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# DETECTION AND REMOVAL OF SHADOW IN STILL IMAGES USING ILLUMINATION INVARIANT METHOD

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***Abstract :****Shadow detection and removal is fundamental problem in computer graphics and computer vision communities, which can greatly improve the performance of various applications, such as image interpretation and object classification. Shadow removal is also beneficial to increase the visual realism and physical realism in image editing and processing. As a preprocess procedure, we present an automatic shadow detection method to obtain accurate shadow boundaries. Then based on the shadow detection results, we develop an efficient shadow removal method using illumination invariant method to produce high-quality shadow-free image. Experimental results show that it can accurately detect the shadow regions in an image. In some cases, intensity of shadow matches with that of dark objects and it founds difficulty to correctly detect the shadow region due to shadings present in the images that of dark intensity objects. The algorithm works well on natural scene images and easily removes the shadow regions in them.*

***Keywords:*** *Shadow-detection, shadow-removal, luminance*

## I. INTRODUCTION

Shadow detection and removal is fundamental problem in computer graphics and computer vision communities, which can greatly improve the performance of various applications, such as image interpretation and object classification. Shadow removal is also beneficial to increase the visual realism and physical realism in image editing and processing. A shadow appears on an area when the light from a source cannot reach the area due to obstruction by an object. The shadows are sometimes helpful for providing useful information about objects. However, they cause problems in computer vision applications, such as segmentation, object detection and object counting. Thus shadow detection and removal is a pre-processing task in many computer vision applications. Shadows can either aid or confound scene interpretation, depending on whether we model the shadows or ignore them. If we can detect shadows, we can better localize objects, infer object shape, and determine where objects contact the ground. Detected shadows also provide cues for illumination conditions and scene geometry. But if we ignore shadows, spurious edges on the bound arias of shadows and confusion between alb do and shading can lead to mistakes in visual processing. For these reasons, shadow detection has long been considered a crucial component of scene interpretation. Yet despite its importance and long tradition, shadow detection remains an extremely challenging problem, particularly from a single image. The main difficulty is due to the complex interactions of geometry, albedo, and illumination.

Figure 1

Figure 1: Different kinds of shadows in image: (a) an overview of different kinds of shadows in one image, (b) cast shadow in a natural scene image.

**Need of shadow removal**

Shadows are an integral part of many natural images. While shadows, and in particular cast shadows, can provide valuable information on an acquired scene e.g. cues for spatial layout and surface geometry they can also pose difficult problems and limitations for various computer vision algorithms. Segmentation algorithms can be significantly affected by the presence of shadows in images as abrupt change in color may introduce spurious segments on coherent surfaces. Image recognition algorithms might be affected as well by illumination changes and shadows in particular .In addition, object tracking algorithms e.g. cars and pedestrians may be confused by the presence of shadows and yield false object contours .For these reasons shadow removal whether from video stream or a single still image, is an important research problem, and developing an effective shadow removal algorithm can help in improving the results of other fundamental algorithms in computer vision if applied as a pre-processing step. Additionally shadow removal might be desired from an esthetic perspective that is for improving image appearance.

**Light source**
The type and shape of the light source is another factor which may influence shadow removal algorithms. Algorithms that assume a certain spectral power distribution, for instance a Planking light source may fail in handling indoor shadow images acquired under artificial illumination. In cases where the light source is not a point-source or more than one light source exists a scan occurs in indoor images for example complex soft shadows may appear that affect shadow removal algorithms considerably.

**Intensity of shadow**
A shadowed surface is part of the surface which is occluded from at least one direct light source in the scene. As a result, a reduction in light intensity is observed in shadow regions. Many methods attempt to remove shadows by first estimating (either explicitly or implicitly) the amount of intensity reduction in the shadow region (the shadow intensity) and deducing the corresponding shadow scale factors. The shadows are then removed by applying the inverse transformation on the shadow regions according to the shadow scale factors.
Two possible cases may be considered with respect to shadow intensity:
The first is where shadow intensity is uniform in the shadow region, resulting in a uniform shadow. The second case is where shadow intensities vary across a shadow region, yielding a non-uniform shadow. The phenomenon of varying shadow intensities usually occurs due to ambient light and is most common in scenes where the occluding object is close to the shadowed surface, thus less ambient light reaches the inner regions of the shadow than the outer parts. Inter-reactions are another source of non-uniformity of shadows and can be caused by the occluding object itself or by other objects in the scene. Determining shadow intensity usually involves estimation of the shadow scale factor. In the case of a uniform shadow, the scale factor is a single unknown, however in the case of a non-uniform shadow, the scale factor is spatially varying and a per-pixel estimate must be determined.

