Shadow Removal Scheme of the Traffic Scenes Using Illumination Analysis and Outer-Region Deleted Strategy

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Abstract

Shadows of objects can really decrease the recognition ratio of the object recognition system and cause the distortion in the collection data. This paper presents an illumination analysis algorithm that can efficiently estimate the directions of the shadows in the traffic scenes image. Meanwhile, the author combine the edge information and the modify SLCCA skill to design a region-based segmentation and edge check (RSEC) method that can exactly distinguish the shadow region and others. Furthermore, the author adopt an outer region deleted on shadow direction (ORDSD) strategy to find the shadow region and delete it. Comparing with other papers, the prposed scheme has two advantages: One is the RSEC method that it can solve the based segmentation problem of multiple threshold values on multiple gray-scale regions and exactly separate the shadow region from others in a cars scene. The other is the ORDSD strategy that can remove the shadow of car image precisely.

Keyword: region-based segmentation (RS), traffic monitoring (TM), cast-shadows (CS), significance-linked connected component analysis (SLCCA).

1. Introduction

Road traffic data plays an important role in programming and designing a new transportation system, as well as in controlling and managing the existing transportation system. The classification and numbering of vehicles are needed in many traffic situations such as traveling time measurement, traffic flow controlling, and the toll collection. Several solutions for the classification of vehicles were developed and many proposals were published. The optical wavelet processor and a diode-laser-based vehicle detector use the image processing method to get the shapes of the vehicles [1] and license plates matching for classification of vehicles.

Zhang and Siyal [2] proposed a segmentation technique for classification of moving vehicles based on color motion segmentation and split-merge segmentation approaches. In their work, a type of motion segmentation was used to determine the rough positions of the moving vehicles in a sequence of images first, and the split-merge segmentation was applied on the color image. In split-merge segmentation process, an adaptive threshold was used to automatically choose the threshold value.

Badenas and Pla [3] presented a new approach for segmenting and tracking moving objects. In their proposal, they integrated segmentations via a frame-to-frame process and accumulated the segmentation information to obtain an improved segmentation. This procedure does not only achieve the tracking of objects, but also improve the segmentation itself once the tracking has been performed. Other segmentation example based on local threshold about color image can be found in [4].

Several research papers [5,7] have been published regarding traffic monitoring. They all encounter the shadow problems during the image processing methods of traffic monitoring. Shadows occur when objects occlude light from a light source. Shadows may cause embarrassments for video application, such as objects mix with their shadows to form the distorted figures and the images of discrete objects that may be connected to one through their shadows. Both of them confuse the object recognition system. Several papers [8,10] about removing shadows from images have been proposed. Han et al. [8] proposed an efficient background-updating algorithm based on dynamic information window (DIW). Furthermore, to cope with shadow problem, a new computational color model was adopted and chromaticity distortion was measured in an effective way.

Wang et al. [11], based on illumination assessment, developed a shadow detection and removal skill. Once a shadow's existence is confirmed, its location and orientation are estimated. Many points can be sampled from shadow candidates, and from what the attributes of shadow are computed. Finally several process steps are used to recover objects' original shapes instead of directly removing shadows.

The detection of object in image with complex background is an essential subject in the scene analysis, but yet remains an unresolved problem. A general method [12] of image segmentation is to consider the similarity of neighboring pixels so that pixels can be grouped together to form regions. One region segmentation method is region growing by pixel aggregation, which is based upon the selection of a seed pixel and followed by the determination of whether the adjacent neighboring pixels belong to the

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region of the seed pixel or not. Another method called region segmentation by splitting and merging is based upon the dividing of an image into smaller and smaller regions until all the pixels within each region satisfied the predefinition of that region.

Shioyama et al. [13] proposed an algorithm for segmentation and extracting an object region by using Gabor filters. In his paper, the criterion is devised to consider the similarity of the region size and the region shape factors that are offered to efficiently merge the feature. Meanwhile, they represent the object region by the normalized cumulative histogram of features. Huang [14] provided a natural representation of dynamically segmented features by extending the object database management group (ODMG) standard with a mechanism, called parametric polymorphism. That proposed an ODMG-based object model for dynamic segmentation. Other segmentation schemes of the traffic scene can be found in [15,17].

