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Vehicle Speed Computation in Night Scenes using Headlight Tracking and Pairing

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Abstract

This paper presents a method for computing vehicle speed at night scenes by tracking the motion of the vehicle through sequence of images. Headlight of the vehicle can be detected by extracting two features namely reflection intensity map and reflection suppressed map. This feature extraction is mainly done for discriminating the headlight from the reflection on the road surface. The reflection intensity map is obtained by analyzing the light attenuation model in the neighboring region, whereas the reflection suppressed map is obtained by using a Laplacian of Gaussian (LoG) filter. By incorporating the grayscale intensity, the reflection intensity map, and the reflection suppressed map into a Markov Random Field (MRF) image work, which is optimized using the Iterated Conditional Mode (ICM) algorithm the headlight of the vehicle can be detected. The headlight is tracked and paired using a bidirectional reasoning algorithm by incorporating the size, position, fading points, and motion information. Finally, the path of the vehicle's headlight is employed to compute the vehicle's speed. Experimental results show that the proposed method can robustly detect and pair the vehicle headlight in night scenes.

Keywords --- Vehicle headlight detection, reflection intensity map, reflection suppressed map, vehicle headlight tracking and pairing, Laplacian of Gaussian Noise

1. Introduction

A higher speed increases the likelihood of an accident. Very strong relationships have been established between speed and accident risk. The rate of increase in accident risk varies with initial speed level and road type. So, in order to avoid this, it is better to calculate the vehicle's speed externally by using a surveillance camera. In daytime traffic monitoring systems, vehicles are commonly detected and analyzed by exploiting the grayscale, color, and motion information. Traditionally, vehicle speed detection or surveillance was obtained using radar technology, particularly radar detector and radar gun. Night vision technology, by definition it literally allows one to see in the dark. Originally developed for armed forces, it has provided the United States with a strategic military advantage, the value of which can be measured in lives. Federal and state agencies now routinely utilize the technology for site security, surveillance as well as search and rescue. Night vision equipment has evolved from bulky ocular instruments in light weight goggles through the advancement of image intensification technology.

2. Objectives

- To detect vehicle headlight using a reflection intensity map and a reflection suppressed map.
- To track and pair vehicle headlight using bidirectional reasoning algorithm.
- To compute and estimate the speed of vehicle during night time by detecting, tracking & pairing of headlight.

3. Materials and Methods

3.1 Materials

MATLAB Tool

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. Developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms. MATLAB is a high-performance language for technical computing. It integrates computation, programming and visualization in a user-friendly environment where problems and solutions are expressed in an easy-to-understand mathematical notation.

MATLAB does not require any type declarations or dimension statements. When a new variable name is introduced, it automatically creates the variable and allocates the appropriate amount of memory. If the variable already exists, Matlab changes its contents and, if necessary, allocates new storage. MATLAB (matrix laboratory) is a numerical computing environment and fourth-generation programming language. It allows implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran. MATLAB was mainly designed to deal with matrices. Comparison can be done using MATLAB R2009b on a Pentium Dual Processor –2.70 GHz personal computer platform with 2 GB memory for illustrative purposes.

MATLAB and the Image Processing Toolbox provide a wide range of advanced image processing functions and interactive tools for enhancing and analyzing digital images. The interactive tools allowed us to perform spatial image transformations, morphological operations such as edge detection and noise removal, region-of-interest processing, filtering. Making graphics objects semi-transparent is a useful technique in 3-D visualization which furnishes more information about spatial relationships of different structures. The toolbox functions implemented in the open MATLAB language has also been used to develop the customized algorithms.

