VEHICLE SPEED ESTIMATION IN NIGHT TIME USING HEADLIGHT INFORMATION

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ABSTRACT

This paper presents an automatic traffic surveillance system to compute the speed of the vehicle externally using vehicles headlight information. The existing methods concentrate on the day time traffic whereas the proposed system concentrates on night time traffic and it involves headlight detection, headlight tracking and pairing and camera calibration and vehicle speed estimation. Initially the vehicles headlights are detected using reflection intensity map and reflection suppressed map. The detected headlights are then tracked and paired using bidirectional reasoning algorithm. Finally, the trajectory of the vehicles headlight is employed to compute the vehicles speed. The proposed method is more robust and accurately estimates the vehicles speed using the trajectory angle of the vehicles headlight.

Keywords: Calibration, Reflection Intensity Map, Reflection Suppressed Map, Traffic Surveillance

I INTRODUCTION

In this technical world, vision based traffic surveillance system extract useful and accurate traffic information for traffic flow control such as vehicle count, vehicle speed and vehicle classification. In traffic roads, government takes extra effort in installing cameras for finding various data like number of vehicles passing through the road, number of pedestrians walking along the road etc. However, most of the existing methods concentrate on traffic monitoring in the daytime and few works on the issue of night time traffic monitoring.

The daytime traffic monitoring system exploits the greyscale, color and motion information so that the vehicles are commonly detected and analyzed. But under the night time traffic environment, these information's become invalid and the vehicles can only be observed by its headlight and rear light. Furthermore, there are strong reflections on the roads surface during night time which complicate the problem. This paper is a night time traffic monitoring system which concentrates on the night time traffic. Here we are mainly focusing on vehicles headlight because vehicles headlight possesses high intensity during night time. The headlight can correctly be discriminated from reflection on the road surface by using the proposed reflection intensity map and reflection suppressed map. The headlights are then tracked and paired and the speed of the vehicle can be calculated.

The proposed system is a novel approach for vehicle headlight detection, tracking and pairing and vehicle speed estimation. The two features for vehicle headlight detection are reflection intensity map and reflection suppressed map based on the light attenuation model. The detected headlight is then tracked and paired using effective bidirectional reasoning algorithm by incorporating the size, position vanishing point and motion information.

Finally, the trajectory of vehicles headlight is employed to calibrate the surveillance camera and estimates the vehicle's speed.

II RELATED WORK

Many works have been put forward in the literature for night time traffic surveillance.

- Wei Zhang et al.[5] proposed a nighttime traffic surveillance system, which consists of headlight detection, headlight tracking and pairing, and camera calibration and vehicle speed estimation. Headlight detection is done by using light attenuation model. Here, Bidirectional reasoning algorithm has been designed to detect and track the vehicle. The trajectory of the vehicle's headlight is employed to calibrate the surveillance camera, and the vehicles' speed is subsequently estimated. The disadvantage of this system is when one headlight of the vehicle is occluded by other vehicles it cannot be paired with other headlights.
- Yen-Lin Chen et al.[6] proposed night-time vehicle detection and tracking system for identifying and classifying moving vehicles for traffic surveillance. Here, multilevel thresholding is used to extract the bright objects (lightening) from greyscale images. Vehicle and non-vehicle illuminating objects are separated by Spatial Classification. Tracking of a vehicle can be done with the motion relation of vehicle components in succeeding frames by analyzing their spatial and temporal features. Identification of a vehicle can be done by assuming a group of lightening components. The disadvantage of this system is it can identify only car and motorbikes. It fails to detect and track other vehicles.
- Ronan O'Malley et al.[4] proposed a system to detect and track vehicle rear-lamp pairs in forward-facing color video. A standard low-cost camera with a complementary metal–oxide semiconductor (CMOS) sensor and Bayer red–green–blue (RGB) color filter is used and could be utilized for full-color image display or other color image processing applications. Rear-facing lamps are segmented from low-exposure forward-facing color video using a red-color threshold. Lamps are paired using color cross-correlation symmetry analysis and tracked using Kalman filtering. The drawback of this system is it fails to detect target vehicles that were greater than 50 m away due to lack of intensity or insufficient resolution of vehicles.
- Robert.k et al.[3], proposed a system to detect, classify and track multiple vehicles at night time. Vehicle is detected on detecting its two headlights. Small bright blobs at large bright blob near the top of image corresponds to headlight. White top hat transforms discards the regions that are too small correspond to headlight. Then it seeks clues of vehicle presence through decision tree. The detected vehicles are then tracked over frames. The disadvantage of this system is not able to detect the vehicles headlight if there may be strong reflections on road surface.
- Rita Cucchiara et al.[2] proposed a system to detect vehicles in urban traffic scenes by means of rule-based reasoning on visual data. It extracts the visual data under various illumination conditions. The image-processing modules used here is to extract the visual data from the scene by spatiotemporal analysis during daytime, and by morphological analysis of headlights at night. A moving object is classified and labeled as a vehicle if its size (in pixels) is in accordance with an initial scene calibration. It can perform tracking over 24 hours in the daytime by using spatiotemporal analysis of moving