Owing to the fact that problems of the shadows in the traffic scene do not yet obtain a prefect solution, our study focuses on the shadow removal. In this paper, the author based on the fact that shadow always located in the outer region along with the shadow orientation within a car object to develop a shadow removal scheme. The remainder of this paper is organized as follows: Section 2 – Region based object segmentation; Section 3 - A shadow removal algorithm; Section 4 - Presentation of Algorithm Empirical results; Section 5 – conclusion.

2. Region Based Object Segmentation

In shadow removal algorithm, the author analyze the shadow properties and traffic scenes, and then the author find that the shadows always locate at the outer area of object, and distribute along with the shadow orientation. Hence, the author take a region based object segmentation technique to distinguish the shadow region and the others. Owing to the region based segmentation usually needs to compute the connectivity of the cluster, then the Significance-Linked Connected Component Analysis (SLCCA) was used to hit the goal.

2.1 Significance-Linked Connected Component Analysis

Chai et al. [18] discovered that the significant coefficients in wavelet field were only loosely clustered. The conventional definition of a connected component had too many components to hold the coding efficiency. So, they enhanced the coding efficiency by using symmetric structuring elements with a size larger than a 3x3 square to connect components that are not geometrically connected. Some structuring elements tested in his experiments are shown in Fig. 1. The Fig. 1(a) generate 4-connectivity and Fig. 1 (b) generate 8-connectivity. The progressive cluster detection using conditioned dilation operation is illustrated in Fig. 2, where image size is assumed 5x5 and 4-connected structuring element is used as shown in Fig. 1(a). The explanatory example about significant map is shown in Fig. 2(a), where, the order of examining in 4-connectivity structure is up, right, down, left. The pixel at point (2, 2) is chosen as a seed, and the remaining steps of the recursive cluster detection are shown in Figs. 2(c)-(i). The final transmitted linking code string of this cluster (region) is ISSI SII I SI SII SI III.

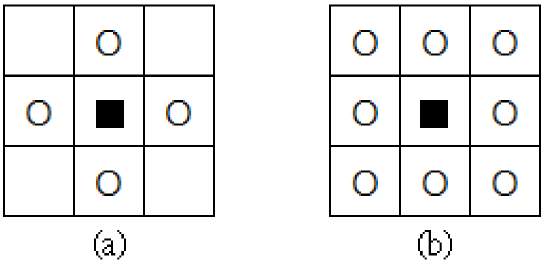


Fig. 1: Structuring elements used in conditioned dilation (a) generate 4-connectivity (b) generate 8-connectivity.

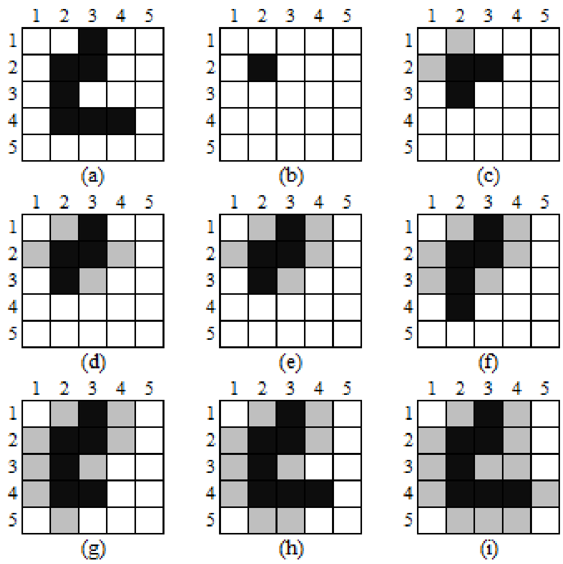


Fig. 2: Demonstration of the progressive cluster detection by using conditioned dilation on a simple example. White pixels are insignificant coefficients and are not coded, black and gray pixels denote encoded significant (S) and insignificant (I) coefficients respectively. (a) The significance map of (b) The seed position, (c)-(i) Steps of the algorithm. The final transmitted linking code string is ISSI SII I SI SII SI III. [18]

2.2 Binarlization and Object Segmentation

To find a method that can quickly and effectively identify the object image from an image is the core work. In this paper, the author transfer the grayscale image into the binary image by using Otsu's method. Otsu's method determines a threshold value for the boundary pixels of the image first. Then according to the threshold value, the boundary pixels are classified into bright or dark pixels. From the binary image, the author can easily distinguish the objects' images from others by using modified SLCCA.

