

Comparison of Shadow Detection based on HSV and YCbCr Color Space

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Abstract - The shadow detection of moving vehicle is a prominent task for all system of vision by computer. Therefore, this study is analyzed the image pixel values of shadows and vehicles based on HSV and YCbCr color spaces and is compared these two color models for getting higher shadow detection rate. The HSV and YCbCr color spaces are evaluated by Thresholding Method using the MATLAB programming. The foreground and background objects are detected by using HSV and YCbCr Color Space. According to the result, The HSV color Space is detected shadows more effectively than YCbCr even though applying auto Thresholding Method in both color spaces.

Keywords - Shadow Detection, HSV, YCbCr Color Space.

I. INTRODUCTION

Shadow detection over the past decades covers many specific applications such as traffic surveillance, face recognition and image segmentation. Object shadow detection has been an active field of research for several decades. Most researches focus on providing a general method for arbitrary scene images and thereby obtaining “visually pleasing” shadow free images. In general, shadows can be divided into two major classes: Self shadow and Cast shadow. A self-shadow occurs in the portion of an object that is not illuminated by direct light.

A cast shadow is the area projected by the object in the direction of direct light. Fig.1 shows some examples of different kinds of shadows in images [1-5]. Cast shadows can be further classified into umbra and penumbra region, which is a result of multi-lighting and self-shadows also have many sub-regions such as shading and inter-reflection.

Usually, the self-shadow are vague shadows and do not have clear boundaries. On the other hand, cast shadows are hard shadows and always have a violent contrast to background. Because of these different properties, algorithms to handle these two kinds of shadows are different. For instance, algorithms to tackle shadows cast by buildings and vehicles in traffic systems could not deal with the attached shadows on a human face.

In this study, the shadow detection of traffic image which contain dark objects and low intensity pixels is improved the accuracy of vehicle detection. The image pixel values of shadows and vehicles are considered in HSV and YCbCr color space by using Thresholding Method. Finally, it is to detect more effective shadow in HSV color space than YCbCr color space.

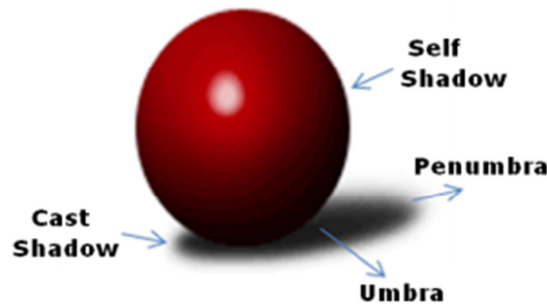


Fig 1. Types of Shadow in Image

II. PROPOSED FRAMEWORK

The block diagram of the proposed shadow detection for vehicle detection system is show in figure 2.

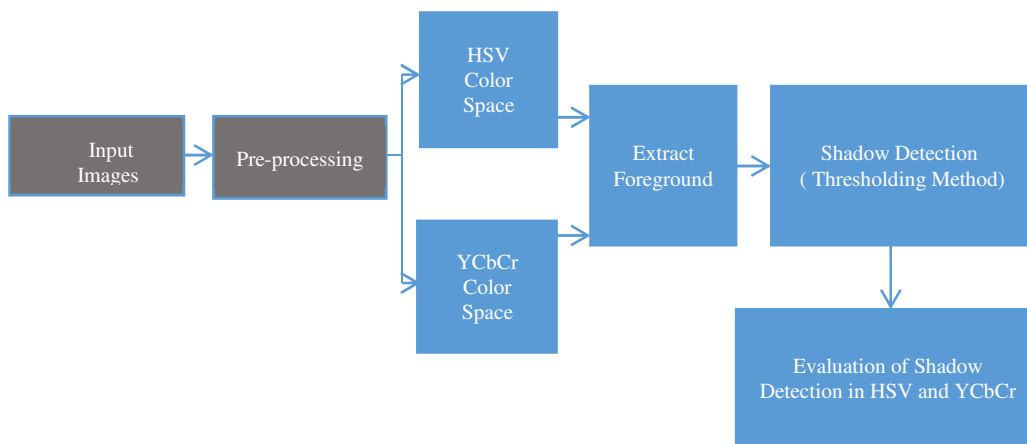


Fig 2. Block Diagram shadow detection system

In the block diagram shown in Fig 2, 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 and YCbCr color spaces are introduced and compared against each other for efficient and reliable detection of cast shadows. Firstly, current image which contains vehicles with shadows and background image are converted to HSV and YCbCr 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. Finally, after getting foreground, shadows are detected in HSV and YCbCr color

spaces based on Thresholding method by analyzing the image pixel values of shadows and vehicles.

