Shadow Removal Using Segmentation Method

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Abstract:
Shadow detection and removal is an important task when dealing with color outdoor images. Shadows are generated by a local and relative absence of light. Shadows are, first of all, a local decrease in the amount of light that reaches a surface. Secondly, they are a local change in the amount of light rejected by a surface toward the observer. Most shadow detection and segmentation methods are based on image analysis. However, some factors will affect the detection result due to the complexity of the circumstances. In this paper a method of segmentation test present to detect shadows from an image and a function concept is used to remove the shadow from an image.

ازالة الظل باستخدام عملية التقطيع الصوري

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الخلاصة:
يُعدُّ الكشف عن الظل وازالته من العمليات المهمة عندما تلتقط صور في الهواء الطلق. يتولد الظل عند غياب الضوء على منطقة معينة في الصورة، وهو اولاً نقصان في نسبة الضوء الساقط على سطح معين، ثانياً هو تغير في نسبة الضوء المنعكس عن السطح. معظم عمليات الكشف عن الظل وعمليات التقطيع الصوري تعتمد على تحليل الصور، وهناك عوامل تؤثر على نتائج الكشف عن الظل مثل الماء وتغير في نسبة كثافة منطقة معينة. في هذا البحث تم اختبار التقطيع الصوري للكشف عن الظل وازالته من الصور وقد استعملت تقنية حد العتبة التفاعلية المعدلة كطريقة للتقطيع الصوري للحصول على نتائج فعالة.

1- General Introduction

Early research into shadow removal typically focused on identifying dark areas upon plain, flat surfaces. More complex methods analyzed the direction of the shadows by assessing the source illumination directly or indirectly. Statistical methods analyze pixel information in sequences of images, while interactive methods provide a means to manually guide the shadow removal process. More recent shadow-detection research has focused on detecting the blue coloring of shadows due to ambient skylight, Most of these methods use some form of edge detection to outline shadow areas. A shadow is an area where direct light from a light source cannot reach due to obstruction by an object [1].

There are a few studies concerned with shadow removal, and the existing approaches cannot perfectly restore the original background patterns after removing the shadows. The patterns of shadow rely on size of objects and the angles of lighting source. This may lead to problems in scene understanding, object segmentation, tracking and recognition. Because of the undesirable effects of shadows on image analysis, much attention is paid to the area of shadow removal over the past decades and covered many specific applications such as traffic surveillance, face recognition, image segmentation and so on. There are disadvantages like loss of information for the surface under the shadows present difficulties for image interpretation, image matching, detection and other applications [2].

There are a number of cues which suggest the presence of shadows in a visual scene and that are exploited for their detection in digital images and image sequences. Shadow removal from respective image can be used for object detection, such as cancer detection, military object detection etc., as sometimes images are covered by shadows. After removing these shadows, objects in the images will appear more obviously so that they are recognized correctly [1].

2- Segmentation

Image segmentation is one of the primary steps in image analysis for object identification. The main aim is to recognize homogeneous regions within an image as distinct and belonging to different objects .The segmentation process can be used for finding the maximum homogeneity in gray levels within the regions identified. There are several issues related to image segmentation that require detailed review. One of the common problems encountered in image segmentation is choosing a suitable approach for isolating different objects from the background [1].

Image enhancement techniques seek to improve the visual appearance of an image. They emphasize the salient features of the original image and simplify the task of image segmentation. The type of operator chosen has a direct impact on the quality of the resultant image. It is expected that an ideal operator will enhance the boundary differences between the objects and their background making the image segmentation task easier. Issues related to segmentation involve choosing good segmentation algorithms, measuring their performance, and understanding their impact on the scene analysis system [2].

In computer vision, segmentation refers to the process of partitioning a digital image into multiple regions (sets of pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics [3].

