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Detection of Vehicle Number Plate and Speed Using Machine Learning

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Abstract - In an era marked by a significant upsurge in vehicular traffic and the resultant increase in road accidents, the need for advanced traffic management systems is paramount. This paper presents an innovative solution, "Detection of vehicle number plate and speed using machine learning" which aims to enhance road safety by addressing the persistent problem of over-speeding.

The project leverages state-of-the-art technologies, including machine learning, deep learning, and computer vision, to develop a smart system that can detect speeding vehicles, recognize license plates, and record crucial data related to speed limit violations. The primary motivation for this endeavor is the escalating rate of road accidents, particularly in India, driven by speeding in areas susceptible to accidents.

The system employs image segmentation, corner detection algorithms, filtering algorithms, and automatic vehicle plate recognition techniques to achieve its objectives. By using machine learning and deep learning models, the system accurately identifies license plates, segments characters on these plates, and recognizes them.

In summary, this project represents a significant advancement in road safety and traffic management. By deploying an intelligent system that can proactively detect over-speeding vehicles and maintain comprehensive records, it strives to create a safer and more responsible driving environment, ultimately working towards the prevention of accidents and saving lives.

***Key Words*:** Automatic Number Plate Recognition, Vehicle Speed Detection, Machine Learning, Computer Vision, Traffic Management.

1. INTRODUCTION

Think about all the cars on the roads nowadays. It seems like there are more of them every day. But with more cars comes a big problem: more accidents. One of the main reasons for accidents is when people drive too fast. To make the roads safer, we need to find a way to stop people from speeding. Right now, we use radar guns to check how fast cars are going, but these tools aren't always great at catching smaller cars or those that change speed a lot. Also, it's hard for these tools to notice cars that are speeding too often or too fast.

That's where our project comes in. We've come up with a smart system that can do two important things. First, it can figure out how fast a car is going, and if it's going too fast, it takes a picture of the car. Second, it can recognize the car's license plate and turn it into letters and numbers using some fancy computer tricks. The system then saves all this information in a file. We use this file to keep an eye on drivers. If someone keeps breaking the speed limit and they, do it a lot, we send them a warning. If they keep breaking the rules, they'll get a ticket.

Why We're Doing This

Traffic accidents are really sad and scary. In India, lots of people are getting hurt or even killed in accidents. One big reason is that people are driving too fast, especially in places where they shouldn't. Our project is trying to stop this from happening.

We want to create a system that can spot cars going too fast and tell the police about it. This way, we don't need a person to watch all the cars. The system does it for us.

How It Works

To make this happen, we use some cool technology. We use computers and cameras to see the cars. The computers can tell us how fast a car is going and take pictures if it's too speedy. We also teach the computer to read license plates. It looks at the numbers and letters on the plate and turns them into something we can understand.

Then we keep track of all this information and give warnings to people who drive too fast. If they keep breaking the rules, they'll get a ticket.

Our project is all about making the roads safer and preventing accidents. It uses fancy computer stuff to catch speeders and help the police keep an eye on drivers. The goal is to save lives and make driving safer for everyone.

2. METHODOLOGY

The methodology employed in the "Automatic Vehicle Plate Recognition and Over Speed Detection Using Machine Learning" project is comprehensive and involves a series of steps to accomplish the objectives of detecting speeding vehicles, recognizing license plates, and recording relevant data. Let's delve deeper into the various components of the methodology:

1. **Image Preprocessing:**

- The process begins with capturing a live video stream of moving vehicles using a camera.
- The video stream is converted into grayscale. Grayscale conversion simplifies subsequent image processing steps.
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2. **Image Banalization:**

- The video stream is converted into grayscale. Grayscale conversion simplifies subsequent image processing steps.
- After grayscale conversion, binarization is performed. Binarization is the process of turning the grayscale image into a binary one, where pixel values are either 0 (black) or 1 (white).
- This transformation helps to separate objects of interest from the background and prepare the image for further analysis.

