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Automatic Speed Measurement and License Plate Reader for Motor Vehicles using CNN

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***Abstract*— Assessing traffic surveillance data is a prevalent utilization of deep learning methodologies. Video processing techniques were employed to develop the system aimed at determining the velocity of vehicles. The analysis of video speed is conducted without the requirement of camera calibration. Frame subtraction and masking techniques are employed to effectively segregate moving vehicles. The suggested system comprises four primary components. Object detection techniques are employed in the initial phase to identify and locate moving vehicles within a given footage. Real-time vehicle recognition leverages the utilization of R-CNN and deep learning techniques. In the subsequent section, algorithms are employed to observe the movement of objects within individual video frames. Optical flow methods are employed in the third segment to ascertain the velocities of the respective vehicles. In the preceding part, the proposed work have utilized image processing techniques in conjunction with deep learning methodologies to accurately decipher the license plates of the automobiles under our surveillance. The experimental evaluation involving the utilization of traffic film demonstrated a system performance of 97% in precisely quantifying speed while achieving a license plate identification accuracy of 95%. The incorporation of state-of-the-art traffic management systems has facilitated the implementation of real-time speed monitoring and license plate reading capabilities. This facilitates the deterrence of automobile theft and the implementation of traffic regulations. Additionally, the methodology has the capability to identify traffic patterns and pinpoint regions of congestion, thus assisting in the effective management of traffic.**

Keywords*— *Deep learning, Vehicle speed detection, Frames, Video footage, Pixel.

I. INTRODUCTION

The worsening of traffic congestion can be attributed to the expanding metropolitan population, which has heightened demand for transportation services. This surge in demand and the constraints imposed by limited road infrastructure and capacity have contributed to the worsening traffic conditions. In light of the gravity of the issues they engender, it is imperative to seek efficacious remedies to mitigate their impact [1]. Accurate measurement of vehicle speeds is crucial in enforcing speed limits and providing precise traffic reports. The identification and surveillance of automobiles play a critical role in urban planning. Excessive speed significantly contributes to the occurrence of traffic accidents. The utilization of deep learning methodologies, such as the faster R-CNN, is employed by the technology to identify and classify automobiles in real-time scenarios accurately. In the subsequent section, the proposed work will discuss algorithms designed to track actors throughout video sequences. The concluding segment entails the determination of vehicle velocities through the utilization of optical flow techniques [2]. The speedometer depicted in Figure 1 exemplifies the latest advancements in technology.

Fig.1. Vehicle speed detection

Car accidents and their aftermath can be mitigated by limiting drivers' speeds and reducing the severity of injuries sustained by those caught in them. Over the past decade, vision-based traffic monitoring systems have received considerable interest. Excessive speeding is the leading cause of traffic accidents, as reported by the World Health Organization [3]. If this program is successful, fewer people will be hurt in accidents, and those who are injured will suffer less trauma as a result. The project proposes a cutting-edge, efficient method for detecting and reporting illegal speeds [4-6]. Excessive speed is a major contributor to traffic accidents. Accidents, significant injuries, and even deaths can result from high-speed collisions. Victims of high-velocity collisions may incur enormous medical bills due to the severity of their injuries. More than 10.2 million people died in traffic-related accidents in 2020, according to the American Community Survey. There were 2,653,434 accidents and 91,223 deaths on Indian highways that year due to speeding [7]. About 30 percent of all traffic fatalities can be attributed to drivers exceeding the speed limit. Excessive speed is a major contributor to traffic accidents. Accidents, significant injuries, and even deaths can result from high-speed collisions.

Some low and middle-income countries have identified speeding as the primary contributor to traffic accidents [8]. In contrast, in high-income countries, speeding is thought to account for about a third of road fatalities. Car accidents and their aftermath can be mitigated by limiting drivers' speeds reducing the severity of injuries sustained by those caught in them. Excessive speed is a common contributor to tragic outcomes [9]. To succeed is a basic human trait. Humans can achieve speeds close to infinity. The likelihood of an accident and its subsequent severity are increased when a quicker vehicle is involved [10]. The goal is to create an algorithm that can detect and calculate the velocity of moving objects in aerial video frames automatically.