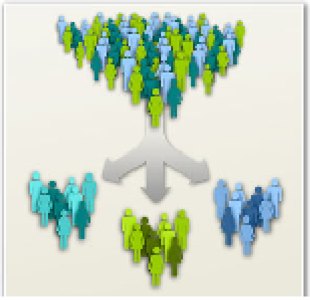


Figure (1): Example of segmentation

3- Threshlding Techniques

In a digital image processing, thresholding is a well-known technique for segmentation gray level images (it is a technique for converting a grayscale or color image to a binary image based upon a threshold value). Because of its wide applicability to other area of the digital image processing, a variety of techniques have been proposed over the years for determining thresholds at which to segment an image in extract objects from their background. Thresholding in its simplest form means to classify the pixels of a given image into two regions objects and background one including those pixels with their gray value above certain threshold. If the gray level ranges occupied by objects and background are sufficiently well separated (e.g., the image light objects on a dark background or vice versa) there will be a valley in the gray level histogram between the two peaks segment at a threshold the located at the bottom of this valley [3].

Let f(x, y) be an image composed of a light object on a dark background and (t) be a threshold, the separation of light and dark regions. Thresholding creates binary images from gray-level ones by turning all pixels below some threshold to zero and all pixels above that threshold to one ,that's mean if a pixel in the image has intensity less than the threshold value, the corresponding pixel in the resultant image is set to black. Otherwise, if the pixel is greater than or equal to the threshold intensity, the resulting pixel is set to white. The result is an image function f(x, y) at gray level (t) is a binary image function g(x,y) such that in equation (1) below [4]:

$$g(x,y) = \begin{cases} 0 \text{ if } f(x,y) < t \\ 1 \text{ if } f(x,y) > t \end{cases} \text{-------} (1)$$

A single threshold will be able to detect all or most of the object boundaries at the object-background discontinuity. However, those boundaries which correspond to object discontinuity or to internal structure if the object may not exhibit a clear foreground-background distinction (such as images of natural outdoor scenes).One cannot expect a single threshold to detect all or even most of the object boundaries in the scene. In order to detect most of the interesting boundaries of an image, some alternative or additional processing must be done to obtain clearer result. One alternative is to use multiple thresholds or threshold that varies across an image. The selection of the following two points should be considered [4] [5]:

- If the threshold level is too high; there will be a loss of information.
- If the threshold too low then it will cause noise to be falsely detected as an image edge.

Thresholding techniques are divided mainly into four types [4]:

- Global thresholding.
- Local thresholding.
- Adaptive thresholding
- Interactive thresholding

3.1 Global Thresholding

It is one that thresholds have the same threshold value throughout the image. All objects should have about equal contrast above the reasonably constant background of the entire image. A simple and effective approach to determine the threshold value t is by calculating the global average of the image as follows:

$$t = \frac{1}{m * n} \sum_{x=0}^{n-1} \sum_{y=0}^{m-1} f(x,y) \text{ -------} (2)$$

Where: m and n are the dimensions of the image.

The problem with global thresholding is that changes in illumination across the scene may cause some parts to be brighter (in the light) and some parts darker (in shadow) in ways that have nothing to do with the objects in the image. It can deal, at least in part, with such uneven illumination by determining thresholds locally. That is, instead of having a single global threshold, it allow the threshold itself to smoothly vary across the image.

3.2 Local Thresholding

This technique is applied to each sub-image, instead of the image (that means of partitioning a given image into sub-images and determining a threshold for each of these sub-images). One of the shortcomings of thresholding is that the pixels are selected by brightness (the pixels in a region can share intensity).

3.3 Adaptive Thresholding

This technique works on different thresholds for each object which is a slowly varying function of a position in the image. Determine the threshold value for each object from local background, object contrast, and other statistical parameters. It works much better than global thresholding, but much more compute intensive.

3.4 Interactive Thresholding

This technique uses two values to define the threshold range. The thresholds are adjusted interactively by showing all pixels within the range in one color and all pixels outside the range to a different color. Since the thresholds are displayed in real-time on the image, the threshold range can be defined locally and varied from slice to slice. All pixels within the range are segmented to generate the final boundaries.