3. **Number Plate Localization:**

- To locate license plates, the Sobel Mask Technique is employed. This technique is a common method for edge detection in images.
- Edge detection helps identify areas in the image where there is a sudden change in pixel intensity, which often corresponds to the edges of objects. In this case, it helps identify the edges of license plates.
- The system locates rectangles within the image that likely contain license plates.

4. **Character Segmentation:**

- Once license plates are detected, the next step is character segmentation. The goal is to separate the individual alphanumeric characters on the license plate.
- Character segmentation can be influenced by various factors, including the boundaries of the license plate frame.

5. **Character Recognition:**

- Character recognition is a critical step. The system needs to transform the segmented characters into machine-readable data.
- This process often involves the use of connected component analysis, a technique used in image processing to identify and label connected regions in binary images.

6. **Speed Detection:**

- The project integrates speed detection with license plate recognition.
- Speed is measured by tracking vehicles as they move across the camera's field of view. The system assumes that vehicles travel at constant speeds along a straight path.
- Vehicle tracking is performed using computer vision techniques and calibrated cameras. The system calculates speed in pixels per meter and frames per second.

7. **Verification of Number Plates:**

- After character recognition, the system verifies the license plate number. It checks whether the recognized plate is valid or not.

8. **Checking Speed Limits:**

- The system checks the speed of vehicles. If the vehicle's speed exceeds the prescribed speed limit, it proceeds to take action.

9. **Enforcement of Traffic Rules:**

- If the detected vehicle exceeds the speed limit, the system checks the past record of that vehicle. If the number of rule violations exceeds a certain threshold, an alert is sent to the driver.
- The system can also issue a warning or a penalty (challan) based on the severity of the violation.

The project's methodology is a robust combination of image processing, computer vision, and machine learning techniques. It involves various steps to seamlessly integrate the recognition of speeding vehicles with license plate identification and enforcement of traffic rules. This holistic approach is designed to enhance road safety by actively monitoring and addressing over-speeding incidents.

3. MODELING AND ANALYSIS

we employ advanced computational techniques to create a model for detecting speeding vehicles, recognizing license plates, and enforcing traffic regulations. Through a series of carefully designed algorithms, image processing, and machine learning, we analyze real-time video data to identify vehicles, their number plates, and their speeds. This section presents the core techniques and methodologies that power our intelligent traffic management system, contributing to enhanced road safety and accident prevention.

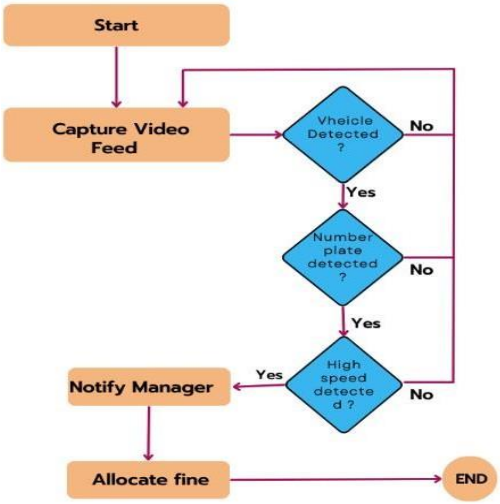


Fig -1: Flow Chart

Start: The process begins with this initial point.

1. Capture Video Feed:

- The system uses a camera to capture a continuous video feed of the road and the vehicles in real time. This video stream provides the raw data for further analysis.

2. Vehicle Detected? (Yes/No):

- The system employs computer vision techniques to analyze the video frames and identify the presence of vehicles. This involves object detection and tracking to spot vehicles within the video stream.
- If the system detects a vehicle, it proceeds to the next step; otherwise, it continues to monitor the video feed for vehicle presence.

3. Number Plate Detected? (Yes/No):

- Upon detecting a vehicle, the system then zooms in on the vehicle to identify whether there is a visible license plate. This step involves object localization and region of interest (ROI) detection.
- If a number plate is detected, the system proceeds to the next stage; otherwise, it continues to monitor the vehicle for a visible license plate.