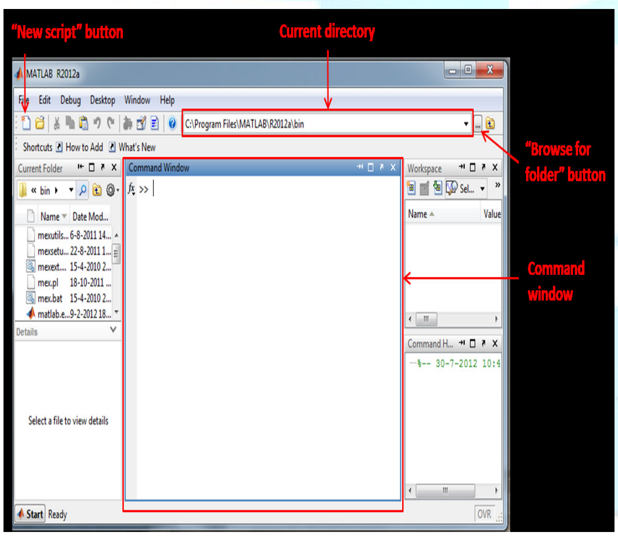

Fig 3.1: Organisation of the MATLAb window

3.2 *Methods*

- Module 1 : Preprocessing
- Module 2 : Headlight detection
- Module 3 : Headlight tracking and pairing
- Module 4 : Vehicle speed estimation

3.3 *Functional architecture*

Functional architecture is an architectural model that identifies the functions and their interactions for the corresponding system needs. It serves as a bridge between the software engineers and the architects. The system gets the sequence of images as input and it removes the low frequency background noise, removing reflections, and masking portions of images by pre-processing the image. The vehicle headlight is detected using a reflection intensity map and a reflection suppressed map based on the analysis of the light attenuation model. The detected headlight can be tracked and paired by bidirectional reasoning algorithm. The trajectories of the vehicles headlight are employed compute the speed of the vehicle. Figure 3.2 shows the functional architecture of the proposed system.

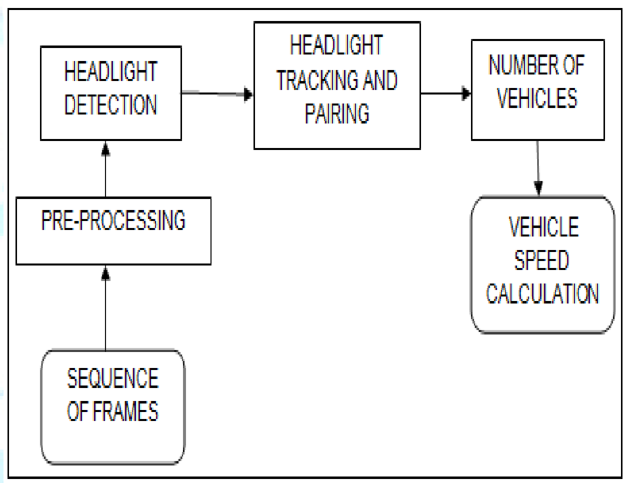

Fig 3.2: Functional Architecture of the System

The system consists of various processes like preprocessing the image, headlight detection, 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 is obtained by analyzing the light attenuation model in the neighboring region, whereas the reflection suppressed map is obtained by using a Laplacian of Gaussian (LoG) filter. By incorporating the grayscale intensity, the reflection intensity map, and the reflection suppressed map into a Markov Random Field (MRF) imagework, which is optimized using the Iterated Conditional Mode (ICM) algorithm the headlight can be detected. The detected headlight is tracked and paired

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using a bidirectional reasoning algorithm by incorporating the size, position, fading points, and motion information. Finally, the Path of the vehicle's headlight is employed to compute the speed of the vehicle. Figure: 3.2 shows the flow chart for the proposed system

4. Results and Discussion

4.1 Simulation Results

The following results are obtained from the proposed system using MATLAB

Image pre-processing is the technique of enhancing data images prior to computational processing. 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 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.