4- Interactive Threshold

This technique uses two values of threshold to define the threshold range. The threshold are adjusted interactively by showing all pixel within rang in one color and all pixel outside rang to a different color, the threshold rang can be defined locally and varied from slice to slice. All pixels within rang are segmented to generate the final boundaries. The threshold values are ($t_{1,}$ t_2) [5] [6].

5 - Gray-Scale Image*s*

Gray-scale images are referred to as monochrome, or one-color, images. They contain brightness information only, no color information. The number of bits used for each pixel determines the number of different brightness levels available. The typical image contains (8 bit/pixel) data, which allows us to have (256) (0-255) different brightness (gray) levels. This representation provides more than adequate brightness resolution, in term of the human visual system's requirements, and provides a "noise margin" by allowing for approximately twice as many gray levels as required. This noise margin is useful in real-world applications because of the many different types of noise (false information in the signal) inherent in real systems. Additionally, the 8-bit representation is typical to the fact that the byte; which corresponds to 8-bits of data, is the standard small unit in the world of digital computers [5].

6- Grayscale Segmentation Methods

There are a variety of grayscale segmentation methods such as thresholding-based segmentation methods edge-based segmentation methods (suffers from incorrect detection of edges due to noise, over-and under-segmentation, and variability in threshold selection in the edge image), seed growing segmentation methods (only ambiguous boundaries between homogenous regions are detected and results are generally dependent on the operator settings), etc. it has other techniques that can be categorized as grayscale segmentation methods, but almost all of them are constrained with a limitation. For instance, an associative memory technique was employed and was found to be very promising [6]

But it involves extensive work making it computationally very intensive which may prohibit their practical use. Thus, gray scale segmentation methods though might provide useful information, are limited to relatively simple structures. For complex information, which is used in the research, so that the original image is converted from the RGB color image to gray scale image? In this paper the described method is modified interactive threshold technique with its implementation to represent the segmentation of shadow image to discover the region of shadow, then fill the discover region without shadow [7].

7- The Proposed Method

This paper will demonstrate how the selected shadow image and segmentation method that have been proposed are suitable for the processing of volume images.

The focus is on classification methods. Its review the original ideas and concepts of selected method, because this information is very important for judging when and under what circumstances a segmentation algorithm can be expected to work properly.

Shadow image removing is one of the most actively studied fields in the past few decades. Therefore, efficient and accurate computational segmentation algorithms become necessary to extract the desired information from the image.

Many of the proposed algorithms could perform well in certain shadow image.

This paper use the current effective segmentation algorithms used for shadow detection, and will focus on the classification method, which are capable of performing the segmentation tasks and their important roles in shadow image .

8- Modified Interactive Thresholding Technique

This technique is a modification of the traditional method of interactive thresholding technique. It was suggested to enhance the segmentation of shadow removal image. It works by adding a specific factor to the minimum value of all the pixels in the image and subtract the same factor value from the maximum value. The selected factor was found experimentally, and applied on two sample images. It's found that this approach gave better results than the traditional approach.

8.1 Modified Interactive Thresholding Algorithm

The algorithm steps are:

1) Convert the image to gray scale.

2) Find the minimum and the maximum values of the pixels in the image.

3) Add the factor to the minimum value and subtract the same factor from the maximum value to generate the thresholing values T_1 and T_2.

4) Assign each point inside the range of threshold value to the value 255, otherwise set the value to (100) (this value of color distinguished clearly between the anatomical structures of image).

5) Represent these steps for all pixels in the image.

6) Discover the region of shadow after the segmentation; then fill the region of shadow with the neighbored region to introduce an image without shadow.

7- Setting the Image to its Original Colors (Grey to RGB Color)

The proposed formula of this technique used an empirical factor equals to (50) as follows:

$$T_1 = MIN + 50 \qquad T_2 = MAX - 50$$

The resulting image g(x,y) of the original image f(x,y) at gray level T_1 and T_2 is a binary image such as in equation(3) and equation(4):

$$g(x,y) = 100 \quad \text{when } T_1 > f(x,y) > T_2 \quad \text{-------}(3)$$

$$g(x,y) = 255 \quad \text{when } T_1 <= f(x,y) <= T_2 \quad \text{------}(4)$$

9- System Performance Measures

System performance could be investigated with several parameters. In this paper a set of parameters is taken into consideration to evaluate the performance of the suggested shadow removal image segmentation method (modified interactive thresholding technique).