III. METHODOLOGIES

3.1. HSV Color Space

In HSV color model, the value of hue (H) is in the range 0-360(in degrees) and saturation(S) and value (V) are in the range between 0 and 1. The hue (H) of a color refers to which pure color it resembles [9]. All tints, tones and shadows of red have the same hue. Hues are described by a number that specifies the position of the corresponding pure color on the color wheel, as a fraction between 0 and 1. The hue component makes the algorithm better immune and thus more robust to lighting variations. This feature makes it better fit in shadow detection[10]. The saturation (S) of a color describes how white the color is. In other words,

saturation indicates range of grey in color space. When the value is 0, the color is grey. When the value is 1, the color is a primary color. A faded color is due to low saturation level, which means color contains more grey. A pure red is fully saturated, with a saturation of 1; tints of red have saturation less than 1; and white has a saturation of 0. The value (V) of

a color, also called its lightness, describes how dark the color is. A value of 0 is black, with increasing lightness moving away from black. With the increase in the value, the color space brightness up and shows various colors. HSV color space is shown in Fig 3.

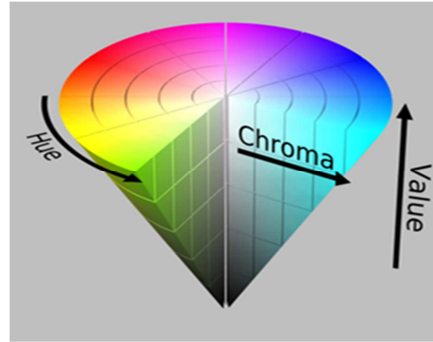


Fig 3. HSV Color Space

RGB Space to HSV Space Transformation equations:

The hue component is given by

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

The saturation component is given by

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

The intensity and value component is given by

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

3.2. YCbCr Color Space

YCbCr color space separates color into one luminance component and two chromaticity components [7,8]. Y represents luminance information; Cb and Cr represent the color information. YCbCr color space is an encoded nonlinear RGB signal. The Y-component is obtained as a weighted sum of the R, G, B components. “Cr” and “Cb” are formed by subtracting the luminance component from red and blue components respectively and multiplying the results by some weight factor. This was a good idea since luminance values for shadow regions and non-shadow regions would significantly vary from each other. Y need to be more accurate than Cb and Cr components because the human visual system is far less sensitive to errors in chromaticity than luminance; allowing for less bandwidth to be used to transmit the chromaticity information. YCbCr color space is shown in Fig 4.

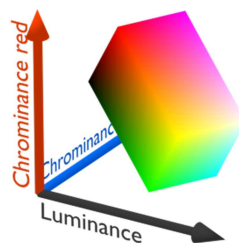


Fig 4. YCbCr Color Space

RGB Space to YCbCr Space Transformation equations:

The luminance component is given by

$$Y = 0.257*R + 0.504*G + 0.098*B + 16 \quad \text{Equation 4}$$

The chrominance blue component is given by

$$Cb = -0.148*R - 0.291*G + 0.439*B + 128 \quad \text{Equation 5}$$

The chrominance red component is given by

$$Cr = 0.439*R - 0.368*G - 0.071*B + 128 \quad \text{Equation 6}$$

3.3. Shadow Detection in HSV and YCbCr Color Space based on proposed thresholding method

Threshold is the simplest method of image segmentation. It is often used to be able to see what areas of an image consist of pixels whose values lie within a specified range, or band of intensities. The input to a threshold operation is typically a grayscale or color image. In the simplest implementation, the output is a binary image representing the segmentation. Black pixels correspond to background and white pixels correspond to the foreground.

