International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 5, August 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Shadow Detection and Removal for Traffic Surveillance System

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How to cite this paper: Aye Aye Win "Shadow Detection and Removal for Traffic Surveillance System" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.1471-1474, **https://doi.org/10.31142/ijtsrd26732**

IJTSRD26732

ABSTRACT

Shadow detection and removal is an important task when dealing with outdoor images. Detection of foreground objects from traffic video sequences is one of the most important parts in many computer vision applications. In traffic surveillance system, detecting vehicles require an accurate method to detect foreground objects. Background subtraction is a common method for detecting foreground objects but it is difficult to obtain pure vehicles because of shadow which is often mistaken as part of vehicles. Shadow removal is identified as a critical step for improving the accuracy of vehicle detection and tracking. This paper proposed to detect shadows by analysing the image pixel values of shadows and vehicles based on HSV color spaces and remove shadows by replacing the pixels of background image at the detected shadow region.

KEYWORDS: *HSV, traffic surveillance system, thresholding method*

1. INTRODUCTION

Many Computer applications involving video segments require detecting and tracking moving objects. Vehicle shadow and superposition have a great influence on the accuracy of vehicle detection in traffic video or image sequences. Shadows and shadings in images occur when objects occlude light from a light source and they appear as surface features. Generally, the cast shadows would be detected as foreground objects since the shadows share the same movement patterns and have a similar magnitude of intensity change as that of the foreground objects.

Therefore, it may take into account as moving object, mistakenly .Shadow is considered as an obtrusive factor that causes serious problems such as erroneous object recognition and tracking, disorder segmentation of moving objects, object shape distortion, false object detection, object missing and object merging, which has a bad impact on object detection and tracking. Therefore, shadow elimination is a critical issue for improving moving foreground objects detection and tracking.

A lot of research has been performed to detect and remove shadows. Most researches [2,4,5] are focused on modeling the differences in color, intensity, and texture of neighboring pixels or regions. Peiwen et al. [1] proposed a method which used illumination-invariant image with the original color image to locate the shadow edges. Bangyu et al. [3] proposed a method to detect vague shadows in an image using derivatives of the input image. The hard shadows were detected using color invariant image. However, they could not identify soft shadows properly. In this method, a shadow-free image was reconstructed by reintegration using Poisson equation.

The aim of the proposed system is to detect shadows by analyzing the image pixel values of shadows and vehicles based on HSV color spaces and remove shadows by replacing the pixels of background image at the detected shadow region. The rest of this paper is organized as follows. In section 2, framework of shadow detection and removal system is discussed. Then, the related methodologies are described in section 3 and analyzing the experimental results are described in section 4.

2. Framework of shadow detection and removal system

Block diagram of the process of shadow detection and removal system are shown in figure 1. That described the fundamental step of shadow detection and removal for traffic surveillance system.