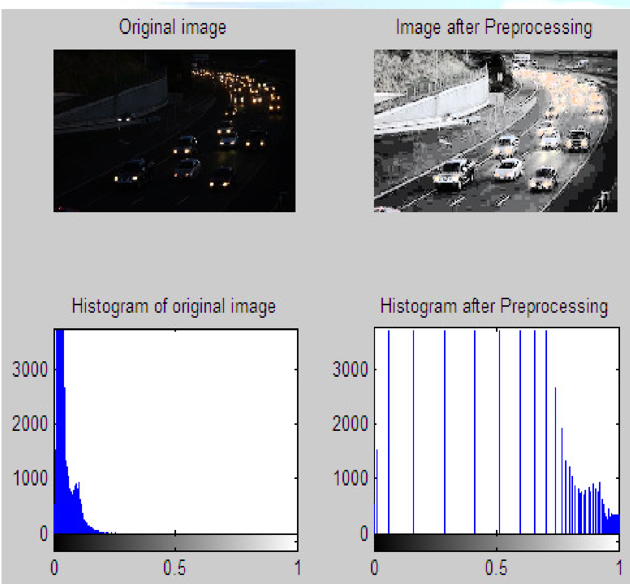

Fig 4.1 Filtered color Image

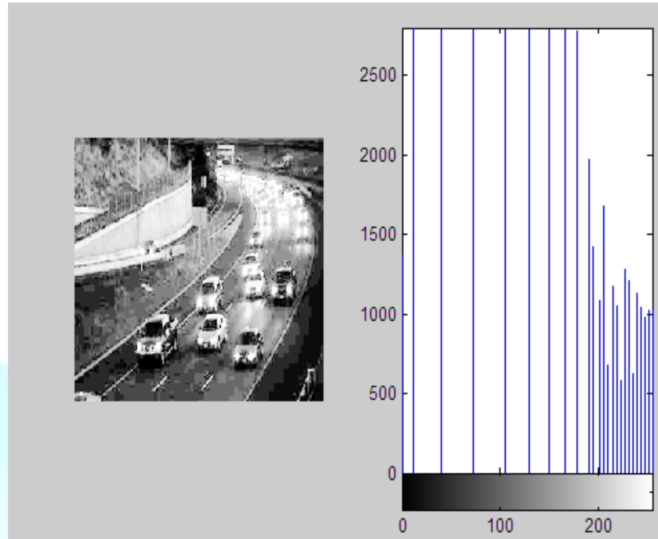

Fig 4.2: Filtered greyscale Image

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. Vehicle's headlight can be detected by incorporating the RI, RS, and I into the MRF imagework to detect the vehicle headlight, and the MRF is optimized by using the ICM algorithm. Figure 4.3 shows the snapshot for Headlight Detection.

Fig 4.3: Headlight detection

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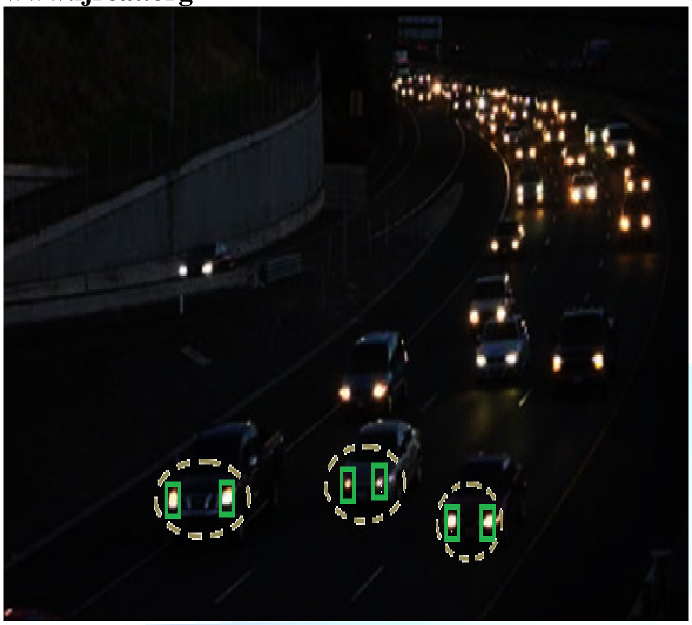

Fig 4.4: Headlight Tracking and pairing

Tracking and pairing can be done by using Bidirectional Reasoning algorithm. For this, first vanishing point has to be detected. It can be detected by using Hough Transform. 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. Figure 4.4 shows the tracking and pairing of headlight.

