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Video Processing Techniques for Real-Time Traffic Applications

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Abstract: The procedure of traffic checking is done predominantly using radar detectors, loop detectors and manual observation. Traffic checking incorporates a lot of tough standards to be followed while guaranteeing that there are no congested driving conditions in the streets. The existing techniques and their shortcomings are briefly stated in the paper.

The need of great importance is an insightful traffic observing framework that can decrease the manual exertion and increment effectiveness. One potential arrangement is the utilization of digital video processing strategies. The examination of clever traffic signal control framework has recently got significantly more importance because of the increase in automobile jams and accidents.

This paper proposes video processing frameworks and techniques for detection of speed of the vehicle, presence of the vehicle and presence of helmet on the rider. The strategy for the most part lies in the internal working of deep neural networks and feature extractors. The proposed frameworks are relied upon to perform better than the current less-proficient systems by in any event a factor of five times. By bringing the proposed new developments and methods into the real world, the pace of congested roads and accidents can be diminished fundamentally

Keywords: CCTV, IoT, HOG, SIFT, SVM

I. INTRODUCTION

Traffic congestion, incidents and traffic rules violation are a common problem in most large and medium sized cities. The traffic management systems that are currently in place make use of radar detectors, inductive loop sensors, infrared detectors, manual observation techniques where traffic police manually control the traffic on roads or video surveillance techniques which follow a semi-manual approach where CCTV cameras capture the traffic flow in real time which are analysed in a control room by the traffic police.

These methods not only lack efficiency but also require a lot of manual effort. In case of detectors and sensors, installation and maintenance also is very hard.

The need of the hour is an intelligent traffic monitoring system that can reduce the manual effort and increase efficiency. One possible solution is the use of video processing techniques.

The cost of installing and maintaining such systems are very low because, all that is needed is a smart CCTV camera with an embedded platform with minimal computing capacity. Installation of such system allows for wide area monitoring and also causes very less disruption of traffic while installation or maintenance.

If computing is done at the source, it will reduce the amount of data that needs to be transmitted to the central traffic control system and also prevents delay in decision making. However one important factor in this is the classification of processing that needs to be done online and in real-time and the processing that can be done offline.

In this paper we first provide a literature review that talks about the related works done and common techniques used in the field. Then we provide a brief overview of the various applications where real time video processing techniques can be used to manage, monitor or control traffic and traffic related incidents and violations. This is followed by a discussion on the offline and online algorithms that can be used in traffic management systems. The rest of the paper provides a brief discussion about the challenges that exist that we might encounter followed by an overview of the results we obtained and conclusion.

II. MOTIVATION

The existing traffic processing detectors and sensors are less-efficient, require high maintenance and require excessive manual effort. Thus, the need for an intelligent system overcoming the above drawbacks is necessary.

This paper proposes frameworks and methodologies to build such intelligent systems and thus mitigate accidents and roadblocks caused by automobiles.

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III. LITERATURE SURVERY

Ample amount of research is made about how video processing techniques can be used in order to manage and control traffic.

[1] Provides information about how the techniques of background subtraction can be used to detect pedestrians and moving vehicles. [2],[3] and [4] propose different methods that can be used for detecting the presence of vehicles and counting the number of vehicles. [5] Emphasizes on the use of a block based algorithm to detect vehicles while the extended Lucas Kanade template matching algorithm can be used for tracking the vehicles in both day and night.

[6] And [7] provide an insight on how artificial intelligence and computer vision techniques can be used in traffic control systems.

[8] Discusses about a system that uses texture information and frame differencing algorithms to extract moving objects like cars from the scene. It describes how computer vision techniques can be used to determine the speed and density of traffic.

[9] Provides an automated and accurate approach to analyze traffic. The said approach also makes use of an up-and-coming stream of technology, i.e. IoT. Using this technology not only makes it socially relevant but also makes it time relevant.

[10] proposes a system that can be used to control city traffic by identifying illegal traffic behavior, such as illegal U-turn, through continuous monitoring of city traffic. It also proposes architecture to handle the vast volume of high-speed real-time videos efficiently. The papers mentioned above provide extensive information about how video processing techniques can be used for traffic analysis. But most of these techniques will be hard to implement in real time as the amount of data that needs to be transmitted across is large and this it will lead to delays. We are trying to incorporate these techniques with edge processing so that results can be obtained faster.

IV. PROBLEM STATEMENT

The existing traffic processing detectors and sensors are less-efficient, require high maintenance and require excessive manual effort. Thus, the need for an intelligent system overcoming the above drawbacks is necessary.

This paper proposes frameworks and methodologies to build such intelligent systems and thus mitigate accidents and roadblocks caused by automobiles.