Chai et al. [18] used the SLCCA to improve the coding efficiency. But the author hire the SLCCA to construct a fast and effective region segmentation skill. However, the author modify the representation of the SLCCA as follow: (a) if a neighboring pixel is similar to the seed pixel, then it belongs to the same cluster and mark it with "same" (S), otherwise mark it with "different" (D), and the mark (N) denotes the pixel that has processed already. (b) Each seed pixel has 4 neighboring pixels, therefore has 4 marks, they are S, D or N according to (a) regularly. (c) Beginning at a seed pixel by according to (a) and (b) to examine and record its neighboring pixels. Repeat examine all of the pixels which are denoted (S) to extract the cluster links to form a region. By modified SLCCA, the final transmitted linking code string of the example of the Fig. 2 is DSSD SDDN DNNN NNSD NSDD NSDN DDDN.

3. Shadow Removal Algorithm

A traffic monitoring and management scheme must extract the car object images from a traffic scene image correctly for further processing. In order to achieve this goal, the background and car-shadows of the traffic scene image need to be removed first. Background subtraction is a popular and effective method for detecting moving object in the scene foreground. While car-shadows removing of the traffic scene image is a hard work. However, the authoradopt several skills that could remove the car-shadows of the traffic scene image exactly.

The overall shadows removal process of our proposed scheme is shown in Fig. 3. The input color image presented by RGB planes are transformed to YIQ planes by RGB2YIQ color mapping transform. Because Y plane has 93% energy and is the majority of color image, it replaces the original color image to be used as an input image to simplify the work. A background removal processing discards useless image part to simplify the shadow removal work. Furthermore, for extracting different objects precisely, it needs a binarlization stage to transfer Y image into binary image. For binary image, a region-based object segmentation (RBOS) technique can easily apart car-objects from the others. After car-objects obtained, illumination analysis (IA) and shadow direction detection (SDD) are used to compute the orientation of the shadow of the car-object. On the other hand, an edge detection (ED) technique is used to get the edge information of the object image. The author design a region-based segmentation and edge check (RSEC) method could exactly distinguish the shadow region and others. Furthermore, an illumination analysis (IA) and shadow direction detection (SDD) steps used to estimate the shadow orientation. According to the shadow orientation, edge information, and object regions, the author take along with the shadow orientation take and the most outer region to delete it. The details of our algorithm are described in the following.

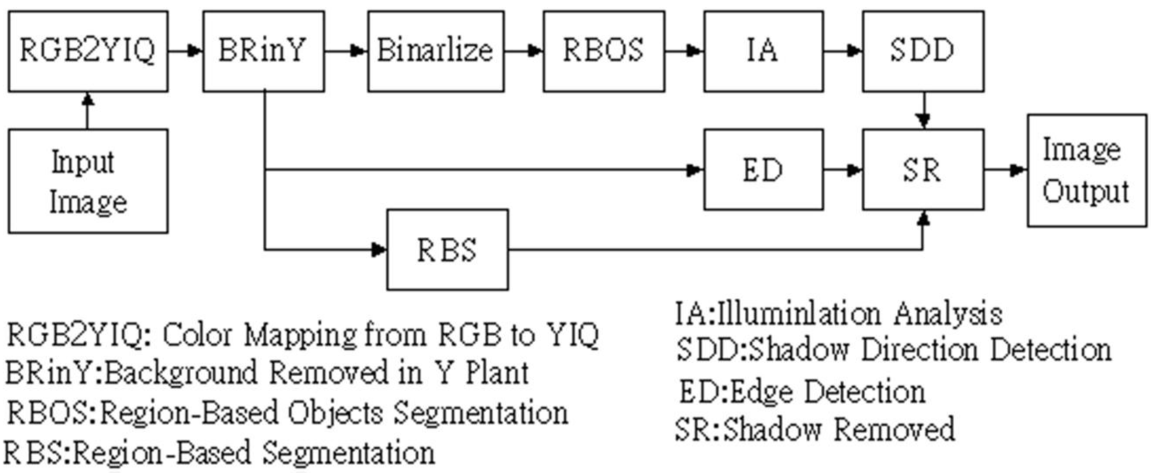


Fig. 3: The flow chart of the shadow removed algorithm

3.1 Color Mapping

The red, green and blue (RGB) are three dimensions of illumination spectrum. They are enough to compose any color an adequately although the spectrum of illumination is infinite dimension. A common alternation to the RGB representation of an image is the YIQ representation. The YIQ representation of an image is the standard model in the television transmission. The YIQ representation of an image obtained from the RGB representation of an image is given by equation (1),