4. Over-speed Detected? (Yes/No):

- With a detected vehicle and a visible license plate, the system now calculates the speed of the vehicle using computer vision and speed measurement techniques.
- It checks whether the vehicle is exceeding the specified speed limit for that particular road or area.
- If the vehicle is found to be over-speeding, the system classifies it as a violation, and it proceeds to allocate a fine or penalty.

5. Allocate Fine:

- In cases where all the conditions are met—vehicle detection, number plate identification, and over-speeding— the system enforces traffic rules by allocating a fine or penalty to the driver.
- The severity of the penalty may vary based on the degree of over-speeding and local regulations.

6. Return to Capture Video Feed:

- Regardless of whether a vehicle is detected, a number plate is visible, or over-speeding is detected, the system loops back to the "Capture Video Feed" step.
- This continuous cycle ensures that the system constantly monitors the road for new vehicles and potential violations.

The flowchart represents the logical flow of the system, where it dynamically analyzes video data, identifies vehicles, checks for license plates, calculates speed, and enforces traffic rules. This process is repeated for each vehicle captured by the camera, contributing to real-time traffic management and accident prevention.

4. PROCESS OF PROJECTS

1. **Realtime video collected of vehicles moving on road: -**

   The process of capturing live video footage of vehicles in motion on a road. This could be achieved through various means such as surveillance cameras installed along roadsides, dash cameras mounted on vehicles, or drones capturing aerial footage.

   The term "real-time" implies that the video is being captured and transmitted instantaneously as the vehicles are moving, allowing for immediate observation and analysis of traffic patterns, vehicle behaviors, and other relevant information.

2. **Extracted frames from video: -**

   "Extracted frames from video" refers to the process of capturing individual images, or frames, from a video file. Each frame represents a single snapshot of the video at a specific moment in time.

3. **Resize all frames: -**

   A preprocessing step in which each frame of a video feed or image sequence containing vehicles is resized

to a standardized dimension before further processing or analysis.

4. **Annoted vehicles using labeling tool: -**

   The process of preparing a dataset for training a machine learning model. Here's a breakdown:

   1. Annotation
   2. Vehicles
   3. Labeling tool

5. **Develop a separate dataset of same vehicle images by annoting number plate detection: -**

   The process of creating a new collection of images containing vehicles, where each image is annotated with the location and boundaries of the vehicle's number plate.

6. **Trained the module using yolov8 module: -**

   The process of using the YOLOv8 (You Only Look Once version 8) object detection model as a basis for training a system to recognize vehicle number plates and estimate their speed.

7. **Downloaded best.pt module of both vehicle detection and number plate detection.**
8. **By using appropriate code. Made vehicle detection on Realtime video input by using trained module**
9. **Assign I'd to every detected vehicle: -**

   The process of assigning a unique identifier (ID) to each vehicle that the system detects. This ID serves as a way to track and differentiate between individual vehicles as they are detected and monitored by the system.

10. **Calculate the center point of every image**
11. **Track the center point direction while tracking each id vehicle**
12. **By using distance formula calculated the centroid speed in km/hr.**
13. **Check every centroid speed and check is it crossing threshold**
14. **Saved every crop image of vehicle**
15. **Give this image as an input to number plate detection module**
16. **Apply OCR on detected number plate: -**

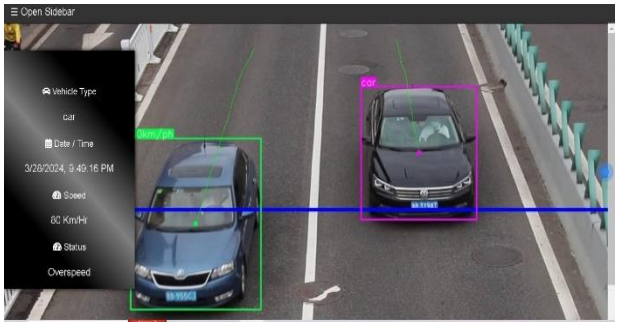
    The process of utilizing Optical Character Recognition (OCR) technology to extract the alphanumeric characters from the detected number plate of a vehicle.