templates is performed, while at night, morphological analysis of headlight pairs is used to identify vehicles.

- Jien Kato et al [1] a car tracker based on a Hidden Markov model /Markov random field (HMM/MRF) based segmentation method that is capable of classifying each small region of an image into three different categories: vehicles, shadows of vehicles, and background from a traffic-monitoring movie. The temporal continuity of the different categories for one small region location is modeled as a single HMM along the time axis, independently of the neighboring regions. The disadvantage of this system is in an illumination conditions or traffic density change a lot, the HMM parameters need to be updated to fit into the new situation.

III PROPOSED SCHEME

Proposed system is to compute the speed of the vehicle during night time by detecting its headlight, tracking and pairing of headlight, and vehicle speed estimation. To detect the vehicle's headlight, the reflection intensity map and the reflection suppressed map must be obtained. The reflection intensity map.

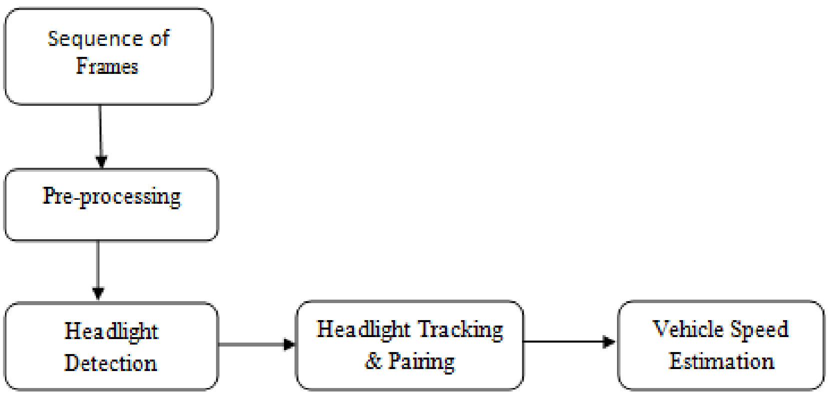

Fig 1: Proposed Model

3.1 Preprocessing

Image pre-processing is the technique of enhancing data images prior to computational processing. Pre-processing images commonly involves removing low-frequency background noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images. Image pre-processing is the technique of enhancing data images prior to computational processing. Mostly night time traffic images have Gaussian noises. So it can be removed by using Laplacian of Gaussian (LoG) filter.

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection (see zero crossing edge detectors). The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian smoothing filter in order to reduce its sensitivity to noise, and hence the two variants will be described together here. The operator normally takes a single gray level image as input and produces another gray level image as output. Figure 1 shows the 2-D Laplacian of Gaussian function. The 2-D LoG function centered on zero and with Gaussian standard deviation σ has the form:

$$G(u,v)=\frac{u^2+v^2-2\sigma^2}{\sigma^4}\exp\left(\frac{u^2+v^2}{2\sigma^2}\right) \qquad (1)$$

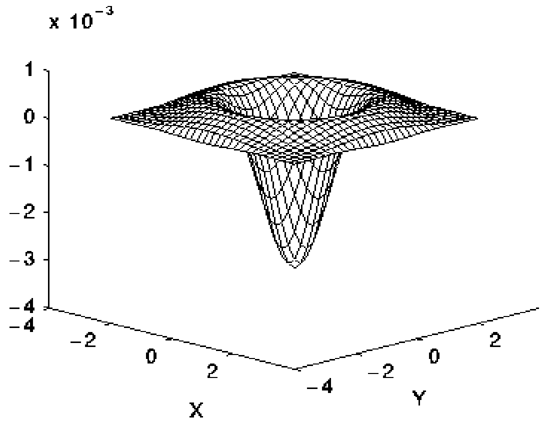

Figure 2: The 2-D Laplacian of Gaussian (LoG) function. The *x* and *y* axes are marked in standard deviations (σ).