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ 0.596 & -0.274 & -0.322 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.956 & 0.621 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.106 & 1.703 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix} \tag{2}$$

Where Y is the luminance or brightness that refers to color density of image, I is the hue that is the dominant color of image such as orange, red or yellow, and Q is the saturation or depth which is the amount of white light mixed with a hue of color. The equation (2) is the inverse transformation of equation (1), to transfer the image in YIQ planes back into the RGB planes.

3.2 Background Removal

Fig. 4 shows the flow chart of image processing procedures for obtaining a grayscale image of moving objects with background removal. The background averaging procedure is used to obtain a background image by averaging more than 30 pictures of a place. Background subtraction is a popular and effective method for detecting moving objects in a scene. Based on the concept of probability, the background image can be constructed from the modified histogram of individual pixel in image sequence. Fig. 5 is an original input image (Y plane) and Fig. 6 shows a constructed background image that is obtained from background averaging procedure. Fig. 7. shows that the objects are aparted from the background in the scene and extracted by erasing the background from original image

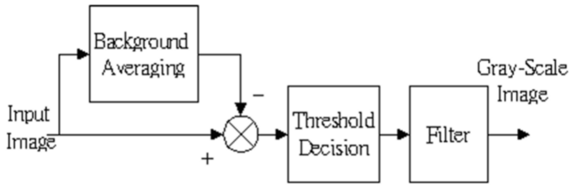


Fig. 4: The flow chart of background removal

Fig. 5: An original input image

Fig. 6: The constructed background image after Background averaging processing

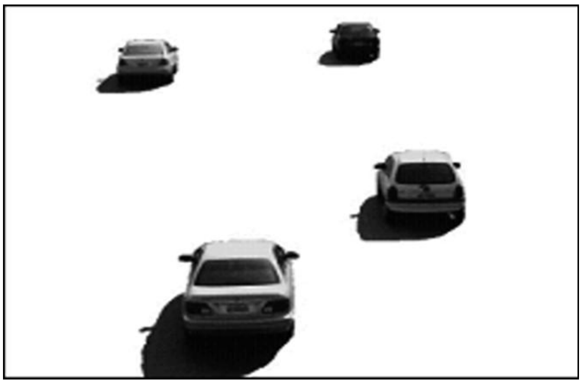


Fig. 7: The foreground objects in the scene after subtract background image

3.3 Region-Based Object Segmentation in Binary Image

All cars' images may be connected together with their shadows in the same scene. The region-based object segmentation is used to distinguish each car and is an easy way to remove shadows. In the study approach, a modify SLCCA skill described in section 2.2 is used to achieve the work. Fig. 8 shows an example using the modify SLCCA to segment four regions denoted R1, R2, R3, and R4 in a scene. The modify SLCCA not only marks different regions but also records their coordinates. This acts a lot of benefits for further processing of the shadow removal.

Fig. 8: The objects segmentation of the scene in binary image

3.4 Edge Detection and Region-Based Segmentation in Grayscale Image

An edge is a set of connected pixels that lie on the boundary between two regions. Edge detection is the most common method for detecting meaningful discontinuities in gray level. In general, the first derivation can be used to detect the presence of an point in an image. Similarly, the sign of the second derivation can be used to determine whether an edge pixel lies on the dark or light side of an edge. The Prewitt and Sobel operators are the most use for computing digital gradients. In spite of the Prewitt masks are simpler to implement than Sobel masks. however Sobel has slight superior noise-suppression characteristics. In this paper, the author used the Sobel gradient mask to find out the edge of the car object in the scenes. Fig. 9 shows a 3×3 region of an image and various masks used to compute the gradient. And Fig. 9(a) is the $Z's$ gray-level values; the Fig. 9(b) and Fig. 9(c) are the masks that are used to compute the gradient for the horizontal and vertical edge respectively.