II. Literature Review

Leite et al. [11] have shown how to improve the accuracy of speed estimates in sensor-less induction motor control. In place of a full-order EKF, a reduced-order extended Kalman filter (EKF) is implemented using a novel discretization method. The proposed model's structure, based on the calculation of rotor flux components and velocity, is novel and useful. This work tries to reduce the total number of tuning parameters in order to reduce execution time and avoid covariance matrix issues. This advancement could improve sensor-free induction motor control shortly.

Wireless gateways used to connect computers to the internet at high speeds are particularly vulnerable, as Gopinath N et al. [12] discussed in their study of network security concerns in business and the financial industry. Despite numerous precautions, the issue of protecting these networks still needs to be addressed. Although quantum key distribution (QKD) was created to increase security, it has its challenges. For example, third-party data theft via covert routes is still possible. This study offers the Shifting Parity with the Fuzzified Qubits (SPFQ) framework, which employs cutting-edge algorithms and fuzzy logic to mitigate the severity of these risks. When compared to QKD, the proposed SPFQ model is demonstrated to be more effective in enhancing network security due to its much reduced mean security losses (0.55).

V. K. Madasu et al. [13] suggested a novel method for calculating the speed of a moving vehicle from its recorded path in a series of pictures. The tracking technique established by Kanade, Lucas, and Tomasi, which is based on an equation that establishes a link between picture rotation and motion in a spherical projection. The Kalman and Extended Kalman filters can anticipate object velocities and feature locations in the next frames. These filters are based on a dynamic state model developed from motion equations. Aside from the capacity to predict vehicle speeds from uncalibrated traffic data, the proposed method offers other advantages. This study paves the way for better real-time algorithms for determining trip durations in congested areas.

Malik et al. [14] created an automated system that detects cars with the most common Punjab license plates in Pakistan, takes a picture of the plate, and sends it to a toll booth for a fine. MATLAB-enabled Digital Image Processing (DIP) technologies are used to read license plates from photographs of passing automobiles. With its exact detection of overspeeding, accurate license plate extraction, and robust performance, the proposed system can be effectively deployed on highways to reduce overspeeding incidents.

M. F. Rachmadi et al. [15] address the urgent need for a flexible traffic signal control system that can help reduce the negative repercussions of heavy traffic. The paper provides an innovative way to collect real-time traffic data using webcams as input sensors. Principal Component Analysis (PCA), used to analyze and categorize objects in video frames, enables the system to recognize vehicles. The time of each traffic signal is determined by the DCSP (Distributed Constraint Satisfaction Problem) algorithm and the number of vehicles in each channel. The Beagle Board is an example of an embedded device capable of executing the proposed system to demonstrate how the technology can dramatically improve traffic management by changing signal timings to actual traffic conditions.

III The Proposed Model

The method proposed in this research demonstrates greater economic viability as it uses software to carry out tasks that were historically executed by specialized hardware. The computer system employs software tools to evaluate the film captured by the input cameras to identify and track the vehicle. Subsequently, the prescribed protocol for determining the velocity of a tracked vehicle is adhered to. Upon completion of the video, the resultant velocity is incorporated. The acquired data has the potential to be utilized to create a blacklist of local drivers who demonstrate a continuous pattern of speed limit violations. Intelligent traffic monitoring cameras can provide valuable data for traffic and road usage statistics and facilitate speed and traffic law enforcement. Using statistical analysis plays a fundamental role in developing and implementing traffic-related solutions inside smart cities. The process of isolating moving autos involves the utilization of frame subtraction and masking techniques. The proposed methodology incorporates analyzing the temporal interval between frames and quantifying the number of corners traversed to ascertain the occurrence of object displacement within a singular frame. These parameters are utilized in the computation of velocity. The implementation of the proposed approach does not require any specialized equipment. It is feasible to implement supplementary system modifications in order to enhance license plate recognition capabilities. The camera hardware of the system is linked to a computer via a network connection. The camera affixed to a publicly accessible structure, offers an elevated perspective of the street underneath it, facilitating precise assessments of vehicular velocities. The same application can utilize many platforms concurrently. The information flows of these systems can be visually depicted through activity diagrams. The method comprises interconnected cameras and a computer. It must be positioned on a prominently visible structure to ensure the camera's efficacy in monitoring traffic and generating accurate speed estimates. The computer provides continuous access to the latest footage with regular updates from the camera. The computer application receives the video feed and provides a real-time display, simultaneously performing car tracking and speed calculations for surrounding vehicles. The Open CV library is utilized for machine learning and computer vision operations. The unit "pixels per meter" (ppm) is commonly employed to quantify distances.

