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Robust Shadow Removal Technique For Improving Image Enhancement Based On Segmentation Method.

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Abstract: *In this paper, we present an efficient and simple approach for shadow detection based on RGB color space in complex urban color remote sensing images for solving problems caused by shadows, as well as give a brief description of the advantages and disadvantages of this method. In the proposed method shadows are detected using intensity information difference and subsequent thresholding based on Otsu's method. Shadow detection and removal is an important step in visual surveillance and monitoring systems. Shadow points are often misclassified as object points causing errors on localization, segmentation and classification of objects. Many algorithms and methods have been developed for different environmental conditions to detect shadow from the images.*
Index Terms: *Shadow detection, Thresholding, Image processing, Intensity, Texture;*

I. Introduction

Cast shadows are a major concern for foreground detection algorithms. Shadow points are often misclassified as object points causing errors on localization, segmentation and classification of objects. They cause problems in computer vision applications like segmentation, object detection and object counting. Differentiating moving objects from shadows is a vital task because shadows arise various problems such as shape distortion, phantom objects etc. It is a necessary step to eliminate shadow and restore the scenes in the shadow area before performing object recognition and image matching tasks for the shadow area. Thus shadow detection and removal is a pre-processing task in many computer vision applications [1]. This report suggests a simple method to detect and remove shadows from a single RGB image. A shadow detection method is selected on the basis of the mean value of RGB image. Shadow edge correction is done to reduce the errors due to diffusion in the shadow boundary.

II. General Concepts Of Shadow

Shadows often degrade the visual quality of images. Shadows can be divided two types: self and cast shadows. A *self shadow* occurs in the portion of an object which is not illuminated by direct light. A *cast shadow* is the area projected by the object in the direction of direct light [2].Self shadow and cast shadow are shown in fig.1. Self and cast shadows produce different brightness values. Self shadows (also called attached shadows) usually have a higher brightness than cast shadows since they receive more secondary lighting from surrounding illumination objects. [3].

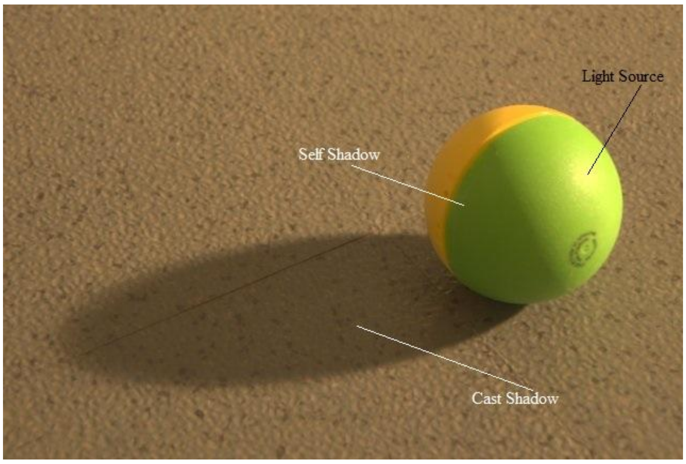

Fig.1 Shadow is divided as self and cast shadows

Shadow Basic Model

Barrow and Tanenbaum in 1978 proposed a model about the formation of image [4]. The model defines an image I(x,y) as composed of reflectance component R(x,y) and the illumination component L(x,y) as follows

I_k (x, y) = R_k (x, y) • L_k (x, y) (1)

where k ∈ R,G,B and '•' denotes pixel-wise multiplication. In shadow regions illumination is reduced and image intensities are reduced by multiplicative scalars of Ck(x, y) . Thus, (1) can be rewritten as:

I_k(x, y) = R_k(x, y) • L_k (x, y) • C_k (x, y) (2)

Hence in log domain, shadow implies an additive change in intensities. Many works have been reported in literature which tries to reduce the additive shadow component. However, separating shadow regions from near black regions needs intelligent shadow segmentation methods, and hence, it is not a trivial task. Self-shading, inter-reflection, nonuniform shadow, geometry of the object casting shadow and the artefacts involved in image capturing make the process of shadow detection more complicated [5].