Thresholding is the process that separates an image into several regions based upon its grayscale level distribution. The key of the selection of a threshold value is an image's histogram, which defines the grayscale level distribution of its pixels. However, to choose the best threshold value depends on the observation of an image's histogram. Typically, the histogram of a complex image is non-bimodal, and the selection of the best threshold is to take the best compromise among the segmentations of the different features in the image. Fig. 10 is the corresponding histogram of the Fig. 7. In this example, there is no the best threshold value for region-based segmentation in general manners. It depends on the conditions that the desired features can be segmented from the other features in the grayscale image. Usually, a trial and error method is used to select the threshold value, depending on one's interpretation of the image to determine whether the selected threshold value can easily extract the desired region features or not.

For a region-based segmentation scheme of the traffic scene, the author don't need so many classes for a grayscale image. In general, each 32 gray-scale belonging to a class will be enough. However, in real situation, the histogram distribution is complex. If one can adaptively define the range of every class in the pick region of the histogram, the result of the segmentation will be improved. In the paper, the author defines 32 scale level for each class and adjust adaptively the classes' range while the peak is appear on the cross boundary. The region-based segmentation is completed when each pixel of the compact images is treated.

It does not have any perfect segmentation skills for multiple gray-scale region based segmentation because the image's gray-scale is so smooth that it does not have the optimal threshold values to suit different clusters in different images. In the car shadow removal, the author combine the edge information and the modify SLCCA skill to design a region-based segmentation and edge check (RSEC) strategy. It can exactly separate the shadow regions from others. In RSEC, the author used the modify SLCCA to segment the object into five clusters a, b, c, d, and e as shown in Fig. 11(a). The cluster f is merged into cluster c because their gray-scale values are similar. Further, the author use the non-outer edge information of the object to divide its two side's areas into two clusters as the cluster c and f in Fig. 11(b).

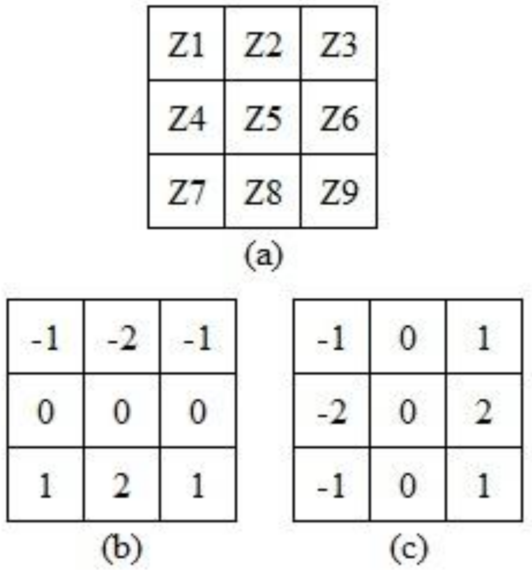


Fig. 9: The Sobel gradient masks, (a) the $Z's$ gray-level values (b) $f_x(x,y)$ (c) $f_y(x,y)$

