Shadow and Nonshadow Detection Using Tricolor Attenuation Model

E.Anil kumar, P.Srinivasulu

Abstract: The shadows are regarded as obstacles in remote sensing image analysis. With high-resolution remote sensing images developed, especially in urban area, shadow detection plays a much more important role in many applications. Shadows, the common phenomena in most outdoor scenes, bring many problems in image processing and computer vision. In this paper ex-tracting shadows from a single outdoor image is presented. Based on image formation theory relationship between shadow and its nonshadow background is derived based on image formation theory.

The parameters of the Tri-color Attenuation Model are fixed by using the spectral power distribution (SPD) of daylight and skylight, which are estimated according to Planck's blackbody ir-radiance law. The proposed shadow detection algorithm when compared to previous methods can extract shadows significantly than the existing methods.

Keywords: Remote sensing, shadow detection, tricolor attenuation model (TAM).

I. INTRODUCTION

Shadow detection is an important aspect of most object detection and tracking algorithms. Shadows and shadings in images occur when objects occlude light from a light source and they appear as surface features. Shadow detection and removal over the past decades covers many specific applications such as traffic surveillance [1, 2], face recognition [3, 4, and 5] and image segmentation [6]. 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. Many techniques [7, 8, and 9] have been proposed for removing shadows from images. This paper aims to give a relatively comprehensive study on the current methods of detecting and removing shadows in both still and moving images. In general, shadows can be divided into two major classes: Self shadow and Cast shadow.

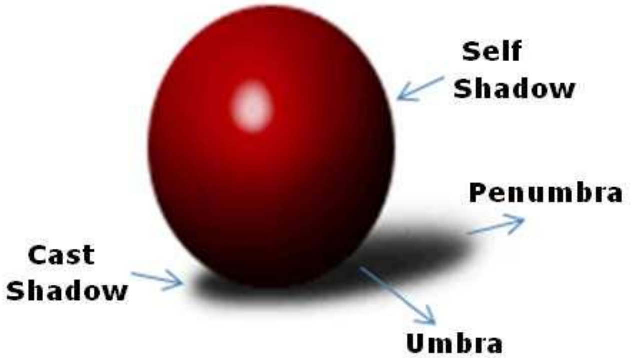

Figure1: Types of shadow in image

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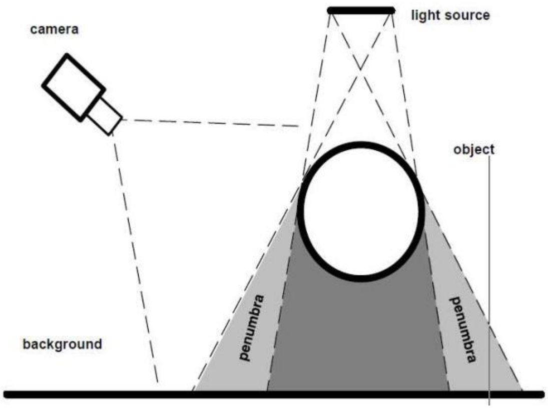

Figure2: cast shadow region in image

Since skylight is a component of daylight, pixel intensity in shadow must be lower than that in non-shadow background. As detecting shadows from image sequences has made great progress, detecting them from a single image remains a difficult problem. In contrast to multi images, shadow detection in still image is more difficult due to less information available. Wu et al. employ the Bayesian approach and shadow matting [10] to extract shadows in a single image, but their method requires user interaction as input. Nielsen et al. [11] employ channel for soft shadow segmentation, but it requires to manually hand pick a sunlit surface and its shadow counterpart to initialize the overlay color.The method proposed in [12] can identify and remove shadows from a sole outdoor image, but it requires user-supplied regions. Thus, these methods cannot be used in totally automatic computer vision tasks. In [26], the authors employ Markov random field model to detect shadows automatically in a single color image. However, this method cannot work on complex scenes. The method called "color invariance" has been exten- sively researched in recent years. Color invariance features are not sensitive to illumination changes to some extent. Color invariance features mainly include YUV [4], normalized RGB [7], hue (H) and saturation (S) [13], and [14]. Shadows mainly change the intensity of the surface that they cover with but seldom change the color invariance features. Therefore, using the shadow invariant image, hard shadow edge mask can be estimated by comparing the original image and the invariant image. Unfortunately, these methods cannot totally eliminate the illumination effect and, thus, are mostly applied in simple scenes. A pixel value vector in a color image derived by a camera can be expressed as

$$F(x,y,k) = G\left[\sigma \int_{\lambda} E(\lambda,\Theta)S(\lambda,\Theta)Q(\lambda,k)d\lambda\right]$$

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where:

- $F(x,y,k)$ is the output signal at location in color channel;
- λ is wavelength;
- Θ is viewing geometry;
- σ is exposure time;
- E is SPD of incident light;
- S is surface reflecting function;
- Q is camera response function;
- G is postprocessing function.