The term "PPM" refers to the measurement of video pixels visible at a distance of one meter. The expeditious computations performed by the technology are effectively demonstrated through a recorded video. The car in motion was captured on film by unnoticed cameras. The video footage is transmitted to the computer system, where it is received and subjected to frame data analysis. The video frames undergo preprocessing using OpenCV, a freely available open-source software library compatible with several operating systems. To modify the dimensions of the frame, a library function is invoked. To streamline subsequent processing, the video frames are transformed into grayscale utilizing the capabilities of OpenCV. Figure 2 gives an overview of the speed estimation of the vehicle.

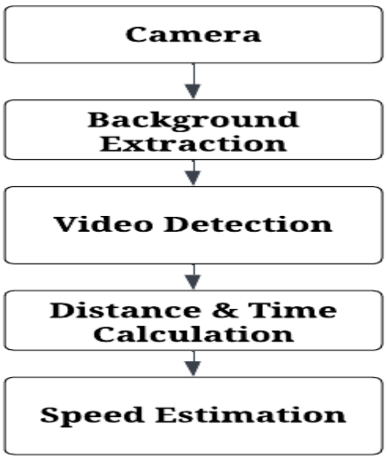


Fig 2. Speed Estimation of Vehicle

The information gathered by intelligent traffic monitoring cameras can improve traffic and road usage statistics, speed, and traffic law enforcement. Some traffic-related solutions in smart cities are based on statistical data analysis. Frame subtraction and masking are used to isolate the moving automobiles. The suggested technique calculates velocity using the time between frames and the number of corners covered to assess whether objects moved within a single frame. The proposed solution does not necessitate the use of any specialized equipment. Additional system improvements are possible to allow license plate recognition. The camera gear in the system is network-connected to a computer. The camera, mounted atop a public structure, provides a birds-eye view of the roadway below, allowing accurate readings of traffic speeds. The same application can run on multiple platforms at the same time. The information flows in these systems can be depicted graphically using activity diagrams. The system is made up of cameras that are linked to a computer. The camera must be situated on a highly visible building to watch traffic and efficiently produce trustworthy speed estimations. Because the camera is constantly updated, the most recent footage is available on the computer. A computer application receives the footage and displays it in real-time while tracking and calculating the speeds of adjacent vehicles. It uses the Open CV[3] library for machine learning and computer vision operations. Distances are expressed in pixels per meter (ppm). The PPM represents the number of video pixels visible from one meter away. A video recording demonstrates the system's lightning-fast calculations. Unknown cameras captured the automobile in motion. The video is gathered and returned to the computer system, which receives it and analyzes it for frame data.

Open CV, a free and open-source tool that may be used across numerous platforms, is used to preprocess the video frames. A library function is used to modify the dimensions of the frame. Video frames are transformed to grayscale utilizing Open CV capabilities to simplify further processing. This video may have a car(s) in the background. The correlation tracker function from the dlib package may track many cars in the video at the same time. A car in the film is given a unique identity that can be used to locate it in the following shots. These approaches are used to locate the vehicle. The coordinates of the vehicle are shown on the screen as pixels. Distance and time traveled must be known before determining speed. The collected coordinates are first used to calculate the pixel shift. Distance is measured in pixel units, which are subsequently translated to SI units. Distances are expressed in pixels per meter (ppm). The ppm value indicates the actual number of visible pixels from one meter away. The results are communicated by replaying the original footage while drawing a box around the detected car. The speed is entered along with the bounding box of the vehicle. Individual bounding boxes include the numerous cars, and embedded speed results are displayed next to the video. Figure 3 demonstrates the proposed work model.