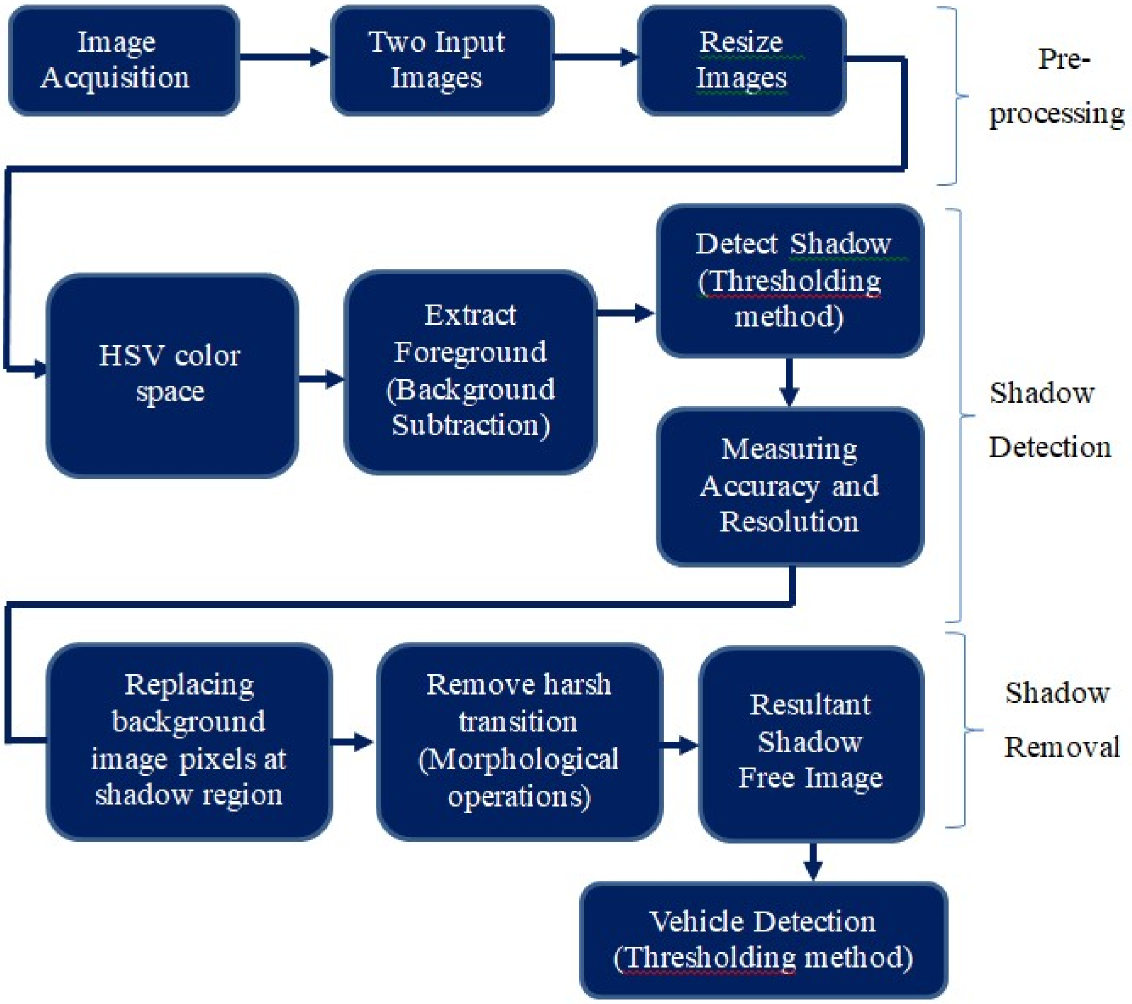

Figure1. Framework of proposed system

The entire system is implemented with two input images such as current traffic image which contains vehicles with shadows and background image. At the pre-processing stage, the input images are resized. In the shadow detection stage, HSV color spaces are introduced for efficient and reliable detection of cast shadows.

Firstly, current image which contains vehicles with shadows and background image are converted to HSV color spaces since these color features are selected due to their remarkable difference between the shadows, background and object pixels. Secondly, the traffic current image is subtracted from the background image to extract foreground including shadow. After getting foreground, shadows are detected in HSV color spaces based on thresholding method by analysing the image pixel values of shadows and vehicles. In the shadow removal stage, shadows are removed by replacing the pixels of background image. In the shadow free image, there is still a harsh transition between vehicle and the parts of replacing the background image pixels which is shadow region before. Therefore, shadow free image with harsh transition is converted into binary image to remove the harsh transition by using morphological operations. Finally, vehicle is accurately detected from shadow free image by using thresholding method.

3. Methodologies

In this section expressed the concept of HSV color space model and the thresholding method for shadow detection and removal in HSV color space model.

3.1. HSV color space

HSV color space separates color into three components, hue, saturation, and value. It is also known as HSB (Hue, Saturation, and Brightness). HSV color space [6, 7] matches people's visual feeling better than RGB and other color spaces. It is one of the color space transforms that separate color from intensity. The intensity of shadow region is lower than that of object region, and the HSV color model can reflect this problem well since the value (V) is a direct measure of intensity. RGB Space to HSV Space Transformation equations:

The hue component is given by

$$H = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}}\right\} \quad (1)$$

The saturation component is given by

$$S = 1-\frac{3}{(R+G+B)}[\min(R,G,B)] \quad (2)$$

The intensity and value component is given by

$$V = \frac{1}{3}(R+G+B) \quad (3)$$

3.2. Thresholding Method for Shadow Detection in HSV Color Space

Shadow pixels do not change its hue compared with objects' region pixels in HSV color space. Since shadows affect only saturation and intensity values, intensity values are significantly decrease in shadow regions and saturation values of shadows region is also lower than that of object's region .Therefore, we do not consider the hue(H)value and we only considering saturation(S) and intensity(V) values to determine whether the pixel is a shadow pixel or not. So, thresholding method can be used to separate shadows from foreground region by analyzing the image pixels values of shadows and vehicles based on HSV color features. Due to my experimental dataset's results, most shadow regions' intensity (V) values are always less than average value of intensity channel and also greater than half-average value of intensity channel. Moreover, saturation (S) values of shadow region are one third maximum value of saturation channel. Therefore, we identify to determine that pixel is a shadow pixel if its intensity values are into the range between half-average value and average value of intensity channel and its saturation values are less than one -third maximum value of saturation channel.

- Shadow regions' intensity values are always less than average value and greater than half-average value of intensity (V) channel.
- Shadow regions' saturation values are always less than one-third maximum value of saturation(S) channel.