3.2 Headlight Detection

A vehicle headlight is detected using a Reflection Intensity (RI) map and a Reflection Suppressed (RS) map and it is incorporated in Markov Random Field (MRF) based on the analysis of the light attenuation model. Light from the headlight involves color at each pixel. So, each pixel intensity value has to be calculated.

RI is obtained by analyzing the attenuation model in the neighboring region.

$$RI(x,y)=|MI^{e}_{x,y}-MA^{e}_{x,y}.\gamma(x,y).\exp(-\in^{e}_{x,v})| \qquad (2)$$

Reflection suppressed map can be find out by using a LoG (Laplacian of Gaussian) filter is used to obtain the reflection suppressed map.

RS is obtained from Laplacian of Gaussian (LoG) filter

$$G(u,v)=\frac{u^2+v^2-2\sigma^2}{\sigma^4}\exp\left(-\frac{u^2+v^2}{2\sigma^2}\right) \qquad (3)$$

Where σ is the standard deviation. G is normalized to obtain a unity maximum value, and let the results be G = G/Max (G). According to the atmospheric scattering model the intensity of the light source decreases in an exponential manner, by the intensity along the diameter of the light source.

When the LoG filter is applied on the image, a high value can be obtained in the exponentially decreasing regions around the headlight, whereas a negative value can be obtained in the light source region because of the negative value in the center of the LoG filter.

Vehicle's headlight can be detected by incorporating the RI, RS, and I into the MRF framework to detect the vehicle headlight, and the MRF am optimized by using the ICM algorithm.

$$P(f_k \mid \Omega_k = \beta) = \frac{1}{\sigma_\beta \sqrt{2\pi}} \exp\left(-\frac{-f_k - \mu_\beta)^2}{2\beta_\beta^2} \right) \quad (4)$$

Ω is initialized as a random label.

The label for each pixel in Ωk is updated by the value that maximizes $P(f_k \mid \Omega_k) p(\Omega_k)$.

For the every iteration of ICM, parameters $\mu_\alpha, \mu_\beta, \sigma_\alpha, \sigma_\beta$ are updated as follows.

$$\mu_\alpha = M(f_k \mid \Omega_k = \alpha); \quad \mu_\beta = M(f_k \mid \Omega_k = \beta);$$

$$\sigma_\alpha = D(f_k \mid \Omega_k = \alpha); \quad \sigma_\beta = D(f_k \mid \Omega_k = \beta); \quad (5)$$

Where M represents the mean value operation and D represents the standard deviation operation. Repeat steps b) and c) until the change in Ω between two iterations is less than 1%.

3.4 Tracking And Pairing Of Headlight

Tracking and pairing can be done by using Bidirectional Reasoning algorithm. For this, first vanishing point has to be detected. A vanishing point is one of possibly several points in a 2D image where lines that are parallel in the 3D source converge. Vanishing points can also refer to the point in the distance where the two verges of a road appear to converge. This is often used to help assess the upcoming curves in the road. If the vanishing point moves towards you or to your sides, the curve is tightening. If the vanishing point moves away from you or comes to center, the curve is straightening. It can be detected by using Hough Transform. Let the centroid and size of the headlight be Hn be (Ci,x, C i,y) and An,i , respectively. Hni and Hn− 1,j are considered as the same headlight object if the following condition is satisfied:

$$|A_i - A_j| < \nu_{A,1}$$

$$\lambda_{n-1,j} < \nu_{C,1}$$

$$\lambda_{n-1,j} = [(C_{i,x}, C_{j,x})^2 + (C_{i,y}, C_{j,y})^2] \quad (6)$$

Where νA,1 controls the area difference, and $\nu_{C,1}$ controls the centroid distance. A trajectory image is maintained by connecting the centroid of headlights that are tracked. We exploit Hough transform to extract the straight lines in the resultant, and the vanishing point along lane is computed as the intersection of these straight lines. Let it be (ξ1,

The Hough transform is a feature extraction technique used in analysis, computer, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. It can be detected by computing the centroid distance and the area difference between the two headlights. As one vehicle commonly has two headlights, therefore, it is necessary to pair each headlight with other headlights in the same frame. The symmetry of the headlights may not be valid because of the detection accuracy. The two headlights $H_{n\ i}$ and $H_{n\ j}$ are paired as belonging to the same vehicle based on their size and centroid distance if the following conditions are satisfied:

$$|A_i - A_j| < \nu_{A,2}$$

$$\lambda_{n-1,j} < \nu_{C,3}$$

$$\lambda_{n-1,j} = [(C_{i,x}, C_{j,x})^2 + (C_{i,y}, C_{j,y})^2] \quad (7)$$

Where $vA,2$ controls the area difference between the paired headlights, and $vC,3$ controls the centroid distance between them. For each headlight pair, we can obtain a straight line.

