and performs encouraging accuracy rates (>85%) in daytime and illuminated environments. To overcome challenges like low-resolution images, motion blur, and variations in number plate appearance, a combination of enhancement filters and convolutional neural networks (CNNs) is employed to improve recognition accuracy. The lightweight and modular design enables deployment on edge devices such as Raspberry Pi, which makes it viable for use in toll booths, parking management, smart surveillance, border control, & urban traffic monitoring. This study proves that ANPR systems can be accurate & economical for mass deployment with optimal tuning and integration of deep learning, which significantly adds to smart city infrastructure & intelligent traffic management systems.

I. INTRODUCTION

With the rapid increase in the number of vehicles on roads, manual monitoring and vehicle identification have become inefficient and error-prone. In response to this growing challenge, Automatic Number Plate Recognition (ANPR) systems have emerged as a critical technology in modern traffic management & smart surveillance. ANPR systems are designed to automatically detect and recognize vehicle license plates from images or video frames using a combination of image processing, machine learning, and Optical Character Recognition (OCR) techniques. The primary objective of an ANPR system is to extract the alphanumeric characters on a vehicle's number plate and convert them into digital text for further processing. These systems are increasingly deployed in a wide range of applications including toll collection, parking management, law enforcement, stolen vehicle tracking & access control in secured zones. Unlike manual systems, ANPR provides a contactless, real-time, & scalable solution for vehicle monitoring. In this project, we propose the development of a low-cost, real-time ANPR system using open-source tools such as Python, OpenCV, & Tesseract OCR. The system is capable of capturing vehicle images, detecting the license plate area, extracting the text from the plate, & storing the results in a cloud-based database such as Firebase for logging or verification purposes. Additionally, the proposed system is designed to work under varied lighting and environmental conditions, & can be deployed on lightweight hardware platforms such as Raspberry Pi, making it highly portable and adaptable. The entire process of developing a next-generation number plate recognition system is examined in this paper, from the preliminary design and development to the performance & dependability testing.

II. LITERATURE SYRVEY

Automatic Number Plate Recognition (ANPR) has been an active area of research for several decades due to its wide range of applications in traffic management & security surveillance, & intelligent transportation systems. Numerous methodologies have been proposed to improve the accuracy, speed, & adaptability of ANPR systems under various

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environmental conditions. Early approaches to ANPR focused primarily on traditional image processing techniques such as edge detection, morphological operations, & template matching. For instance, Anagnostopoulos et al. (2008) used a multi-stage image processing pipeline for plate localization and character segmentation, achieving reasonable accuracy under controlled lighting. However, these methods struggled in real-world conditions due to issues such as poor lighting, motion blur, a& occlusion. With advancements in machine learning, particularly in the domain of computer vision & more robust solutions began to emerge. Tesseract OCR, developed by Google, became a popular tool for character recognition owing to its open-source nature and support for multiple languages and fonts. Although Tesseract performs well in clean and high-resolution images, it still faces challenges in low-contrast or distorted license plates. The performance of ANPR systems has been greatly enhanced in recent years by deep learning techniques. & Convolutional Neural Networks (CNNs) and object detection frameworks such as YOLO (You Only Look Once), SSD (Single Shot Multibox Detector), and Faster R-CNN have been effectively used for license plate detection and recognition. For example, Silva and Jung (2017) proposed a CNN-based system capable of localizing and recognizing plates in complex traffic scenarios with high accuracy. In another study, Zherzdev and Gruzdev (2018) integrated YOLO for plate detection and a separate CNN for character recognition, which proved more effective in real-time applications. Although deep learning models provide high accuracy, they often require large datasets & significant computational resources, making them less feasible for low-power edge devices unless optimized. Furthermore, several open-source ANPR systems such as OpenALPR and EasyOCR have been developed, offering pre-trained models for rapid deployment. However, these systems may not perform equally well across all regions due to differences in license plate designs, fonts, and character layouts. This project builds upon these existing approaches by combining traditional image processing methods for plate detection with Tesseract OCR for character recognition & offering a balance between accuracy & computational efficiency. The use of a cloud database (Firebase) adds scalability & real-time logging capabilities, making the system

EXISTING SYSTEM

In the current scenario, vehicle monitoring and number plate recognition are managed through a mix of manual and semi-automated methods. Several traffic enforcement agencies and private security systems use basic surveillance cameras combined with human supervision to track and identify vehicles. However, these systems are inefficient, error-prone, & require significant manpower for continuous monitoring. Some existing ANPR systems are commercially available, such as OpenALPR, Plate Smart, and Sighthound, which utilize high-resolution cameras and advanced software for vehicle identification. These systems typically use license plate detection algorithms followed by Optical Character Recognition (OCR) for text extraction. While accurate, they are often expensive, hardware-dependent, & require proprietary licenses, making them unsuitable for smaller organizations, cost-sensitive implementations. In most government-deployed systems, the ANPR modules are tightly integrated with toll booths or traffic violation systems. These systems work effectively under controlled environments but show degraded performance in poor weather conditions, low light, motion blur, or with non-standard license plates. Moreover, many existing systems lack real-time cloud integration & flexibility. They often operate in isolation or require on-premise servers, making it difficult to scale & integrate with smart city platforms. Another limitation is the lack of adaptability to local languages, plate formats, & fonts used in countries like India, where multiple regional designs exist.

