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Vehicle Detection & Speed Tracking

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ABSTRACT:

This paper introduces an innovative system for vehicle detection and speed tracking utilizing computer vision technology. It targets to predict the speed of a vehicle with respect to the data from a recorded video source. Serving as the hypothesis, the paper portrays the various important procedures such as unequivocal Gaussian blend, models, DBSCAN, Kalman channel, Optical stream. The game plan and the delineation of procedures for correspondence of individual area are included in the execution part. The type of vehicles, the nature of driving and the vehicle's position at the time of video capture is taken into consideration. Ensuring reliability across diverse weather and traffic conditions integrated speed estimation modules enable accurate real-time tracking of vehicle velocities. The effectiveness of the system is validated through extensive experiments, demonstrating superior performance compared to existing methods. With applications ranging from traffic management to law enforcement, the proposed approach showcases its potential to enhance safety and optimize transportation systems in urban settings. This research contributes a scalable and efficient solution to the challenges of contemporary traffic monitoring and control.

Keywords: DBSCAN, Kalman channel, Gaussian Mix Modeling, congestion identification, speed limits enforcement, intelligent transportation systems, frame-to-frame tracking.

1. Introduction:

One of the most important aspects of town planning is the detection and tracking of vehicles. A lot of attention has been paid to vision-based traffic monitoring systems in the past ten years. Speed monitoring and vehicle detection can assist with this. The monitoring system provides a variety of data, including the number of vehicles, traffic jams, and vehicle speed. Speed is one of the primary causes of traffic accidents. If you want to know if the car is travelling faster than what is allowed, you can extract frames from the video and compare the speeds of two spots. For the purpose of extracting automobiles from the background, numerous algorithms are available. Radar systems have historically been employed for these purposes, albeit they have certain drawbacks. Thus, numerous strategies for vehicle speed measurement utilising image processing have been developed in order to get around the shortcomings in the systems that are now in use.[7] However, the primary variables that might impact these image processing techniques are illumination, camera noise, and branch waving. In order to collect more vehicle and traffic data, the current research aims to develop an automatic vehicle counting system that can also detect speed. The system will be able to process videos recorded from stationary cameras over roads, such as CCTV cameras installed near traffic intersections / junctions, and count the number of vehicles passing a spot in a given amount of time. Vehicle speed surveillance plays a major role in traffic law enforcement. Radar technology, which comprises of a radar gun and a radar detector, was traditionally used to monitor vehicle speed. The abbreviation for radar is Radio Detection and Ranging. The electromagnetic energy produced by radar systems is converted into radio waves, which can be directed into the atmosphere and move at the speed of light, or 3.08 x 108 metres per second, or about 186,000 miles per second. Radar can be used to detect objects and range them, or determine their position and distance from the radar system, thanks to the transmission of these signals and the gathering of returned energy, or returned pulses, that bounce off of objects in the path of the radar's transmission. A radar uses a phenomenon whereby the motion of the car relative to the radar modifies the frequency of the return signal radio wave to detect an object's speed (for example, when a police officer with a stationary radar gun is detecting the rate at which an automobile is moving). The return signal radio wave frequency rises when the car approaches the radar device. This shift in frequency can then be used by the radar gun to calculate the vehicle's speed. The Doppler effect refers to this principle, which states that the relative motion of the source with respect to the object affects the difference between the frequency of the emitted pulse and the frequency of the return pulse. Therefore, an object's speed may be determined by measuring the difference in pulse characteristics between the transmitted and received echo, while its distance can be determined by measuring the time it takes to detect the return pulse. This gives rise to a velocity known as the radial velocity, which is along the direction the radar is pointed. One thing to keep in mind is that the variations in pulse characteristics utilised to determine the speed of a moving item, such as an automobile, will rely on the relative position of the car to the radar.

WHAT IS VEHICLE DETECTION

Vehicle detection refers to the use of technology to identify and locate vehicles in a given area. This technology is commonly used in various applications, including traffic management, surveillance, parking systems, and autonomous vehicles. The goal of vehicle detection systems is to accurately and efficiently identify the presence, location, and sometimes the type of vehicles in a specific environment. Vehicle detection is a crucial component of many modern transportation and surveillance systems. It plays a key role in improving traffic flow, enhancing security, enabling smart parking solutions, and supporting the development and deployment of autonomous vehicles. The accuracy and reliability of vehicle detection systems are essential for their successful implementation in various applications.