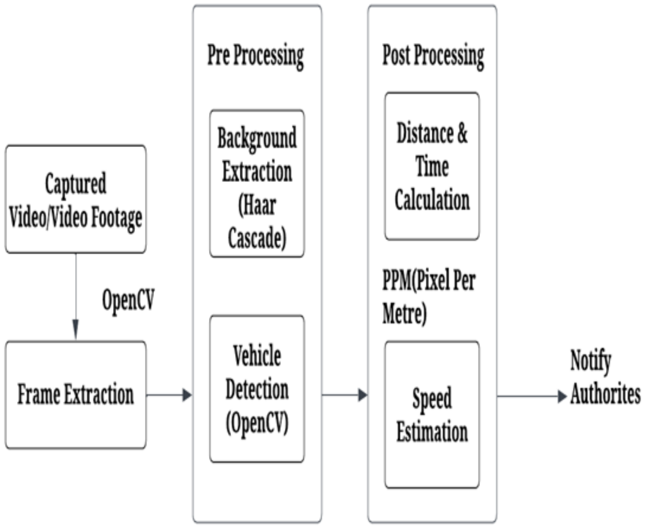


Fig.3. Proposed work model

A. Vehicle Detection

Isolating the vehicles from the external environment is crucial to becoming enclosed within the frames. The proposed approach utilizes the Haar Classifier to differentiate between cars and frames. The Adaboost algorithm is a widely recognized boosting approach that significantly enhances the efficacy of vehicle detection. By integrating multiple weak classifiers, it is possible to develop a robust classifier with high accuracy in detecting automobiles. If the classifier successfully detects an automobile, it will provide feedback by returning the coordinates of a rectangular region encompassing the car. Subsequently, an OpenCV module function delineates the vehicle's contours.

B. Vehicle Tracking

The utilization of the dlib library is employed in the recommended methodology. The presence of mobile vehicles in the surrounding environment is a possibility. The correlation tracker function of the dlib module is employed due to its ability to track many automobiles simultaneously. Each car in the video is allocated a unique numerical identifier, which may afterward be utilized to locate the corresponding car in still photos. Implementing a precautionary strategy is of utmost importance as it safeguards drivers from the provision of inaccurate speed limit information. This strategy involves tracking automobiles using the Dlib library. The correlation tracker function from the dlib package enables simultaneous tracking of multiple cars in the video. In cinematic production, a distinct identification is allocated to a vehicle, enabling its subsequent retrieval within succeeding frames. The progression of tensors TensorFlow is capable of constructing dataflow graphs and structures that illustrate the movement of data across a graph. This is made possible because of the language's ability to accept inputs in the format of multidimensional arrays, which are referred to as Tensors.
The assigned identification is deleted, and a new one is generated as soon as the vehicle departs the area of interest.

C. Speed Estimation

Performance evaluations necessitate the use of distance and trip time calculations. Each Pixel's displacement is initially calculated using the amassed coordinates. The distance is initially given in pixel format before being converted to SI units. Distance is indicated in meters and quantified as pixels per meter (ppm). The PPM specifies how many pixels would be visible in the video at a standard viewing distance of one meter. The frame rate of the camera is used as a time reference.

D. Number Plate Detection

The first step in the vehicle detection system, image processing, involves the acquisition of vehicle images. The subsequent procedure involves converting the RGB image into a grayscale image, characterized by a reduction in color channels to two, hence facilitating a more straightforward analysis. Segmentation is a crucial step in the process of automatic license plate identification, serving as a fundamental procedure. The area Properties function in MATLAB is a valuable tool for efficiently calculating many qualities of an image, regardless of whether the image is monochromatic or labeled. The purpose of this technology is to transform visual representations of textual content into corresponding alphanumeric characters and symbols. The primary objective of optical character recognition (OCR) is to categorize graphic patterns that are linked to individual characters. The findings derived from the license plate reader are depicted in Figure 4.

Fig. 4. Number Plate Detection

ALGORITHM

Region-Convolutional Neural Network (R-CNN), Haar Cascade Classifier, and Pixel Per Meter (PPM) algorithms were used in this research work.