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. In YCbCr color space, Shadow pixels do not change its chrominance blue and chrominance red compared with the corresponding background pixels. Since shadows affect only luminance values, luminance values are significantly decrease in shadow regions. Thresholding Method can be used to separate shadows from foreground region by analyzing the image pixels values of shadows and vehicles based on HSV and YCbCr color features. The performance of shadow detection system can be tested using two metrics namely shadow detection rate (η) and shadow discrimination rate (ξ):

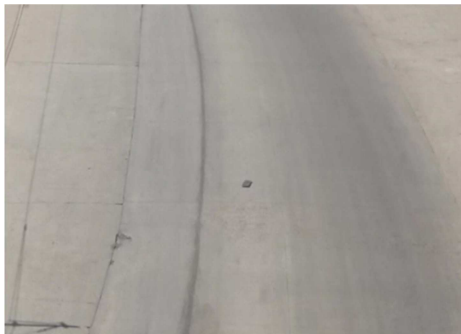
$$\text{Shadow Detection Rate } (\eta) = TP_S / (TP_S + FN_S) \quad \text{Equation(7)}$$

Shadow Discrimination Rat

$$e(\xi) = TP_F / (TP_F + FN_F) \quad \text{Equation(8)}$$

IV. RESULTS OF SHADOW DETECTION IN HSV AND YCBCR COLOR SPACE

This study is considered the ten images for shadow detection analyzing two color spaces. The example of one image detection is described in the following figures. Two input images are needed such as original image and background image as shown in Fig 5 (a), and 5 (b).



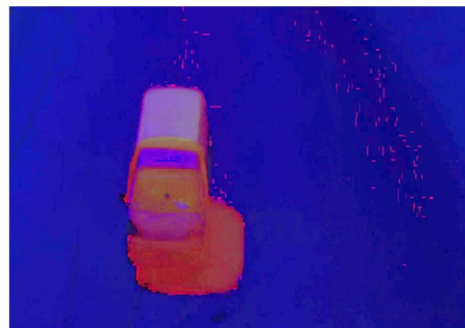
(a) Background Image 1



(b) Original Image 1



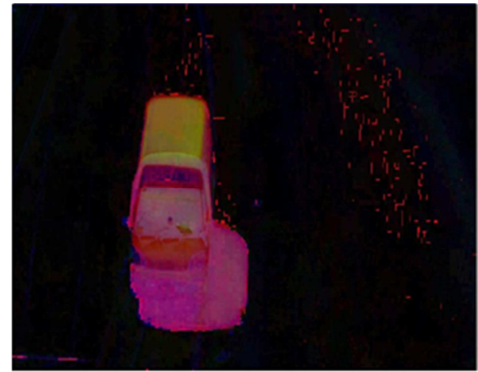
(c) Background HSV Image 1



(d) Current HSV Image 1



(e) Foreground HSV Image 1



(f) Shadow Detection for Image 1

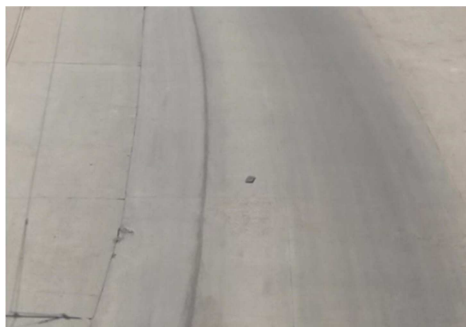
Fig 5. (a) Background Image 1, (b) Current Image 1, (c) Background HSV Image 1, (d) Current HSV Image 1, (e) Foreground HSV Image 1, and (f) Shadow Detection for Image 1

After taking the background and current image, it is necessary converted RGB to HSV. HSV color space represents hue, saturation and intensity values. It is separated 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 is shown in Fig 5(c) and 5 (d).

Background image is subtracted from original image. After that, foreground including shadow is extracted. Foreground HSV image is shown in Fig 5 (e). After getting

foreground HSV image, it is needed to detect shadow. Shadows are sometimes as big as vehicles. Shadow is detected by Auto Thresholding method. Shadow detection is shown in Fig 5 (f). Finally, vehicle is accurately detected from shadow free image by using thresholding method.