This model is difficult to be analyzed so a simplified model is derived as

$$F_k = \sigma \int E(\lambda)S(\lambda)Q_k(\lambda)d\lambda, \quad k = \{R, G, B\}.$$

And further reduced to

$$F_k = \sigma E(\lambda_k)S(\lambda_k)q_k.$$

Different Techniques in shadow detection

A. Model Based Techniques

In this, the 3D geometry and illumination of the scene are assumed to be known. This includes the sensor/camera localization, the light source direction, and the geometry of observed objects, from which a priori knowledge of shadow areas is derived. For example, consider polygonal regions to approximate the shadows of buildings or urban elements in some simple urban scenes. However, in complex scenes with a great diversity of geometric structures, as it is usually the case of quick bird images, such models are too restrictive to provide a good approximation. In addition, in most applications the geometry of scene and/or the light sources are unknown [10, 11].

B. Image Based Techniques

This makes use of certain image shadow properties such as colour (or intensity), shadow structure (umbra and penumbra hypothesis), boundaries, etc., without any assumption about the scene structure. Nevertheless, if any of that information is available, it can be used to improve the detection process performance. Some common ways of exploiting image shadow characteristics are:

- The value of shadow pixels must be low in all the RGB bands. Shadows are, in general, darker than their surrounding, thus it is delimited by noticeable borders (shadow boundaries) [12, 13].
- Shadows do not change the surface texture. Surface markings tend to continue across a shadow boundary under general viewing conditions [13]
- In some colour components (or combination of them) no change is observed whether the region is shadowed or not, that is, this is invariant to shadows [12, 14].

C. Colour/Spectrum Based Techniques

The colour/spectrum model attempts to describe the colour change of shaded pixel and find the colour feature that is illumination invariant. Cucchiara [15] investigated the Hue-Saturation- Value (HSV) colour property of cast shadows, and it is found that shadows change the hue component slightly and decrease the saturation component significantly. The shadow pixels cluster in a small region that has distinct distribution compared with foreground pixels.

The shadows are then discriminated from foreground objects by using empirical thresholds on HSV color space. Salvador et al. [13] proposed a normalized RGB color space, C1C2C3, to segment the shadows in still images and video sequences. K. Siala [16] consider the pixel's intensity change equally in RGB colour components and a diagonal model is proposed to describe the color distortion of shadow in RGB space.

D. Texture Based Techniques

The principle behind the textural model is that the texture of fore ground objects is different from that of the background, while the texture of shaded area remains the same as that of the background. The several techniques have been developed to detect moving cast shadows in a normal indoor environment. The technique proposed by D. Xu [17]) include the generation of initial change detection masks and canny edge maps.

E. Geometry Based Techniques

Geometric model makes use of the camera location, the ground surface, and the object geometry, etc., to detect the moving cast shadows. The Hsieh [18], Gaussian shadow model was proposed to detect the shadows of pedestrian.

The model is parameterized with several features including the orientation, mean intensity, and center position of a shadow region with the orientation and centroid position being estimated from the properties of object moments.

The Proposed Method

Algorithm for shadow detection:

Step 1: The Color image (RGB) is Transformed to Gray image.
Step 2: Similar colors are segmented using Watershed algorithm
Step 3: The mean value for each region is calculated.
Step 4: Pixels whose values are larger than the mean value of region are detected as the non-shadow region.
Step 5: Shadows are often darker than the mean value so the pixel values below mean are made to binary values
Step 7: Shadow is obtained.

Experimental results

Figure3 (a): Input image Man

Figure3 (b): Mean estimated Image of Man image

Figure 3 (c): Shadow detection of Man image

Figure3 (d): Binarized form of Man image

Figure 4 (a): Input image of a group of people image

Figure 4 (b): Mean estimated Image of a group of people image

Figure4(c): Shadow detection of a group of people image

Figure 4 (d): Binarized form of group of people image

II. CONCLUSION

In this paper, first the basics of shadow is discussed that how shadow occurs, then different types of shadows are mentioned which can appear in the images. Various approaches of shadow detection and segmentation are given, along with hythesis test that is used to detect shadows in the inages. At last results are shown in which original image is taken and shadow detected image is produced. Shadow identification in single image is difficult but has wide applications. In the paper, we use image formation theory to deduce the tricolor attenuation model, and employ blackbody irradiance to estimate its parameters. Unlike most previous methods are suitable for image sequences, this method can extract shadows from only a single image, even for image with complex outdoor scenes. Definitely, the method proposed here also can be used in video sequence (in each frame).

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