## II. PROPOSED TECHNIQUE

Proposed method works according to luminance contrast and chromaticity values of pixels for detection and removal of shadow. The most important aspect of color choice in shadow removal is luminance contrast. Luminance is simply a statistic designed to express the fact that lights of equal power but different wavelengths do not all appear equally bright .Even though the lights of the various wavelengths are equal in power from a physical standpoint, the visual system is not equally sensitive to them. For moderate-to-high light energies, brightness is greatest at wavelengths in the vicinity of 555 nm and decreases toward both ends of the spectrum. Shadow or shading comes in low brightness domain. Color matching refers to a procedure in which an observer is presented with two spots of light. One spot, the test light, is fixed. The second spot, the matching light, contains light that is a variable mixture of several light sources of different colors. The observer's task is to adjust the intensity of each of the component sources in the matching light until the color appearance of the matching light equals that of the test light. Normal human observers are able to match any test light with a matching light made up of only three sources. This tri-dimensionality of color matching has a great advantage for both basic and applied color work: If we define three standard primary sources for the matching light and define a standard observer's color matching behavior, then any test light can be described by just three numbers, the intensities of the primaries that produce a color match for the standard observer. In this system, any test light is characterized by three numbers ("tri stimulus values"), X, Y, and Z, which are the amounts of each of the three primaries needed by the standard observer to match the test light. Y, for example, was defined to be mathematically identical to the luminance of the test light. For convenience in plotting colors graphically, the chromatic variables are characterized by a two-dimensional derivative statistic (the "chromaticity coordinates") which are derived from X, Y, and Z by normalizing each to their sum:

$$x = X / (X + Y + Z) \qquad \text{.....................1}$$
$$y = Y / (X + Y + Z) \qquad \text{.....................2}$$
$$z = Z / (X + Y + Z) = 1 - (x + y) \qquad \text{.......3}$$

Any two of these (conventionally x and y are used) plus the luminance, Y, fully capture the standard observer's color match to the test light. Graphs of the x and y coordinates of lights are called chromaticity diagrams. Chromaticity diagrams show two of the three dimensions of color, the third being luminance which can be reduced to zero by finding a perpendicular direction to chromaticity planes. The resulted image will be shadow free but will be find out in gray scale. Below are the steps that are involved in this procedure of shadow removal

- Load the images needed for shadow detection and removal.
- Calculate x, y, z for three primary colours R,G and B as decided by equations 1, 2 and 3 and take log of these parameters.
- Choose any two colour parameters from log(x), log(y) and log (z) and draw them in orthogonal planes. We choose x and z as colour parameters which corresponds to red and blue intensities.
- Choose a line which gives illumination direction for each one-to-one colour set and is determined in the logarithmic plot that is orthogonal to the non-linear illumination-invariant image. Vary the direction of this orthogonal line and evaluate maximum possible shadow removal in the image. It gives illumination invariant image which is free from the shading effects present in an image.
- Apply morphologically operations and fuzzy techniques to detect the best shadow region in the image along with shadow removal.

## III. EXPERIMENTAL RESULTS

This approach has been tested and implemented on many images taken from World Wide Web.
The images have been taken from different perspectives i.e. varying texture, camera distance, natural images, indoor images etc. Below is a brief description of the outputs in the proposed method and Can be thought of as a collection of vectors pointing in the direction of increasing values of *F*. As images are

 