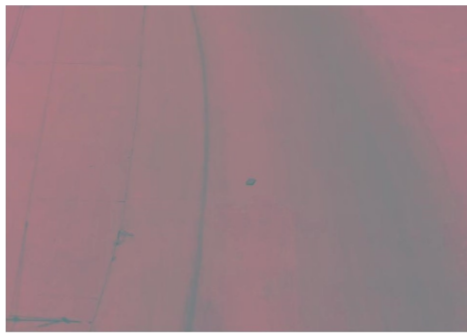
In shadow detection and removal in YCbCr color space, two input images are needed such as original image and background image as shown in Fig 6 (a) and (b). After getting input images, it is needed to convert RGB to YCbCr as shown in Fig 6 (c) and (d).



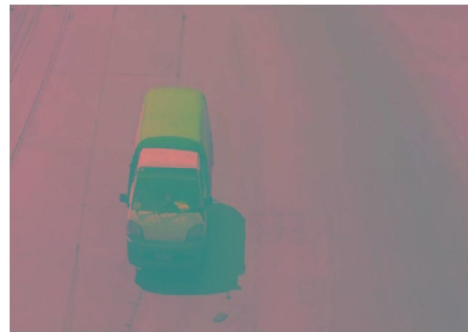
(a) Background Image 1



(b) Current Image 1



(c) Background YCbCr Image 1



(d) Current YCbCr Image 1



(e) Foreground YCbCr Image 1



(f) Shadow Detection for Image 1

Fig 6. (a) Background Image 1, (b) Current Image 1, (c) Background YCbCr Image 1, (d) Current YCbCr Image 1, (e) Foreground YCbCr Image 1, and (f) Shadow Detection for Image 1

Fig 6 (e) shows Foreground image. After getting YCbCr images, the traffic current image is subtracted from the background image to extract foreground including shadow.

Fig 6 (f) shows shadow detection image. After getting foreground, shadows are detected effectively by using auto-thresholding method based.

Table 1. Comparison of Shadow Detection Rate and Shadow Discrimination Rate for Two Color Spaces (Ten Images)

Image	Shadow Detection Rate or Accuracy (HSV)	Shadow Discrimination Rate or Resolution (HSV)	Shadow Detection Rate or Accuracy (YCbCr)	Shadow Discrimination Rate or Resolution (YCbCr)
1	96.7%	85.2%	92.5%	73.2%
2	95.7%	85.1%	91.4%	73.3%
3	97.1%	85.7%	92.1%	71.7%
4	97.2%	87.2%	92.3%	75.2%
5	94.2%	84.2%	91.3%	73.1%
6	96.5%	85.7%	93.5%	71.3%

7	97.3%	86.7%	92.4%	73.7%
8	95.5%	86.8%	91.5%	74.8%
9	96.6%	86.9%	92.6%	72.7%
10	96.8%	86.7%	92.8%	73.7%

The comparison of shadow detection rate and shadow discrimination rate for two color spaces is demonstrated in Table 1. According to the result, the HSV color space is more effective shadow detection than YCbCr color space by using Thresholding Method.

V. DISCUSSION AND CONCLUSION

In this study, shadow detection for vehicle detection system had revealed that shadow removal was critical stage for correct vehicle detection system, since vehicles' shadows that was wrongly identified as parts of vehicles. Shadows disordered segmentation of foreground objects or vehicles. It also distorted true shape, color and size of vehicles. These above effects were caused serious problems in detection, counting and classification of vehicle types. It was detected better true shape, color and size of vehicles. Furthermore, it was improved the accuracy of vehicle detection, counting and classification of vehicle types. The result was presented that shadow detection was the most difficult stage for vehicle detection system because its success dependent on the imaging quality of input traffic images.

According to the result of shadow detection by using HSV color space, it achieved higher shadow detection rate since windshields of vehicles which had dark color were hardly misclassified as shadows. It was detected shadows more effectively than YCbCr even though applying auto thresholding method in both color spaces. According to the result of shadow detection by using YCbCr color space, Windshields of vehicles which had dark color were misclassified as shadows. Low intensity pixels were also detected as shadows pixels because they had similar luminance (Y) values. Therefore, shadow detection in HSV color space is better performance than shadow detection in YCbCr color space.

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