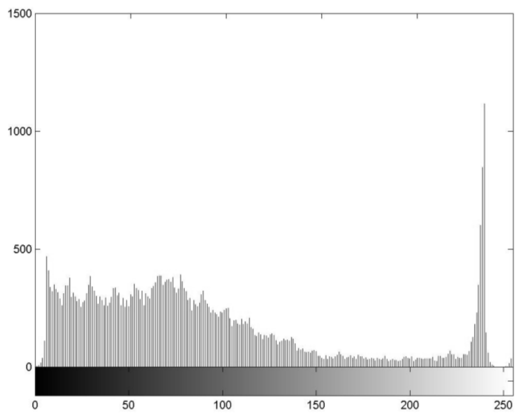


Fig. 10: The corresponding histogram of the Fig. 7

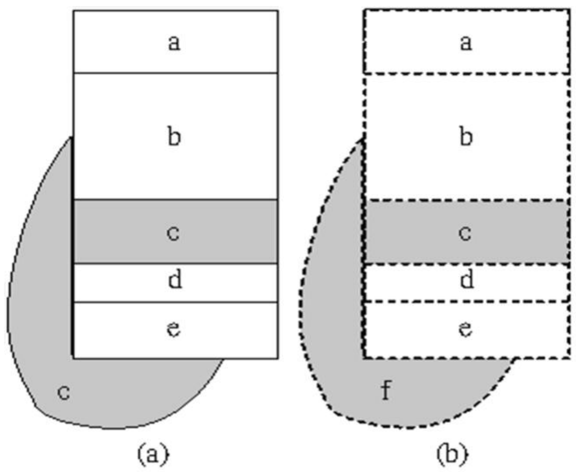


Fig.11: The schematic of the region-based segmentation and edge check strategy

3.5 Illumination Analyses and Shadow Direction Detection

Shadows can be broadly divided into cast-shadows and self-shadows. The self-shadow is the part of object that not irradiated by the light source. The cast-shadow is a shadow of the background near the object that doesn't belong to the original object. In object recognition and other applications, cast-shadows are undesired and must be eliminated from the image. Meanwhile, self-shadows are parts of the objects and shall be preserved [11].

Having confirmed shadows existing in an image, the author still need to know where they are located in the image. To achieve it, the shining direction was estimated and the selected foreground image was adopted. The author used Otsu's method to determine a threshold value for the boundary pixels of the image. According to the threshold value, the boundary pixels are classified into bright or dark pixels. Furthermore, the center of gravity (x_c , y_c) was used as shown in Equ. (3) of the image; the image was divided into four non-overlapping parts (upper, lower, right and left halves) as shown in Fig. 12. u , d , r and l are the numbers of dark boundary pixels located in the upper, lower, right and left parts, respectively. $N=(u+d+r+l)/4$, x and y denote the two largest numbers in { u , d , r , l }, a and b are the direction numbers corresponding to x and y , $A=(a+b)/2$ and $B=|a-b|$, then the direction of illumination o that defined eight directions of shining, as shown in Fig. 13, will be detected by the follow equations [11].

$$x_c=\frac{\sum_{i=1}^{m} x_i}{m}, \quad y_c=\frac{\sum_{j=1}^{n} y_j}{n} \tag{3}$$

$$o=\begin{cases} -1 \ , & (x<N, y<N) or (B<4) \\ a \ , & x \geq N, y<N \\ b \ , & x<N, y \geq N \\ B+1, & B=6 \\ A \ , & otherwise \end{cases} \tag{4}$$

Where $o=-1$ denotes the direction of illumination is undefined.

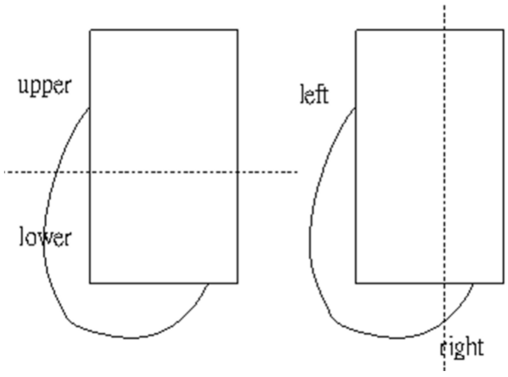


Fig.12: The schematic of the gravity calculation

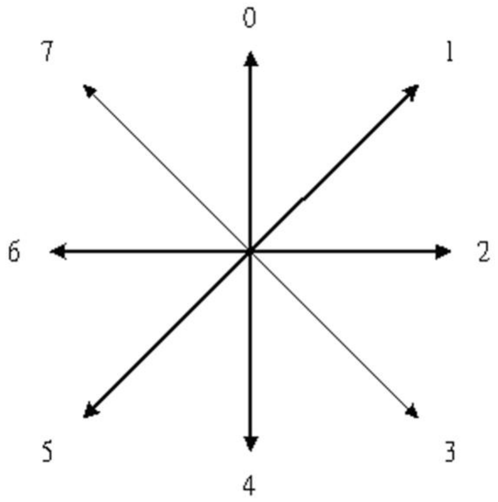


Fig.13: Eight directions of illumination

3.6 Shadow Removed

Having analyzed the shadow properties and traffic scenes, the author found that the shadow is located at the outer area of object, and distributed along with the shadow orientation. Furthermore, the author discovered that the gray-scale values of those points in shadow are almost all the same. Based on this phenomenon, several steps were used to remove the shadows; these are: (a) calculate the shadow orientation by means of illumination analysis. (b) Use edge image of the traffic scene in the binary image to search a point which is located wherever of the shadow region along with the shadow orientation. (c) Divid the region of the car object into several sub regions by using RSEC strategy. (d) Find and delete shadow region that located at the outer and adjacent region of the car object along with the shadow orientation axis.