17. **Finally get the Excel file of every vehicle passing throw the road With column- tracking I'd, vehicle type, number, speed status**
18. **By using appropriate frontend shows all Realtime data on localhost**

5. IMPLEMENTATION

1. **Vehicle type and speed: -**

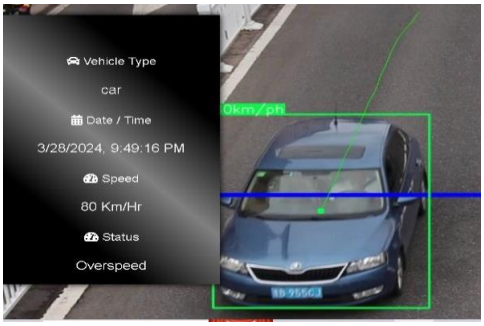
   Vehicle type and speed" refers to two key pieces of information that can be extracted from the analysis of vehicle data using machine learning algorithms.

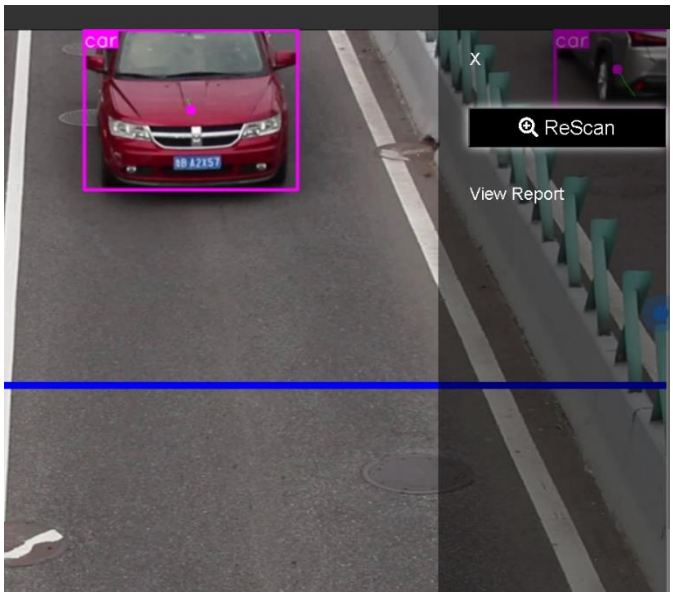


2. **Object Tracking: -**

   The process of identifying and following specific objects within a scene across consecutive frames of a video or images. In the context of detecting vehicle number plates and speed using machine learning, object tracking plays a crucial role.

   Euclidean distance is a measure of the straight-line distance between two points in Euclidean space. In a two-dimensional space (such as a flat plane), it's calculated using the Pythagorean theorem. In machine learning, Euclidean distance is often used as a measure of similarity or dissimilarity between two data points.





This bottom iterate all the images stored in files of vehicles passing through road. Apply number plate detion model on it. And update the number with respected vehicles in report.

Then it redirects to new page and show the report with generated on section (current date and time) with auto update facility

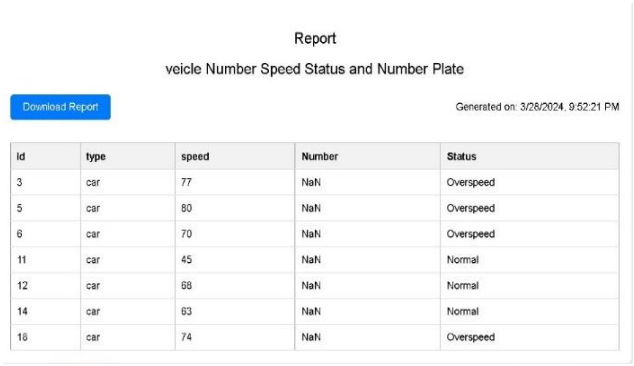
3. Process Labelling

Process labeling in the context of detecting vehicle number plates and speed using machine learning refers to the technique of assigning labels or categories to different stages or steps within the overall process. This labeling helps in organizing and understanding the workflow involved in the detection process.

4. No plate Detection: -

The process of identifying instances where a vehicle's number plate (license plate) is not detected or is obscured in an image or video frame. In the context of detection of vehicle number plates and speed using machine learning, this process plays a crucial role in accurately identifying and extracting license plate information.