There are different technologies employed for vehicle detection:

- Video Surveillance Systems: Cameras equipped with computer vision algorithms can analyze video feeds to detect and track vehicles on roads or in parking lots.
- Radar Sensors: Radar systems use radio waves to detect the presence and movement of vehicles. They are commonly used in traffic management and collision avoidance systems.
- LIDAR Sensors: Lidar (Light Detection and Ranging) sensors use laser light to measure distances and create detailed, three-dimensional maps of the surroundings. They are often used in autonomous vehicles for object detection, including vehicles.
- Infrared Sensors: Infrared sensors detect heat signatures, and they can be used to identify the presence of vehicles based on the heat they emit.
- Magnetic Sensors: Magnetic sensors can detect changes in the Earth's magnetic field caused by the presence of metal objects, such as vehicles.

WHAT IS SPEED TRACKING

Speed tracking involves the systematic monitoring and recording of vehicle speeds within defined area, such as roadways, highways, or specific zones. This process is designed to measure and regulate the velocity of vehicles in order to enforce adherence to established speed limits, enhance overall road safety, and gather valuable data for effective traffic management. Various technologies are employed for speed tracking, including radar systems, Lidar technology, camera-based systems, GPS technology, and infrared sensors. Radar and Lidar systems use radio waves or laser light to detect the speed of moving vehicles, while cameras capture images for speed calculation. GPS technology can track vehicle movement, and infrared sensors measure speed based on the time it takes for a vehicle to pass between two points.

The data obtained through speed tracking serves multiple purposes, including law enforcement by identifying and penalizing speeding drivers, contributing to improved road safety. Additionally, this information is crucial for traffic management, helping authorities optimize traffic flow and implement measures to enhance transportation efficiency. Speed tracking is an integral part of efforts to create safer and more effective transportation systems by promoting compliance with speed regulations and providing valuable insights into traffic behavior.

Methodology:

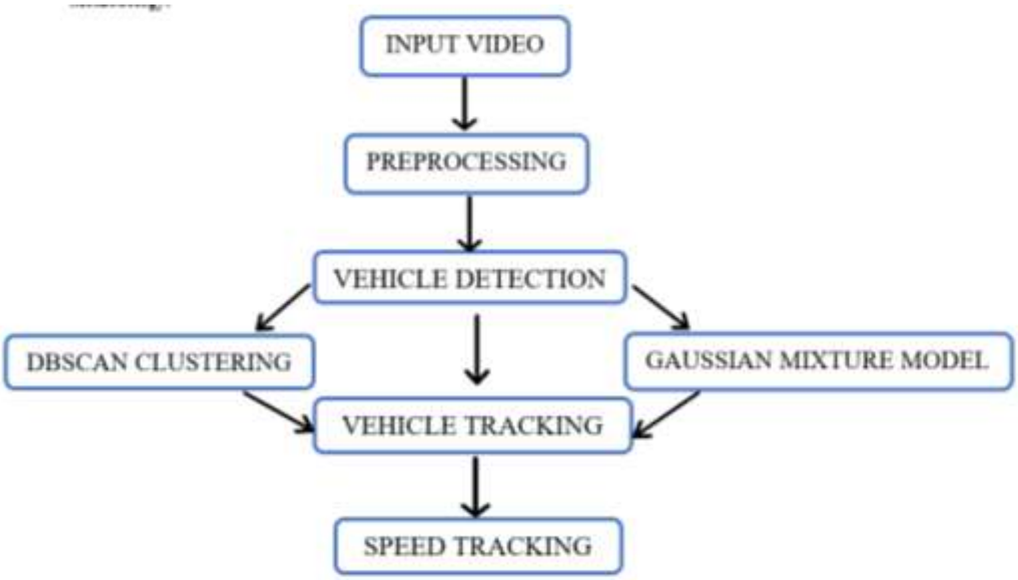

Fig 1 – Working

1. **INPUT VIDEO -** In vehicle detection and speed tracking systems, the input video serves as a critical source of information, typically obtained from surveillance cameras strategically positioned along roadways or specific monitoring areas. These cameras capture real-time footage of vehicular movement, providing the necessary input for sophisticated algorithms designed to detect vehicles and track their speeds. The quality of the input video is paramount to the accuracy and reliability of the system. Factors such as resolution, frame rate, camera placement, lighting conditions, and coverage area play crucial roles. Higher resolution and frame rates contribute to more precise vehicle tracking, while strategic camera placement ensures comprehensive coverage of key areas, such as intersections or highways
2. **PREPROCESSING:** In vehicle detection and speed tracking, preprocessing plays a pivotal role in enhancing the effectiveness of algorithms and ensuring accurate analysis of input video data. Preprocessing involves a series of steps aimed at refining and optimizing the raw video feed before it undergoes detection and tracking algorithms. One crucial preprocessing step is image or video normalization, where adjustments are made to account for variations in lighting conditions, contrast, and color. Additionally, noise reduction techniques, such as smoothing or filtering, are often applied to mitigate the effects of sensor noise or artifacts in the video feed. Frame stabilization may be employed to compensate for camera vibrations or movement, providing a more consistent and stable input for the subsequent analysis. In some cases, background subtraction techniques are utilized to isolate moving objects from the static background, facilitating more accurate vehicle detection.
3. **VEHICLE DETECTION -** In the realm of vehicle detection and speed tracking, the process of vehicle tracking emerges as a critical component, adding a dynamic dimension to the overall system. Once vehicles are detected within the input video stream, tracking algorithms come into play to monitor their movements over time. Vehicle tracking involves assigning a unique identifier to each detected vehicle and continuously updating its position as it navigates through the monitored area. Various tracking techniques, such as Kalman filtering or correlation-based methods, are employed to predict a vehicle's future location based on its previous trajectory, ensuring accurate and consistent tracking. The benefits of effective vehicle tracking are numerous. It enables the system to not only identify vehicles but also monitor their speeds and trajectories over specific intervals.
4. **VEHICLE TRACKING -** Vehicle tracking is an essential facet within the domain of vehicle detection and speed tracking, adding a dynamic layer to the comprehensive analysis of traffic flow. Once vehicles are identified through detection algorithms, tracking mechanisms take over to monitor their movements continuously. This involves assigning a unique identifier to each detected vehicle and then updating its position as it progresses through the monitored area. Various sophisticated tracking techniques, such as Kalman filtering or correlation-based methods, are deployed to predict a vehicle's future location based on its past trajectory, ensuring accurate and consistent tracking over time. The significance of robust vehicle tracking becomes apparent in its contribution to calculating and analyzing vehicle speeds. By monitoring a vehicle's trajectory over successive frames, the tracking system enables the computation of speed, a crucial metric for applications such as traffic management, law enforcement, and overall transportation efficiency.
5. **SPEED DETECTION** - Speed detection stands as a fundamental component within the broader framework of vehicle detection and speed tracking systems. Once vehicles are successfully identified and tracked, determining their speeds becomes a critical objective. Speed detection involves calculating the rate at which a vehicle traverses a specific distance within a given time frame. This calculation is facilitated by tracking a vehicle's position over successive frames of the input video. Various algorithms and methodologies, often incorporating principles from physics and computer vision, are employed to derive accurate speed measurements. The process typically starts with the estimation of the distance traveled by a vehicle between two consecutive frames. This distance, combined with the known time interval, enables the computation of the vehicle's speed. The precision and reliability of speed detection are influenced by factors such as the resolution of the input video, the accuracy of the tracking algorithm, and the calibration of the system.
6. **OBJECT DETECTION -** In our project, the object detection depends on adaptable foundation subtraction procedure called Gaussian blend model. After every pixel is gathered by this model framework, portions of the frontal area focuses are shown by DBSCAN (Density − based spatial social affair of organizations with tumult) gathering technique.

Distance between Vehicle and starting point measured in Kilometre

Distance = Df * (D/Dx) * (Pn - Po) (1)

Time that vehicle spent in order to move to Pn in unit of hour

Time =Tf * (tn - to) (2)

Vehicle speed measured in format of kilometre per hour

Speed = Distance / Time (Kilometre per Hour) (3)

Were,

D = is the real distance between two marking points (start point and end point) measured in meter.

Dx = is the distance between two marking points measured in pixels.