In order to remove the shadow of the traffic scenes, the author adopted an outer region deleted on shadow direction (ORDSD) strategy to find the shadow region and delete it. In ORDSD, the shadow direction was computed from the eight directions of illumination candidate at the first. Then, an edge image obtained from gray image and operated by Sobel filter of the cars scene is needed in ORDSD. According the edge image and the direction of the shadow, the author assumed that the shadow area is the region between the first point and the second point along with the shadow direction as shown in Fig. 14. After the shadow location point is defined, the shadow region could be found and deleted. Finally, reserved the other regions of the car object, and ensured the shadow was removed eventually. Repeating this procedure for other car-object of the input image till all car-object was processed. Then all the shadows of the car scenes were removed.

While the shadow region location searching was being processed, the author used a mask for point detection as shown in Fig. 15 to check the first and second points along with the shadow direction. If the pixel is located on the edge, its value is greater than one after the mask operation. However, there are eight possibilities for the directions of the shadow. Therefore, the mask was used to calculate the pixel whether it locates on the edge or not. In our scheme, four kinds of masks as shown in Fig.15 were offered for different orientation computation.

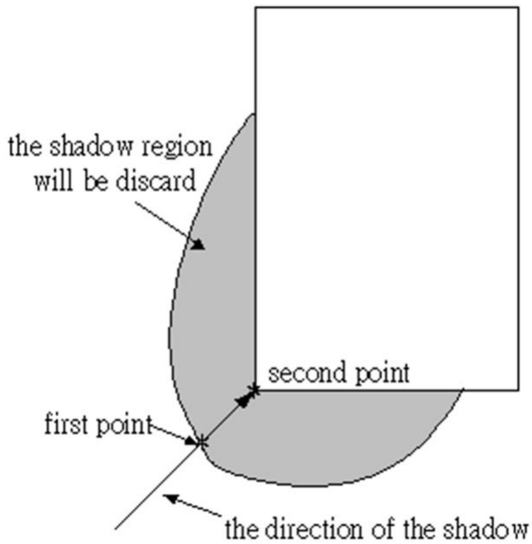


Fig.14: The schematic of the shadow removed.

0	0	0
1	1	1
0	0	0

(a)

0	1	0
0	1	0
0	1	0

(b)

0	0	1
0	1	0
1	0	0

(c)

1	0	0
0	1	0
0	0	1

(d)

Fig.15: The masks of the point detection; (a) the 90 degree and 270 degree orientation (b) the 0 degree and 180 degree orientation (c) the 45 degree and 225 degree orientation (d) the 135 degree and 315 degree orientation

4. Empirical tests

Several images of traffic scene with size (640×480) were used in simulation for demonstrating the performance of the proposed scheme. The result images were obtained by through several processes, and are described as following. The Fig. 16 is an original input image that is one of test images. It is a color image and taken at the free way in Taiwan in a sharp angle with against the sunshine. After finding the difference between the original image and its background image, the extracted foreground object image in Y plane of the traffic scene is shown in Fig. 17. The steps keep on; Fig.18 is the results of the region-based segmentation corresponding to the Fig. 17. In Fig.18, the different region was colored with different color to make distinguish of distinct regions. Furthermore, the Fig.19 and the Fig. 20 is the zoom in object and the corresponding results of the region-based segmentation from the original input image, respectively. Finally, the direction of the cast-shadows of an object in the traffic scene is shown in Fig. 21. The experiment results of multiple cars are shown in Fig. 22 and Fig. 23.