4.2 Performance Analysis

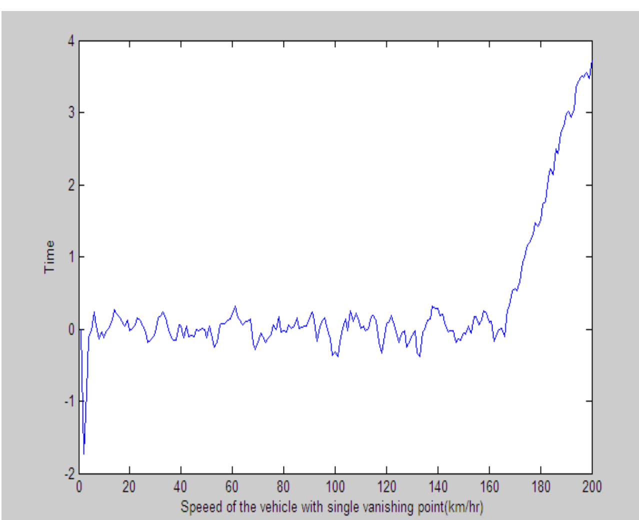

Fig 4.5: Vehicle speed estimation

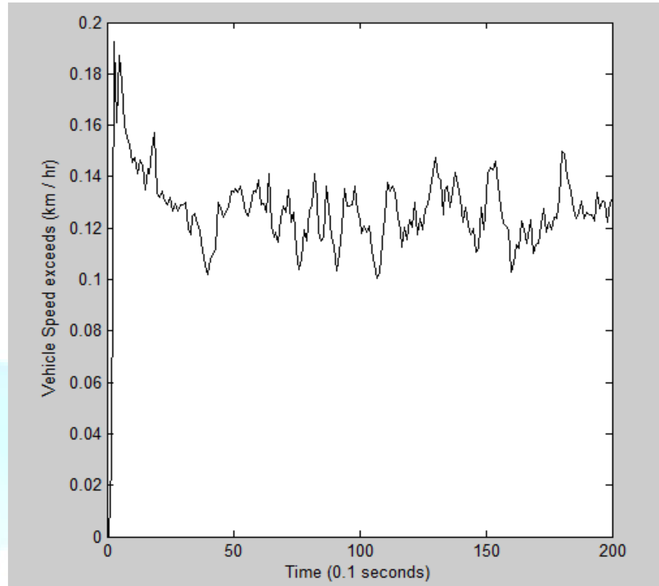

Fig 4.6: Vehicle over speed estimation

The speed of the vehicle in each image is calculated using the position of the vehicle in each image. The next step is to find out the centroid and bounding box of the blob. The centroid of the blob is essential to understand the distance of the vehicle moving in consecutive images and therefore as the image rate of captured moves is recognized, the calculation of the vehicle speed becomes possible. This information must be recorded accordingly 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 4.5 and Figure 4.6 shows the snapshot for vehicle speed estimation and vehicle over speed estimation.

5. Conclusion

In this thesis, a night time traffic monitoring system is suggested for detecting the headlights, pairing the headlights and estimating the speed of the vehicles. The proposed system consists of headlight detection, headlight tracking and pairing, and vehicle speed estimation. Vehicle headlight is detected by using reflection intensity map and reflection suppressed map based on the analysis of light attenuation model. Then the headlight tracking and pairing is done by utilizing the bidirectional reasoning algorithm. The path of the vehicle's headlight is employed to attune the camera, and the vehicles' speed is then computed. Experimental results on typical scenes show the efficiency of the proposed method on headlight detection, tracking, and pairing. The proposed method is simple and can detect the vehicle headlight robustly in the presence of strong reflection. Thus, the problem of headlight tracking and pairing and speed computing are combined and jointly considered in the proposed method.

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