X= is the width of the video scene measured in pixels

Y = is the height of the video scene measured in pixels

Po = is the right most of the vehicle position at time t = 0 measured in unit of pixels

Pn = is the right most of the vehicle position at time t = 0 measured in unit of pixels

to = is the tickler (timestamp) saved at time t = 0 measured in unit of milliseconds

tn = is the tickler (timestamp) saved at time t = n measured in unit of milliseconds

Df = is the distance conversion factor from meter to kilometre, which is (1.00/ (1000.00*60.00*60.00))

Tf = is the time conversion factor the conversion is from millisecond to hour, which is (1.00/1000.00)

Sample_Duration = Sample_Frames / FPS

Detected_Duration = (Detected_Frames * Sample_Duration / Sample_Frames

Velocity = (Distance_Between_Points / Detected_Duration) * 3.6

1. **DBSCAN CLUSTERING -** DBSCAN algorithm is based on intuitive notion of cluster and noise. The key idea is that for each point of cluster the neighborhood of a given radius has to contain at least minimum number of points.

DBSCAN algorithm requires two parameters –

1. It defines the neighborhood around a data point i.e. if the distance between two points is lower or equal to 'eps' then they are considered as neighbors. If the eps value is chosen too small, then large part of the data will be considered as outliers. If it is chosen very large then the clusters will merge and majority of the data points will be in the same clusters. One way to find the eps value is based on the k-distance graph.
2. Min Pts: Minimum number of neighbors within eps radius. If the dataset is large, we should choose larger Min Pts value. In general, the minimum Min Pts can be derived from the number of dimensions D in the dataset as, Min Pts >= D+1. A minimum of 3 Min Pts values must be chosen.

In this algorithm, we have 3 types of data points.

1. Core Point: A point is a core point if it has more than Min Pts points within eps.
2. Border Point: A point which has fewer than Min Pts within eps but it is in the neighborhood of a core point.
3. Noise or outlier: A point which is not a core point or border point.

DBSCAN algorithm can be explained in the following steps –

1. Find all the neighbor points within eps and identify the core points or visited with more than Min Pts neighbors.
2. For each core point if it is not already assigned to a cluster, create a new cluster.
3. Find recursively all its density connected points and assign them to the same cluster as the core point.
4. Iterate through the remaining unvisited points in the dataset. Those points that do not belong to any cluster are noise.

Results

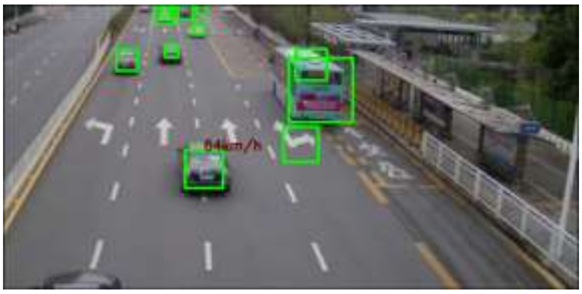

Fig 2 – Speed detection of vehicle

```
 Creating new tracker0
 Creating new tracker1
 Creating new tracker2
 Creating new tracker3
 Creating new tracker4
 Creating new tracker5
 Creating new tracker6
Removing carID 2 from list of trackers.
Removing carID 2 previous location.
Removing carID 2 current location.
 Creating new tracker7
 Creating new tracker8
 Creating new tracker9
 Creating new tracker10
Removing carID 10 from list of trackers.
Removing carID 10 previous location.
Removing carID 10 current location.
 Creating new tracker11
Removing carID 11 from list of trackers.
Removing carID 11 previous location.
Removing carID 11 current location.
 Creating new tracker12
Removing carID 5 from list of trackers.
Removing carID 5 previous location.
Removing carID 5 current location.
Removing carID 0 from list of trackers.
Removing carID 0 previous location.
Removing carID 0 current location.
 Creating new tracker13
```

Fig 3 – Speed detection of Vehicle

Conclusion

In this project, we suggest that the computer program be able to determine the precise speed of a moving object. For accurate representation of the moving objects, this technique was combined with a Gaussian mix model. Even with poor visual quality, the combination of the optical stream and the Kalman channel aids in outcome prediction. In our ongoing work, we hope to enhance the DBSCAN division so that it can recognize each component of the collection of cars, as well as employ flexible heaps of pixels to sense vertical advancements' speed.

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