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AUTOMATIC NUMBER PLATE RECOGNITION SYSTEM

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Abstract— Automatic Number Plate Recognition (ANPR) is a technology that detects number plates from images and uses optical character recognition to read them. Its primary aim is to accurately identify vehicle number plates aiding in vehicle tracking and traffic data collection while minimizing the need for direct driver interaction. It has various applications, including law enforcement, toll collection, parking management, and traffic monitoring. This technical report outlines the development, implementation, and evaluation of an ANPR system.

Keywords— Automated Number Plate Recognition (ANPR), image processing, YOLOv8, Machine learning, Deep learning, CNN

I. Introduction

In the realm of modern-day surveillance and traffic management, the Automated Number Plate Recognition (ANPR) system stands as a beacon of innovation and efficiency. ANPR is a sophisticated technology that combines the prowess of optics, artificial intelligence, and data processing to effortlessly identify and track vehicles on the move. The objectives of the ANPR project are as follows:

- Develop an ANPR system capable of accurately detecting and recognizing license plates from images.
- Implement the system using computer vision and machine learning techniques.
- Evaluate the system's performance in terms of accuracy, speed, and robustness under various environmental conditions.

A. Research questions and how to address them

1) Accuracy of ANPR algorithms: Continuously improve ANPR algorithms through research and development. Experiment with deep learning techniques such as convolutional neural networks (CNNs) for better feature extraction and recognition accuracy.

2) Impact of environmental factors: Develop robust ANPR systems that can adapt to varying environmental conditions. This may involve implementing algorithms that can adjust parameters dynamically based on factors like lighting and weather. Additionally, consider using multiple cameras with different viewpoints to improve recognition accuracy under challenging conditions.

3) Effectiveness of pre-processing techniques: Evaluate and optimize pre-processing techniques tailored to specific ANPR use cases. Experiment with various image enhancement algorithms, noise reduction filters, and edge detection methods to enhance the quality of input images before recognition.

4) Optimal hardware requirements: Conduct thorough performance testing on different hardware configurations to identify the optimal setup for ANPR systems.

5) Comparison of ANPR systems: Perform comprehensive evaluations of ANPR systems based on key criteria such as accuracy, speed, scalability, ease of integration, and total cost of ownership. Engage with vendors, conduct pilot projects, and gather feedback from users to assess the strengths and weaknesses of different solutions.

6) Ethical and legal considerations: Prioritize transparency, accountability, and user privacy in ANPR system design and deployment. Implement data protection measures such as encryption and access control techniques to safeguard sensitive information.

B. Explanation of Keywords

1) Automatic Number Plate Recognition (ANPR): ANPR is a technology that uses optical character recognition to read and interpret license plates on vehicles.
2) Image processing: It refers to the manipulation and analysis of digital images using various techniques such as filtering, enhancement, and segmentation to extract useful information.
3) YOLOv8: "You Only Look Once version 8," is a deep learning-based object detection algorithm that simultaneously predicts bounding boxes and class probabilities for multiple objects in images, providing fast and accurate real-time object detection.
4) Machine Learning: Machine learning is a subset of artificial intelligence that enables systems to learn and improve from experience without being explicitly programmed.
5) Deep Learning: Deep learning is a subset of machine learning that uses artificial neural networks with multiple layers to model and extract patterns from data.
6) Convolutional Neural Network (CNN): CNN is a type of deep neural network commonly used in image recognition tasks, characterized by its hierarchical structure of convolutional layers.

III. Literature Survey

Ms.Sushama, H.Bailmare, Prof. A.B.Gadicha[1] presented an approach based on simple and efficient morphological operation and sobel edge detection method. They also presented a simple approach to segment all the letters and numbers used in the number plate. After reducing noise from the input image they tried to enhance the contrast of the binarized image using histogram equalization to identify each number separately.

M. M. Shidore, S. P. Narote [2] implemented the number plate extraction, character segmentation and recognition work, with English characters. Number plate extraction is done using Sobel filter, morphological operations and connected component analysis. Character segmentation is done by using connected component and vertical projection analysis. Character recognition is carried out using Support Vector machine (SVM). The segmentation accuracy is 80% and recognition rate is 79.84 %.

Prof. Pradnya Randive, Shruti Ahivale, Sonam Bansod, Sonal Mohite, Sneha Patil [3] proposed an ALPR where the vehicles number plate photo will be captured by the android phone and then it will be send to the server. The server will perform the plate region extraction on the image and will convert it into grey scale. The Otsu algorithm will perform binarization and morphological operations on grey scale image. The number will be extracted using OCR algorithm. The server will send the correct result back to the android phone.

Aniruddh Puranic, Deepak K. T., Umadevi V. [4] applied canny edge detection to detect the presence of vehicle and SVM to recognize the vehicle. A morphological-based license plate location, Maximum Average Correlation Height (MACH) filter and Log r-theta Mapping techniques were applied to recognize the type of vehicle irrespective of scale and rotation variation of vehicles. The MACH filter was used for detection of targets in cluttered environment.