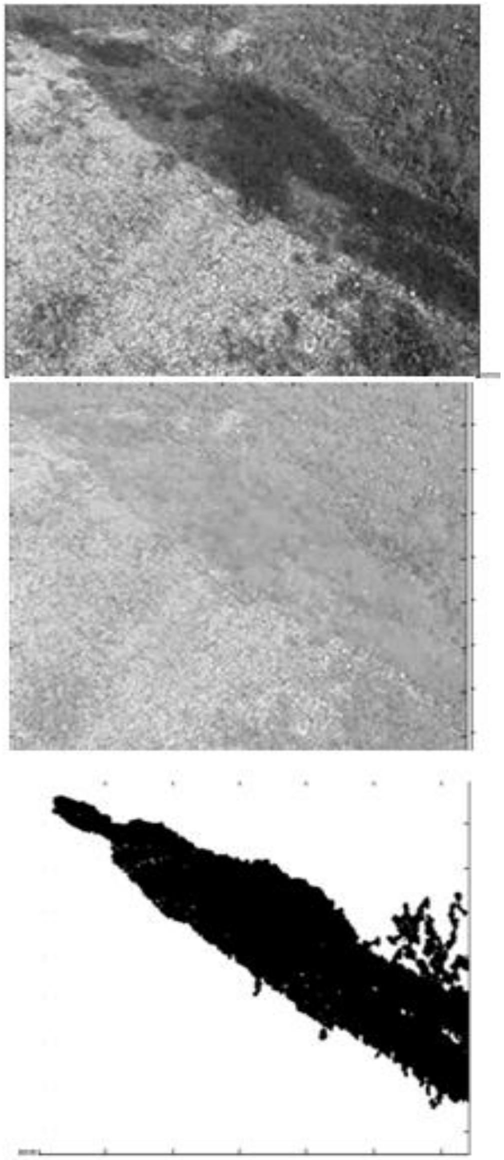

Fig 5.1

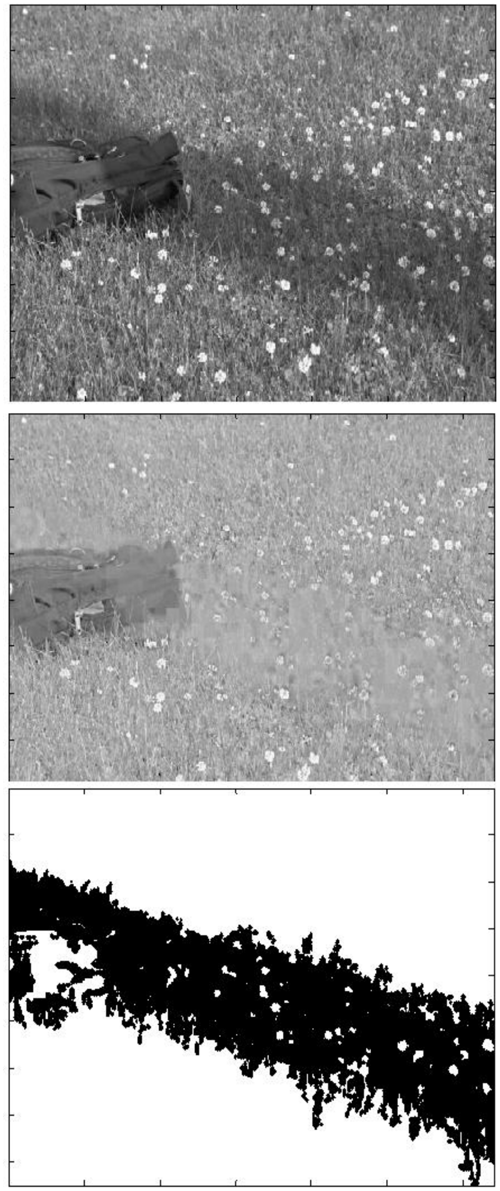

fig 5.2

*Figure 5.1: (a) Cast shadow image 1(b) Image with shadow removal (c) Detected shadow area*
*Figure 5.2: (a) Cast shadow image 2(b) Image with shadow removal (c) Detected shadow area*

The *gradient* of a function of two variables, $F(x, y)$, is defined as

$$\nabla F = \frac{\partial F}{\partial x}\hat{i} + \frac{\partial F}{\partial y}\hat{j}$$

- Two dimensional vectors we can find the average gradient in both horizontal and vertical direction of the image. As images with shadow have large variations in intensity of shadow and non-shadow region, shadow free images should have more value of average gradient than images having shadow. Gradients of one dimensional and two dimensional signals have been explained below.

 

- For one dimensional signal:
- FX = gradient (F) where F is a vector returns the one-dimensional numerical gradient of F. FX corresponds to $\partial F/\partial x$, the differences in x (horizontal) direction.
- For images or two-dimensional signals
- [FX,FY] = gradient (F) where F is a matrix returns the *x* and *y* components of the two-dimensional numerical gradient. FX corresponds to $\partial F/\partial x$, the differences in *x* (horizontal) direction. FY corresponds to $\partial F/\partial y$, the differences in the *y* (vertical) direction. The spacing between points in each direction is assumed to be one.
- It has been found that image1 has gradient value 0.0483 and removing the shadow, same image after has gradient value 0.0573, which has been increased by about 20 %. Similar results have been found for other images as well.

## IV. CONCLUSION

For an input image, the illumination conditions are usually complex, and the different materials usually have different reflectance (able do) to the illumination, which make the shadows usually non-uniform. However we proposed a universal method which works well in most of the unconstrained conditions of light. Shadow boundary is the transition zone between the shadow areas and non-shadow areas, however, shadow removal around the shadow boundary is a challenging problem for the following reasons: The shadow boundary area usually cannot be accurately detected out, especially for complex shadow; the illumination usually changes dramatically in the boundary regions, which makes it difficult to design an effective shadow removal algorithm on these regions. Our method works well on images having more high frequency contents like grass. The main drawback of this algorithm is that output image comes in gray scale. In future we will modify this algorithm to obtain the results in RGB colour scale.

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