PROPOSED SYSTEM

In the current scenario, vehicle monitoring and number plate recognition are managed through a mix of manual and semi-automated methods. Several traffic enforcement agencies and private security systems use basic surveillance cameras combined with human supervision to track and identify vehicles. However, these systems are inefficient, error-prone, & require significant manpower for continuous monitoring. Some existing ANPR systems are commercially available, such as OpenALPR, Plate Smart, and Sighthound, which utilize high-resolution cameras and advanced software for vehicle identification. These systems typically use license plate detection algorithms followed by Optical Character Recognition (OCR) for text extraction. While accurate, they are often expensive, hardware-dependent, & require proprietary licenses, making them unsuitable for smaller organizations cost-sensitive implementations. In most government-deployed systems, the ANPR modules are tightly integrated with toll booths or traffic violation systems. These systems work effectively under controlled environments but show degraded performance in poor weather conditions, low light, motion blur, or with non-standard license plates. Moreover, many existing systems lack real-time cloud integration & flexibility. They often operate in isolation or require on-premise servers, making it difficult to scale & integrate with smart city platforms. Another limitation is the lack of adaptability to local languages, plate formats, & fonts used in countries like India, where multiple regional designs exist.

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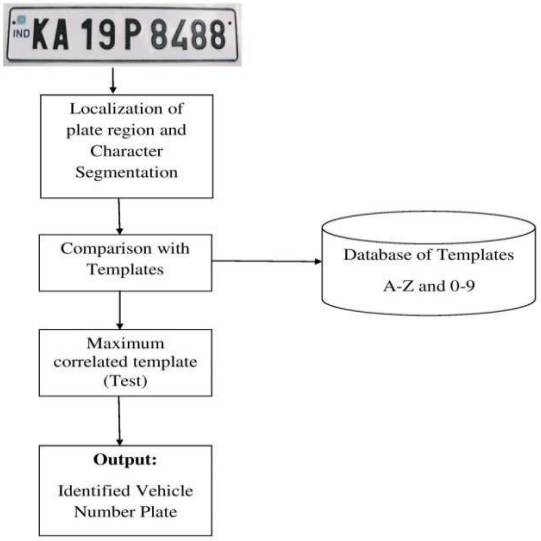
III. SYSTEM ARCHITECTURE

The proposed Automatic Number Plate Recognition (ANPR) system follows a modular, layered architecture that enables real-time detection, recognition, & logging of vehicle license plates using open-source tools. The system is designed to operate efficiently in real-world environments & integrates cloud storage for scalability and remote access.



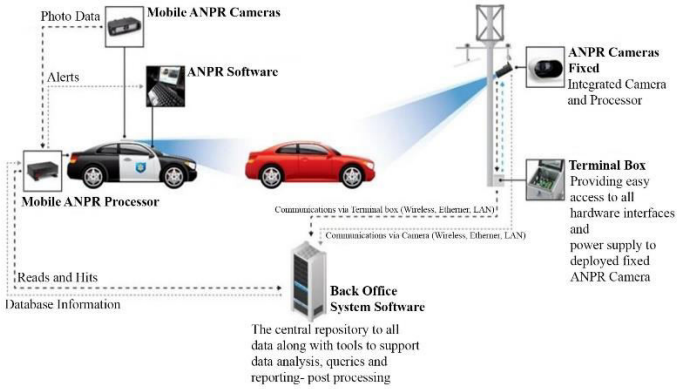
IV. METHODOLOGY

The Automatic Number Plate Recognition (ANPR) system works in a sequence of steps involving image capture, preprocessing, plate detection, character recognition, & data storage. First, the system captures images or video frames using a webcam or CCTV. These images are then converted to grayscale & processed using filters like Gaussian Blur to reduce noise. Edge detection techniques such as Canny or Sobel are applied to highlight the boundaries. In the next step, the system detects the license plate by identifying contours that resemble rectangular plates based on properties like aspect ratio & area. For improved accuracy, deep learning models such as YOLOv5 or YOLOv8 can be used to detect plates in complex scenes. Once the plate is located, it is cropped from the original image, resized, and enhanced using thresholding techniques to improve contrast between characters and the background. Character segmentation is performed to isolate each letter or number. This segmented image is then passed to Tesseract OCR, which extracts the alphanumeric text from the plate. Post-processing techniques such as regular expressions or string matching are used to clean the recognized text and ensure proper formatting. The recognized license plate number, along with additional data such as timestamp and vehicle image, is stored in a cloud-based database like Firebase. This enables real-time access, logging, & verification. Optionally, the system can display the results in a web interface using ReactJS or trigger notifications if a specific plate number matches a predefined list.