Shadow Detection Condition $=F\_V < avg\_V \;\&\&\; F\_V > avg\_V/2 \;\&\&\; F\_S < max\_S/3$

Where, avg_V = Average value of Intensity channel
max_S= Maximum value of Saturation channel
F_V = Intensity value of Foreground
F_S = Saturation value of Foreground

4. Experimental results and analysis

Two input images are needed such as original image and background image as shown in Figure 2 and 3. After taking the background and current image, it is necessary convert RGB to HSV. HSV color space represents hue, saturation and intensity values. It can separate intensity from color information. It is used for shadow detection and also used to select various different colors needed for generating high quality computer graphics. The result of HSV images can be seen in Figure 4 and 5.

Figure2. Background image

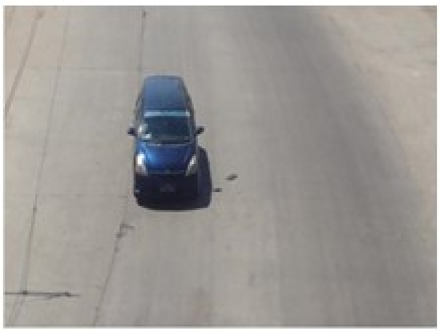

Figure3. Original image

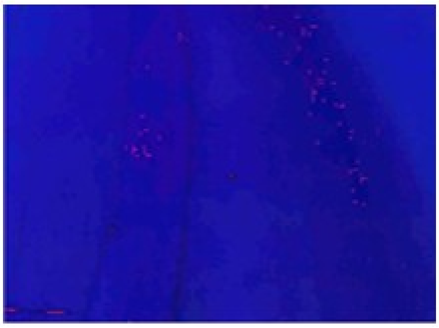

Figure4. Background HSV

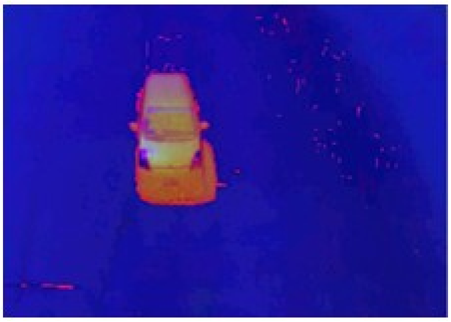

Figure5. Original HSV

Background image is subtracted from original image. After that, foreground including shadow is extracted. After we get foreground HSV image, we need to detect shadow. Shadows are sometimes as big as vehicles. Shadow is detected by Auto Thresholding method. Shadow detection is shown in Figure6.

In the shadow removal stage, shadows are removed by replacing the pixels of background image. In the shadow free image, there is still a harsh transition between vehicle and the parts of replacing the background image pixels which is shadow region before. Therefore, shadow free image with harsh transition is converted into binary image to remove the harsh transition by using morphological operations. Finally, vehicle is accurately detected from shadow free image by using thresholding method. The result of shadow removal is shown in figure 7.

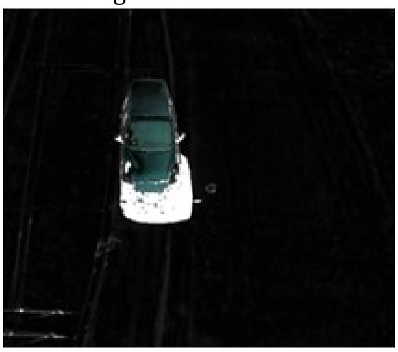

Figure6. Shadow detection

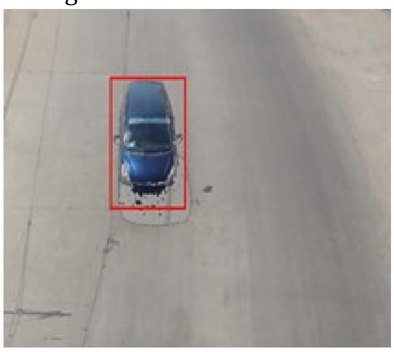

Figure7. Shadow removal

Table1. Comparison of shadow detection and removal rate

Methodology	Shadow Detection Rate	Shadow Removal Rate
Deterministic Nonmodel-Based (DNM) Method by Rita. Cucchiara, Costantino. Grana, M. Piccardi, Andrea Prati and Stefano Sirotti	86.8%	82.5%
Proposed Method	96.3%	85.9%

Table 1 showed the analysis of shadow detection and removal rate which results are compared with other related work and proposed system. This table revealed that proposed model achieved higher accuracy for shadow detection and removal rate than other methods. The proposed shadow removal rate is not too much differing with other related works.

5. Conclusion

This paper revealed that shadow detection is done by analyzing the image pixel values of shadows and vehicles based on HSV color spaces and remove shadows by replacing the pixels of background image at the detected shadow region. According to the result of shadow detection by using HSV color space, it achieves higher shadow detection rate since windshields of vehicles which have dark color are hardly misclassified as shadows. It can robust to illuminate variation since hue component makes algorithms less sensitive to lightning conditions. The advantage of this method is the shape of the defects is thin and sharp. The limitations of this system are large variety of fabric surfaces has not to be examined, the defects may take different forms that are difficult to classify and fabric image with defect is detected as defect-free image when background and foreground color are same.

6. References

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