5. Before number plate detection: -



Report

veicle Number Speed Status and Number Plate

Download Report

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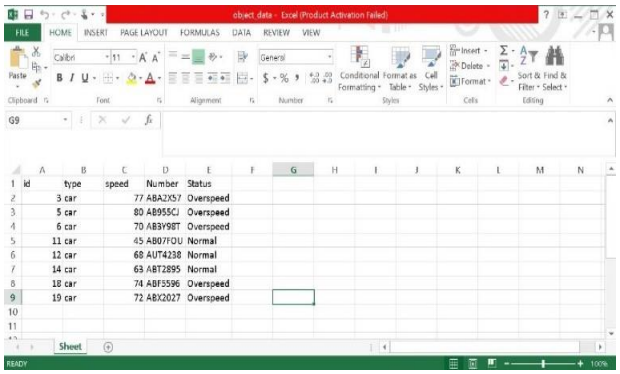
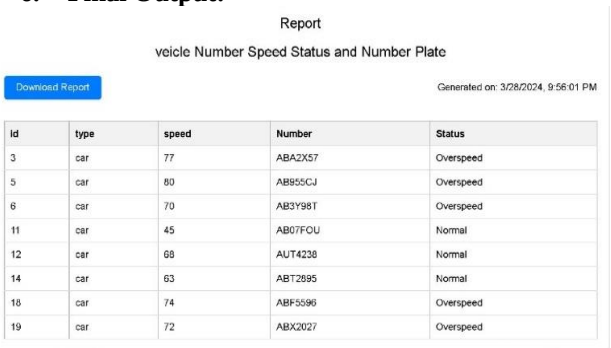
Id	type	speed	Number	Status
3	car	77	NaN	Overspeed
5	car	80	NaN	Overspeed
6	car	70	NaN	Overspeed
11	car	45	NaN	Normal
12	car	68	NaN	Normal
14	car	63	NaN	Normal
18	car	74	NaN	Overspeed



id	type	speed	Number	Status
3	car	77	ABA2X57	Overspeed
5	car	80	AB955CJ	Overspeed
6	car	70	AB3Y98T	Overspeed
11	car	45	AB07FOU	Normal
12	car	68	AUT4238	Normal
14	car	63	ABT2895	Normal
18	car	74	ABF5596	Overspeed
19	car	72	ABX2027	Overspeed

6. Final Output: -



Report

veicle Number Speed Status and Number Plate

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Id	type	speed	Number	Status
3	car	77	ABA2X57	Overspeed
5	car	80	AB955CJ	Overspeed
6	car	70	AB3Y98T	Overspeed
11	car	45	AB07FOU	Normal
12	car	68	AUT4238	Normal
14	car	63	ABT2895	Normal
18	car	74	ABF5596	Overspeed
19	car	72	ABX2027	Overspeed

CONCLUSIONS

The "Detection of vehicle number plate and speed using machine learning" project represents a pioneering initiative in the domain of traffic management and road safety. Through the integration of computer vision algorithms and machine learning models, the system demonstrates robust capabilities in accurately identifying vehicle number plates and estimating their speed with high precision.

By leveraging machine learning techniques such as object detection, image classification, and regression analysis, the system achieves real-time processing of video streams from surveillance cameras, enabling prompt identification of vehicles and their associated number plates. Furthermore, the incorporation of speed estimation algorithms enhances the system's functionality by providing valuable insights into vehicle velocity, facilitating effective traffic monitoring and enforcement of speed limits.

The successful development and deployment of this system hold immense potential for various applications, including law enforcement, toll collection, parking management, and traffic flow optimization. Moreover, the scalability and adaptability of the underlying machine learning framework offer opportunities for further enhancements and customization to suit specific use cases and environments.

In summary, the integration of machine learning techniques in the detection of vehicle number plates and speed represents a significant technological advancement with profound implications for improving road safety, traffic efficiency, and overall transportation management. As technology continues to evolve, this system stands as a testament to the transformative power of machine learning in addressing complex real-world challenges.

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