9.1 Mean Square Error

Mean square error (MSE) is an old proven measure of control and quality. In the literature of statistical process control (SPC) it is often referred to as the mean square deviation (MSD). MSD is the mean of the squares of the deviations from target. It is used to measure the error between the original image and the reconstructed image. It is calculated by the following equation [6]:

$$MSE = \frac{1}{N}\sum_{i=0}^{N-1}(w_i - r_i)^2 \text{ -------} (5)$$

Where:

w_i : is the value of the ith sample in the original data.

r_i: is the value of the ith sample in the target or intended data, (i.e. reconstructed wave after encoding phase).

N: is the number of sample (i.e. size of image).

9.2 Signal to Noise Ratio

Signal to noise ratio is an engineering term for the power ratio between a signal (meaningful information) and the background noise [6]:

$$SNR = \left[\frac{\sum_{i=0}^{N-1} w_i^{\;2}}{MSE}\right] \text{ ---------------} (6)$$

Since signals may have a very wide dynamic range, SNRs are usually expressed in terms of the logarithmic decibel scale. In decibels, the SNR is 10 times the logarithm of the power ratio:

$$SNR(dB) = 10\ Log_{10}\left[\frac{\sum_{i=0}^{N-1} w_i^2}{MSE}\right] \text{ ------} (7)$$

Most of the time, the quality of signal is expressed by using the peak signal to noise ratio (PSNR), which represent the ratio between the peak value of the signal and the mean square error (MSE), and it is calculated by the following equation

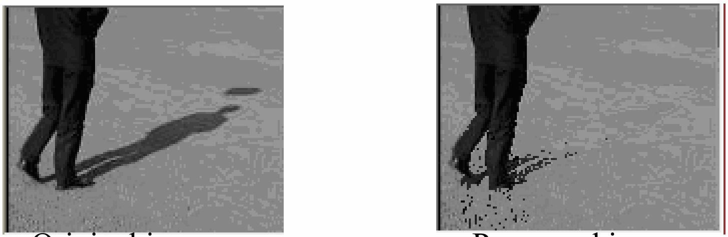
$$NR(dB) = 10\ Log_{10}\left[\frac{(255)^2}{MSE}\right] \text{ ------} (8)$$

Where, the value (255) represents the dynamic range of the image (for the case of sample resolution equal to 8 bit). PSNR is the most commonly used measure to evaluate the objective quality of the reconstructed signal after image segmentation. Typically, PSNR value range between (20-to-40). They are usually reported up to two decimal points. The actual value is not meaningful, but the image segmentation between the two values for different reconstructed image gives more indications about the quality.

10- Results and Analysis

In this paper the shadow removal algorithm capable of removing shadows from complex Backgrounds for use in outdoor images. It does not rely on shadow shape, or upon underlying scene texture but upon color information only. Results show that the algorithm performs well in a cluttered background environment, even with grey and dark colored objects casting shadows, but this method give us a few amount of noise, so in the future work will include further evaluation of the proposed approach to get rid from noise.

To discover the performance of the shadow image segmentation is dependent on interactive thresholding method, this method was applied on two samples of shadow images to declare the behavior of this method. The figures bellow shows the proposed method applied on shadow images is; with table (1) below showing MSE and PSNR results as obtained. The table gives the quality measure for shadow removal images using the proposed method, and it is found that this method gave better quality measure.



Original image Processed image

Figure (2): Shadow image of man (before and after removing the shadow)

Original image Processed image

Figure (3): Shadow image of hours (before and after removing the shadow)

Table (1): the values of MSE and PSNR of both images

Image	MSE	PSNR
Man	14.3327014797199	36.5675230535121
Hours	29.7547899449036	33.3952347217505

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