III. Methodology

A. Data Collection and Preprocessing

1) Image Acquisition: Camera is the significant component for any ANPR system, this system is built for accessing all the cameras using their IP address. Image acquisition can be done from CCTV cameras of Traffic control, Border crossings, Parking system cameras. Still image is processed for the detection of the vehicle.
2) Data Preprocessing: The collected images were pre-processed to enhance quality and facilitate feature extraction. Preprocessing steps included resizing, normalization, noise reduction, and contrast enhancement.

B. License Plate Detection

1) License Plate Extraction: Locate the number plate using YoloV8 algorithm. Perform the edge detection algorithm to the imported image to remove all the other information except the edges. Separate the number plate area from the image and resize the isolated number plate by removing the border around the plate.

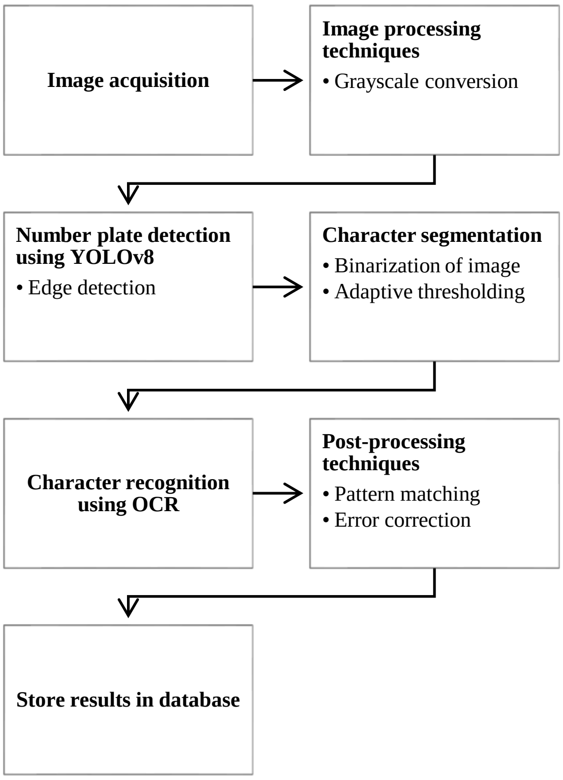

Fig. 1: Block diagram of proposed system

C. License Plate Recognition

1) License Plate Segmentation: The accuracy of the system is significantly influenced at this stage. This phase extracts the license plate from the image that had been acquired in previous stage. The proposed approach involves converting the RGB into Grayscale, binarization of the image and finding and filtering the noise from the image.
2) Character Recognition: Optical Character Recognition (OCR) is used for the conversion of images of number plate into ASCII code. The extracted data is stored in database which can be accessed to get license plate information when required.

D. Post-processing and Integration

1) Post-processing: Recognized characters were subjected to post-processing techniques such as error correction, dictionary lookup, and pattern matching to improve accuracy and reliability.
2) Integration: The license plate detection and recognition modules were integrated into a cohesive system capable of processing images.

IV. IMPLEMENTATION

The ANPR system was implemented using the following technologies and frameworks:

- Programming Language: Python
- Libraries: OpenCV, easyOCR
- Models: YOLOv8 for fine-grained detection, and OCR for character recognition.
- Images were taken using mobile camera to implement this project.

A. Research Goals and Strategic Approaches for it

1) Train YOLOv8 model: Train a YOLOv8 model by feeding it labelled images with object annotations, adjusting its parameters to improve its ability to detect objects during optimization.

2) Import Libraries: The code starts by importing necessary libraries such as OpenCV (cv2), NumPy (numpy), EasyOCR (easyocr), and Matplotlib (matplotlib).

3) Load the Image: It loads an image from a specified path using OpenCV's cv2.imread() function and converts the color space from BGR to RGB.

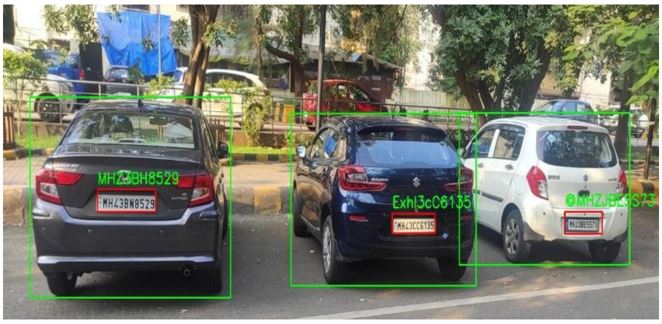

Fig. 2: Number plate recognition of multiple cars

4) Convert Image to Grayscale: The image is converted to grayscale using cv2.cvtColor() function.

5) Detect Vehicles: The code detects vehicles in the image using the YOLOv8 model. It retrieves bounding boxes of the detected vehicles.