Since short lines may produce a large error, therefore, the straight lines whose lengths are more than l are selected, and the intersection of the entire detected headlight pairs are computed as the vanishing point vertical to the lane; let it be ($\xi 2$, $\eta 2$). Calculate the intersection for both lines. Now consider the centroid distance, the area change, and the vanishing point deviation to track headlights and apply in bidirectional reasoning algorithm. For the area change between headlight $H_{n,i}$ and $H_{n-1,j}$, we define their area ratio $\Phi^{n,i}_{n-1,j}$ as

$$\Phi^{n,i}_{n-1,j} = \frac{Min(Ai - Aj)}{Max(Ai - Aj)} \quad (8)$$

The vanishing point deviation is defined as the distance between the centroid of $H_{n-1,j}$ and the line connecting ($\xi 1$, $\eta 1$) and the centroid of H_i. Let it be $\Theta[(\xi 1, \eta 1)/(C_{i,x}, C_{i,y}), (C_{j,x}, C_{j,y})]$. Now apply a bidirectional manner and associate $H_{n\ i}$ and $H_{n-1,\ j}$ as the same headlight if they both have the minimum distance to each other, i.e.,

$$D_{i,j} = \text{Min}\,(D_{i,1}, D_{i,2}, \ldots, D_{i,k-1})$$

$$D_{i,j} = \text{Min}\,(D_{1,j}, D_{2,j}, \ldots, D_{k-1,j}) \quad (9)$$

For the two headlights of the same vehicle, the distance between their centroid should not be too large or too small with respect to the headlight's area $A_{ni.}$

3.5 Vehicle Speed Estimation

The speed of the vehicle in each frame is calculated using the position of the vehicle in each frame, so the next step is to find out the blobs bounding box, and the centroid. The blob centroid is important to understand the distance of the vehicle moving in consecutive frames and therefore as the frame rate of captured moves is known, the calculation of the speed become possible. This information must be recorded consecutively into an array cell in the same size as the captured camera image because the distance moved by the centroid is needed which is a pixel with a specific coordinate in the image to find out the vehicle speed

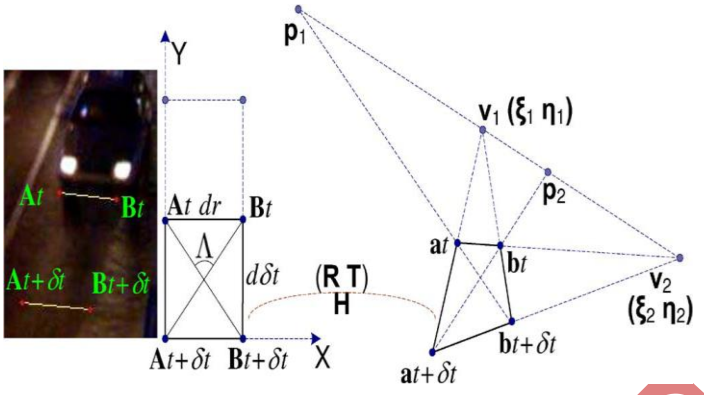

Figure 3: Trajection of the Headlight

Speed of the vehicle is computed by exploiting the trajectories of the headlight pairs. Under perspective projection, a 3-D point X in space is projected to an image point m via a rank-3 projection matrix as follows:

$$s1m = PX = K[R, t]X \qquad (10)$$

IV CONCLUSION

The proposed night time traffic surveillance system consists of headlight detection, headlight tracking and pairing, and vehicle speed estimation. First, vehicle headlight is detected by using reflection intensity map and reflection suppressed map based on the analysis of light attenuation model. Second, the headlight is tracked and paired by utilizing the bidirectional reasoning algorithm. Third, the trajectory of the vehicle's headlight is employed to calibrate the surveillance camera, and the vehicles' speed is subsequently estimated.. In comparison with state-of-the-art methods, the proposed method is simple and can detect the vehicle headlight robustly in the presence of strong reflection. Furthermore, the problem of headlight tracking and pairing and speed computing are combined and jointly considered in the proposed method.

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