Step 1. Region Convolutional Neural Network

The selective search algorithm is utilized to identify numerous potential bounding-box object regions, also known as "regions of interest." Subsequently, the distinctive attributes pertaining to each region are retrieved and classified. Analyze the image to identify potential locations of objects. These proposed areas are sometimes referred to as "regions." Request regional recommendations for CNN programs. Arrange the objects based on the identified characteristics.

Step 2. Haar Cascade Classifier

The Haar feature, employed in detection windows, involves the computation of adjacent rectangular regions. To determine the disparity between the quantities, it is necessary to aggregate the pixel intensities at each location. The process of completing a picture. Integral images are a useful tool for efficiently calculating Haar characteristics. In order to expedite computations, pixels are organized into smaller rectangular units and subsequently employed as points of reference inside an array. The Adaboost algorithm selects the most significant features and instructs classifiers to prioritize their inclusion. The proposed technique may involve the utilization of a "strong classifier" that has been constructed by combining multiple "weak classifiers." In the context of employing cascading classifiers, it is observed that each successive tier encompasses individuals who exhibit substandard performance. The technique of "boosting" involves aggregating the predictions made by multiple weak learners in order to train a single, highly accurate classifier.

Step 3. Pixel Per Meter

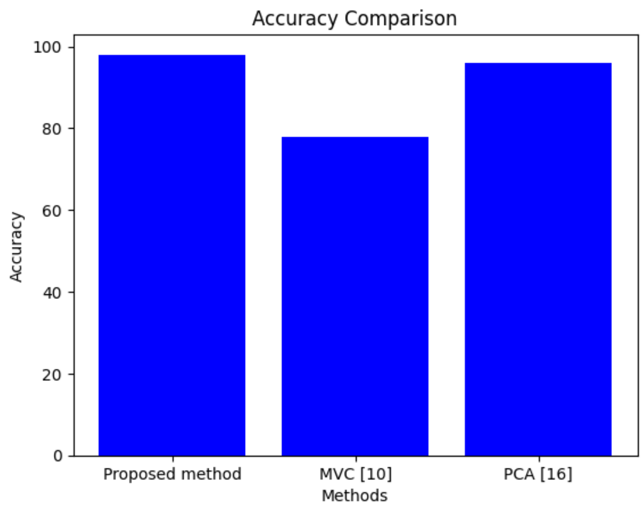
A digital image is made up of a grid of pixels, or blocks, and within each Pixel or block is information about the color at that location within the image. A pixel per meter (ppm) value is used to measure the distance in meters. The PPM value designates the number of points or divisions that will be imaged by the camera per one meter of the subject. The results are shown in Table 1. The relative accuracy is shown in Table 2 and Fig. 5.

Table 1 Performance Metrics

Metrics	**Value**
Detection Rate	0.95
Accuracy	98%
Frames Per Seconds	60
Speed Estimation Error	±1 km/h

Table 2 Comparison of existing and proposed methods

	Accuracy (%)
Proposed method	98
MVC [10]	78
PCA [16]	96



Fig, 5. Accuracy comparison of proposed and existing method

IV Conclusion

The fundamental impetus behind this concept's development was traffic surveillance. The system's significance lies in its versatility across various situations and its ability to consistently deliver dependable outcomes. The model's performance exhibits a relatively low sensitivity to alterations in context. The camera must demonstrate optimal performance in capturing footage of both mobile and stationary vehicles. The utilization of the technology on urban roadways is also a viable option. The technique under consideration exhibits significant promise for utility and demonstrates adaptability across a diverse array of vehicles. A level of accuracy of 91% has been attained. The proposed assignment is developing a system that utilizes GSM technology to effectively detect and alert the appropriate authorities on instances of speeding drivers.

Furthermore, the utilization of infrared cameras may prove advantageous in pursuing elusive targets within environments characterized by limited illumination. Researching a range of artificial intelligence (AI) and computer vision algorithms specifically designed for implementation in automated systems for measuring vehicle speed and identifying license plates is advantageous. One potential avenue for future research involves using intricate multiple algorithms to enhance the system's accuracy.

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