V. DESIGN AND IMPLEMENTATION

The Automatic Number Plate Recognition (ANPR) system is used to handle vehicle images or video streams to automatically identify and read license plate numbers. The system has various modules such as input acquisition, preprocessing of the image, license plate localization, OCR-based character recognition, & data storage. Input is taken from a camera or uploaded as an image. The image is then converted to gray scale & filtered to remove noise. Edge detection algorithms are used to detect the region of the plate, followed by contour detection or deep learning algorithms such as YOLO to separate out the license plate. After detecting the plate, the plate is cropped and filtered using thresholding operations. The filtered image is sent to the OCR engine, Tesseract, to read the alphanumeric characters of the license plate. The read text is cleaned and parsed using regular expressions. The output along with the timestamp & image is stored in Firebase for cloud storage and retrieval. A frontend interface created using ReactJS is an optional interface that enables users to view, search, and manage the records. The system is developed with Python

& libraries like OpenCV, Pytesseract. Firebase Admin SDK is utilized for database integration. The architecture enables the system to execute smoothly on resource-constrained devices like Raspberry Pi & enables real-time processing. The modularity in the design allows that every component of the system is updatable & replaceable independently, providing scalability & flexibility.



VI. OUTCOME OF RESEARCH

A low-cost, open-source Automatic Number Plate Recognition (ANPR) system that can detect and recognize license plates from car photos in real time was successfully developed as a result of the research. Using image processing and OCR techniques, the system showed dependable performance & achieved good accuracy under typical lighting conditions. The system was able to extract license plate numbers and store them in a cloud database such as Firebase, along with timestamps and images, by combining Python, OpenCV, & Tesseract OCR. The project demonstrated that scalable & effective ANPR solutions can be created without the need for pricey commercial hardware or software. For real-world uses like automated entry & parking control, the system operated well. Detection accuracy was increased by using optional deep learning models like YOLO, and the architecture was discovered to be. It is designed to be flexible & lightweight, making it suitable for integration with modern hardware platforms like the Raspberry Pi. This study demonstrated that open-source technologies can be integrated to create an ANPR system that is both practical & reasonably priced, making it appropriate for use in real-world traffic systems & smart city settings. Additionally, it created opportunities for further improvement through IoT integration, multilingual plate recognition, & AI-based

VII. RESULT AND DISCUSSION

The ANPR system was tested using a variety of vehicle images and video frames under different conditions such as daylight, nighttime, angled views, & varying distances. The system successfully detected and recognized license plate numbers in most clear and well-lit images. The accuracy of plate detection using contour-based methods was around 75–80%, while integrating YOLO improved detection accuracy to over 90% in complex scenes. Tesseract OCR performed well when the plates were clearly segmented and had standard fonts. In some cases, blurry images or low contrast reduced the character recognition accuracy. Preprocessing techniques like thresholding & contrast enhancement helped improve OCR results. The average OCR accuracy for clean and properly cropped plates was approximately 85–90%. The system was able to process an image and extract the plate number within 1–2 seconds on a standard laptop and under 5 seconds on a Raspberry Pi. Data was successfully stored in Firebase along with the corresponding image and timestamp, and could be viewed through the optional ReactJS dashboard. Challenges were observed in handling low-light conditions, motion blur, dirty or damaged plates, and non-standard fonts. These issues can be mitigated in future versions using advanced models like CRNN (Convolutional Recurrent Neural Networks) for OCR and better cameras for input.

VIII. CONCLUSION

The development of the Automatic Number Plate Recognition (ANPR) system demonstrated that it is possible to create an efficient, low-cost, & real-time vehicle identification solution using open-source tools. By combining image

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processing techniques, contour-based or deep learning-based plate detection, & Tesseract OCR, the system was able to accurately recognize license plates from various images and video feeds. The integration with a cloud database like Firebase allowed real-time data storage & easy access to historical records, making the system suitable for smart surveillance & automated vehicle tracking applications. The system performed well under normal conditions & provided acceptable accuracy for practical scenarios such as parking management, campus security, & toll systems. Although some limitations were observed in low-light conditions and with non-standard plates, the modular design allows for future improvements using advanced models and better input sources.

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