V. OBJECTIVE

The aim of the paper is to propose a system that uses real time video processing techniques integrated with edge computing in order to perform the following tasks.

A. Speed Detection
B. Helmet Detection.

VI. METHODOLOGY

A. Speed Detection

The task of detecting the speed of the vehicle involves three major subtasks:

1) *Calibrating the Camera:* The most important part in any image processing task is to find the correlation between the real-world coordinates and the image based coordinates. Knowing the mapping between real-world coordinates and image based coordinates allows us to derive constants that will be used in the image processing and result analysis modules. Analysing the size of the vehicle, distance between the vehicles, vehicle speed from a video requires the mapping of a 2D image frame with a 3D video frame. However, since the motion of vehicles on the roads is not 3D, and the vehicles move in a straight line on the lane, the transformation from 2D to 3D will not be hard as it will be very similar to a 2D to 2D mapping. This means that if u and v refer to the coordinates of a vehicle in the video, U and V refer to the coordinates of the vanishing point, x and y refer to the coordinates of the vehicle on road, then the relationship between them can be expressed as

$$x = \frac{Au}{V-v} \qquad (1)$$

$$y = \frac{B}{V-v} \qquad (2)$$

Where, A and B are constants.

2) *Vehicle Detection:* Vehicle detection involves many subtasks like identifying the static parts and distinguishing the dynamic parts from the static parts of the video, removing the shadows, edge detection etc. In order to classify the static part from the moving parts, we need to consider how smoothly the pixels are changing in the frames.

The static part is called as the background and the dynamic part is called as the foreground. Hence, roads and billboards and other objects will come under background pixels, where as the moving vehicles and pedestrians will come under the foreground pixels.

In our case, the region of interest is the foreground pixels. This is done by first extracting the background pixels and then subtracting them from the foreground pixels to get our region of interest.

Firstly, frames that are 20s apart from each are considered. Then the difference in intensity for every pixel in the frame is calculated. If a pixel constitutes of a background frame, then the difference in pixel will be very less and hence it can be considered as a static frame. Since at least 50% of the image consists of background frames, we can calculate a threshold t, such that if the difference in pixel intensity is greater than a certain threshold t, then the frame is considered as a foreground frame, else it is considered as a background frame.

However, background pixels do change because of light and this also needs to be considered as one of the concerns.

There are many papers that talk about how varying light intensities can be handled.

The steps that can be used to detect a vehicle are as follows:

Let P(i,j) refer to the difference in intensity of a pixel at coordinate (i,j)

Then,

a) P(i,j) = (Intensity at t=x) – (Intensity at t=x+20s)
b) If P < threshold, then P is a background pixel, else P is a foreground pixel
c) Mark all the background pixels as 0 and foreground pixels as 1
d) Make clusters and in each individual cluster, if the number of foreground pixels is less than a certain threshold, consider that cluster as a background cluster
e) In this way all the foreground pixels can be identified and that will help us to detect the vehicle.

3) *Speed Detection:* The first step in the process of speed detection is extracting information about the vehicles present in a frame. Consider a vehicle V. Check for the presence of V in each of the successive frames every 20s. This will enable us to estimate the number of frames the vehicle V appeared in before it went out of the vanishing line. By using the information about the number of frames, interval between the frames and the distance that the camera covers, the speed of the vehicle can be calculated using the formula

$$V = \frac{dx}{dt}$$

B. Helmet Detection

The automatic detection of bike riders without helmet utilising surveillance videos in real time is proposed here.

The existing challenges faced in this problem are summarised below. It demands lot of time and compute power to process large amounts of video frames and apply filtering, feature extraction, classification and tracking. It poses difficulty in visualising images in 3D and finding direction of motion. It is difficult to process images with interferences caused by temporary conditional changes like sunlight, shadows, illumination and occlusion. Video quality and resolution is primary factor in deciding image usefulness.

Existing approaches were based on using geometrical shape of helmet and variations of luminance at different portions of helmet and also includes Hough transform based circle arc detection method. This approach suffers from ambiguity in helmet shapes and portrays other similar shaped objects as helmets and also works only when helmet is captured in full frame. Another approach tries to overcome these difficulties by using Gaussian mixture model with foreground refining and tracks vehicles using Kalman filter. Both the above approaches are computationally very expensive, and are passive in nature, thus unsuitable for real-time applications.

The detection of bike-riders without helmet is carried out by initially detecting bike-rider, then head is located, then determined if helmet is used. The results are consolidated from successive frames and a prediction is made based on this. This analysis has to be applied on static objects alone else the approach fails.