Fig. 16: An original input image

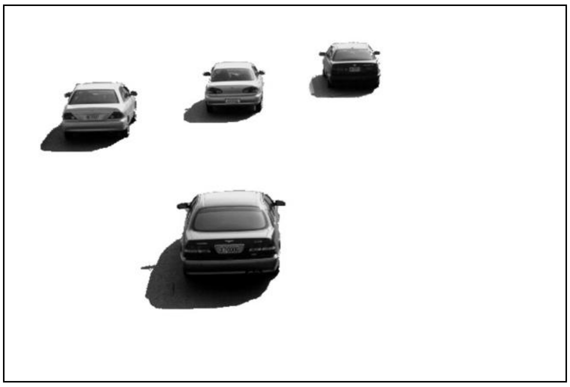


Fig. 17: The foreground object of the Y plane in the scene from original image in Y plane subtract background image.

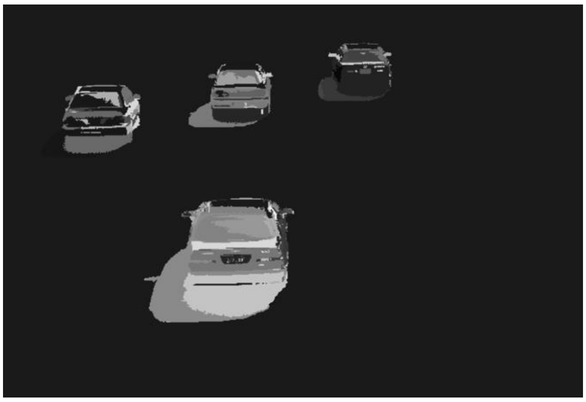


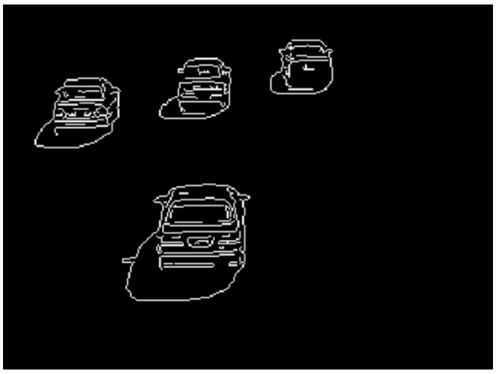
Fig. 18: The results of the region-based segmentation corresponding to the Fig.16.

Fig. 19: The zoom in object from the original input image.

Fig. 20: The results of the region-based segmentation corresponding to the Fig. 19.

Fig. 21: The direction of the cast-shadows of an object of the Fig 20 in the traffic scene.

(a)



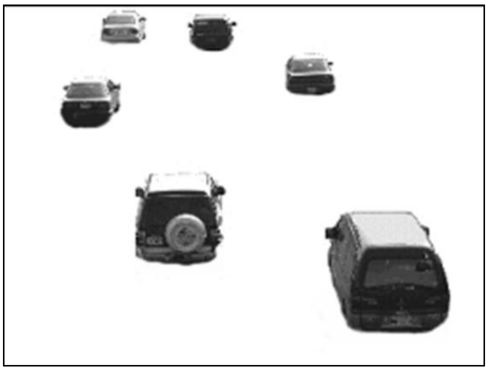
(b)

(c)

Fig. 22: The experiment results of the case 1, (a) original image (b) edge image of car objects (c) shadow-removed of car objects.

(a)

(b)



(c)

Fig. 23: The experiment results of the case 2, (a) original image (b) edge image of car objects (c) shadow-removed of car objects.

5. Conclusion.

Shadows of objects may really interfere with the video application in a few ways: objects mix with their own shadows to form distorted contours that are different from the original poses of objects, and the images of discrete objects may be connected to one through their shadows. They can decrease the recognition ratio of the object recognition system and cause the distortion in the collection data.

In this paper, the author design a RSEC method to solve multiple threshold value on multiple gray-scale region based segmentation problem, the method exactly parted from the shadow region and others in a car scenes. Meanwhile, the author used illumination analysis and shadow direction computing to clarify the shadow's orientation. Beside, having analyzed the shadow properties and traffic scenes, the author found that the shadow is located at the outer area of object, and distributed along with the shadow orientation. Hence, the study use the ORDSD strategy to remove the shadow of car image precisely.

The experiment results show that the proposed scheme can correctly remove the shadows wherever they are located in the image. Simultaneously, the results also show that our scheme works well in the multiple cars case. Our next target is to develop a fast algorithm that could be real time processing.

Acknowledgements

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