6) Initialize Vehicle Tracker: It initializes a SORT (Simple Online and Realtime Tracking) tracker for tracking vehicle IDs.

7) Track Vehicles: The code iterates over the detected vehicle bounding boxes, updates the SORT tracker with the detections, and retrieves the tracked vehicle IDs.

8) Detect License Plates: It detects vehicles in the input image using YOLOv5, filters out non-vehicle detections, and initializes a tracker to assign unique IDs to each vehicle. It retrieves the bounding boxes of the detected license plates.

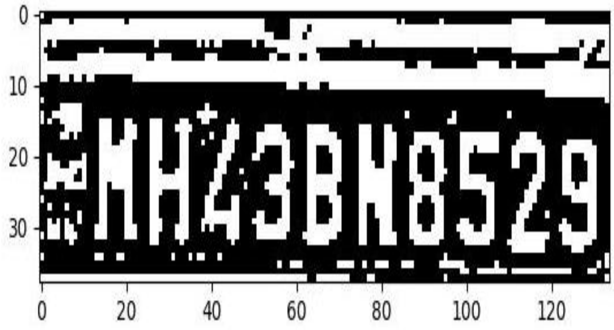

Fig. 3: License plate segmentation

9) Initialize OCR Reader: An OCR (Optical Character Recognition) reader is initialized using EasyOCR.

Fig. 4 : Number plate detection and recognition

10) Loop Over License Plates: For each detected license plate, it associates the license plate with a tracked car (if found), crops the license plate region, applies preprocessing steps like adaptive thresholding, and then reads the text using OCR.

11) Formatting and Correction: It corrects potential OCR errors by mapping similar characters (e.g., 'M' to 'N' or 'H', 'J' to '3' or '4') and ensures the extracted text confirms to a predefined license plate format.

```
- Car Bounding Box: [62.09340286254883, 158.80026245117188
- License Plate Bounding Box: [217.34201049804688, 316.233
- License Plate Text: MHL3BN8529
- Formatted License Plate Text: MH43BN8529
- License Plate Bounding Box Score: 0.9304786324501038
```

Fig. 5: Results which will be stored in CSV file

12) Data Storage: It stores the results, including the vehicle IDs, bounding boxes, detected license plate text, and formatted text, in a CSV file.

B. Hardware and software requirement

1) Software requirements: Python, YOLOv8 for object detection, OCR for character recognition and other pre-processing algorithms.
2) Processor (CPU): A modern multi-core processor is recommended for efficient execution.
3) Memory (RAM): At least 4GB of RAM is recommended, but more is beneficial for handling larger images or multiple operations.

4) Storage: Sufficient storage space to store image files and any additional files generated by the code.
5) Operating System: Any OS supporting Python and OpenCV will work (Windows, macOS, Linux).
6) Other requirements: such as cameras are not included within the primary scope of this project.

V. Result And Discussion

A. Results

The ANPR system successfully detected and recognized number plates with 85% to 90% accuracy on a test dataset of still images of the front view of number plates and around 80% accuracy for images at an angle. Thus, it demonstrated reliable performance under moderate lighting conditions.

B. Unexpected behaviours

Certain characters were being misinterpreted such as ‘MH’ was being recognized as ‘MM’ in certain number plates.

The YOLOv8 model couldn’t detect license plates in images with significant angles.

C. Research gaps and areas to work upon

- Performance under Challenging Conditions: ANPR system may face difficulties in accurately recognizing license plates under challenging conditions such as poor lighting, bad weather, occlusion or vehicle speed. Research efforts could focus on improving the robustness of ANPR algorithms by developing techniques for illumination normalization, noise reduction, and handling occlusions through advanced image processing and deep learning methods.

- Images taken beyond a certain angle not being detected: Since images taken from an angle might have perspective distortions, we may need to perform preprocessing to correct the perspective. This can involve techniques like image transformation and perspective correction.

- To handle large volumes of data, that requires sophisticated querying and analysis capabilities, prioritize scalability and data integrity, and have stringent security requirements, storing ANPR data in a database would be more appropriate.

- We need to enhance ANPR systems by transitioning from capturing still images to utilizing video input and processing it frame by frame.

- Incorporating a camera into our ANPR project is essential to evaluate its real-time efficiency and enhance its functionality and accuracy accordingly.

V. Conclusion

The development and implementation of the ANPR system demonstrated its capability to accurately detect and recognize license plates in real-time. Further optimizations and refinements could enhance its performance for practical applications such as traffic management, law enforcement, and toll collection. Continued research in computer vision and machine learning will contribute to the advancement of ANPR technology.

This project will focus on developing the software components of the ANPR system where we considered the vehicle number plate as input image and system should extract that number from the image and should search the database for that recognized number plate. Hardware requirements, such as cameras and computing resources will be considered but are not within the primary scope of this project.

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