It is carried out through two stages. The first stage involves detecting bike-riders. It is done through background subtraction method which uses variable number of Gaussian models to simulate adapting background. It also involves feature extraction methods like Histogram of Oriented Gradients(HOG) for object detection mainly, Scale Invariant Feature Transform(SIFT) for capturing key-points in images and Local Binary Patterns(LBP) for capturing texture information in frames. Then classification is carried out by providing features extracted above as input. The classification is carried out by Support Vector Machine (SVM) with different kernels like linear sigmoid, radial basis function(RBF) to obtain hyperplane.

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The next stage deals with detecting if a bike-rider is wearing a helmet or not. This stage is also carried out by extracting features at first using methods as in first stage. These features are then input to a classifier, which can be any binary classifier, thus we use SVM for predicting hyperplane which partitions bike riders with helmet and without helmet into two different planes.
The experimental results show detection accuracy of upto 94 percent and are computationally less expensive when performing in real-time having processing time of 11ms per frame.

C. Edge Computing for Video Processing
Sending the videos captured by the surveillance cameras to the servers that are far away from the cameras will lead to a lot of delay and congestion. [14] provides a methodology for using edge computing techniques for video processing.

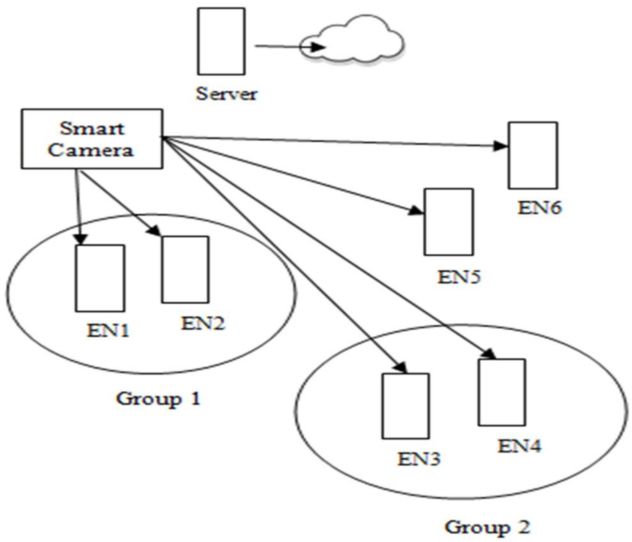

Fig.1. Architecture of edge computing system

The first step is traffic offloading which refers to the method of partitioning the task into various sub-tasks. This is done using DLT (Divisible Load theory). Cooperative processing is used where related sub tasks are grouped together. Later, edge computing can be used to process the different subtasks. Fig.1 depicts the architecture of an edge computing system that can be used for traffic surveillance applications which is based on the system that is described in [10]. The system consists of a surveillance camera node which will be a static camera that will be fixed on top of street lights or traffic lights. This will be performing the task of dividing the video processing task into various subtasks. It then compresses the various chunks of video and passes them on to the different edge nodes. A video group matching algorithm is used to group the different tasks and each edge node will receive the video chunks accordingly. These edge nodes will be mobile devices and will be closer to the smart camera nodes and hence the delay will be much less. There will be a centralized server that can perform other complex tasks which needn't be performed immediately and which might need a lot of computational effort. It will have immense computational capabilities.

VII. CHALLENGES

A. Camera Positioning
Positioning the camera accurately is a major difficulty while trying to use video processing techniques for analysis of traffic. This is because, it can lead to a number of issues like the angle at which the camera is tilted may affect the calibration. Sometimes multiple cameras might be needed to capture the entire frame that is needed.

B. Occlusion
There are some problems that can't even be solved under ideal circumstances. These include occlusion, where the size of the vehicle changes as it moves away from or towards the camera. This can cause a problem to the image detection algorithms.

C. Weather
Foggy weather, dim light, rain etcetera can also be major barriers while analysing the video frames. Another difficulty is that the luminescence changes throughout the day. So, it's possible that the algorithm performs differently under different levels of light.
[15] provides more details about the challenges that might be encountered due to the usage of video streams for analysis of traffic and the possible solutions.

VIII. CONCLUSION

Traffic applications based on video processing have been developed for more than 20 years, but only a few are in practical use. From this statement, we can imagine the difficulties involved in traffic processing applications. The difficulties are summarised above as challenges, but the most primary challenges faced in traffic applications is non-availability of high resolution, good quality camera feed data and there are many scenarios that can occur in road traffic thus toughening the process of obtaining good results.

This paper attempts to provide a concise summary of video processing techniques for real-time traffic applications. It briefly brings out the inherent challenges involved in such processing applications. It surveys other related works to identify its shortcomings and then propose solutions that overcome such limitations. Mainly, the paper discusses on speed detection, helmet detection and the usage of edge computing. The implementation for the proposed frameworks and methodologies is underway and will be carried out in the future.

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