Review Of Shadow Detection Approaches

It is easier for the human eye to distinguish shadow from objects. However, identifying shadows by computer is a challenging research problem. It is therefore of great importance to discover ways of properly detecting shadows and removing them while keeping other details of the original image intact. A significant amount of research has been performed on detecting and removing shadows over the past few years.

The Texture-Based shadow removal was proposed [6] to detect and remove shadows from the images. Texture-based shadow detection methods typically follow two steps: **(1)** selection of candidate shadow pixels or regions, and **(2)** classification of the candidate pixels or regions as either foreground or shadow based on texture correlation [7]. Selection of the shadow candidates is done with a weak shadow detector, usually based on spectral features. Then, each shadow candidate is classified as either object or shadow by correlating the texture in the frame with the texture in the background reference. If a candidate's texture is similar in both the frame and the background, it is classified as shadow.

Prati et al [8] evaluated the usefulness of several shadow detection methods using the following two metrics, which indicate the shadow detection rate ($\boldsymbol{\eta}$) and the shadow discrimination rate ($\boldsymbol{\xi}$):

$\eta = \frac{TP_S}{TP_S+FN_S}$ and $\xi = \frac{TP_F}{TP_F+FN_F}$ (1)

Here TP and FN stand for true positive and false negative pixels with respect to either shadows (S) or foreground objects (F). The shadow detection rate is concerned with labeling the maximum number of cast shadow pixels as shadows. The shadow discrimination rate is concerned with maintaining the pixels that belong to the moving object as foreground. Current shadow detection methods present a compromise between the two rates [9].

III. Proposed Shadow Detection Method

In our proposed method it is possible to use existing foreground segmentation algorithm, such as thresholding. Thresholding is one of the widely prominent method for image segmentation. It is useful in discriminating foreground from the background. By selecting an adequate threshold value T, the gray level image can be converted to binary image. But only employing thresholding is not enough to separate shadow pixels from the object region. Thresholding method gives foreground mask in each new frame but this method fails to distinguish between an object and its shadow as shown in fig.2.

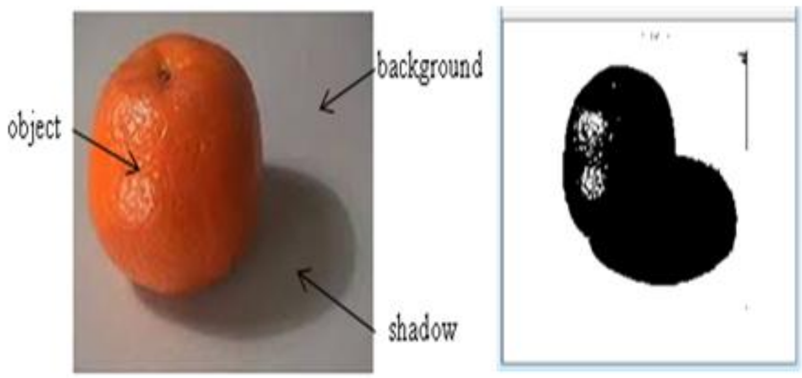

Fig. 2. Fail segmentation result

Our proposed algorithm using the segmentation technique accurately separate shadow pixels and remove it from the image without object shape distortion.

First detected using HSV color model and then it is removed using a buffer area around the shadow region. RGB image with shadows is given as input. This input image is converted from RGB to HSV space as Hue-Saturation-Value (*HSV*) color space. Shadow segmentation is done in HSV color space using Otsu's method of thresholding this separates shadows and non shadows as in [10].

In the third step, for each candidate region, the gradient magnitude $|\nabla p|$ and gradient direction Θp at each pixel p= (x , y) are calculated using.

$$|\nabla p| = \sqrt{\nabla x^2 + \nabla y^2} \quad (1)$$
$$\Theta p = arctan2(\nabla y \,/\, \nabla x) \quad (2)$$

where ∇y is the vertical gradient (difference in intensity between the pixel and the pixel in the next row), while ∇_x is the horizontal gradient. The function arctan2(·) is a variant of arctan(·) that returns an angle in the full angular range [-π, π], allowing the gradient direction to be considered a true circular variable.

We detect the object based on the differences of pixels between the reference frame and the foreground frame. If there is a difference between the current frame and the reference frame in terms of pixels, then the different pixels are counted as an object remain region considered as shadow and it removed from the binary shadow mask.

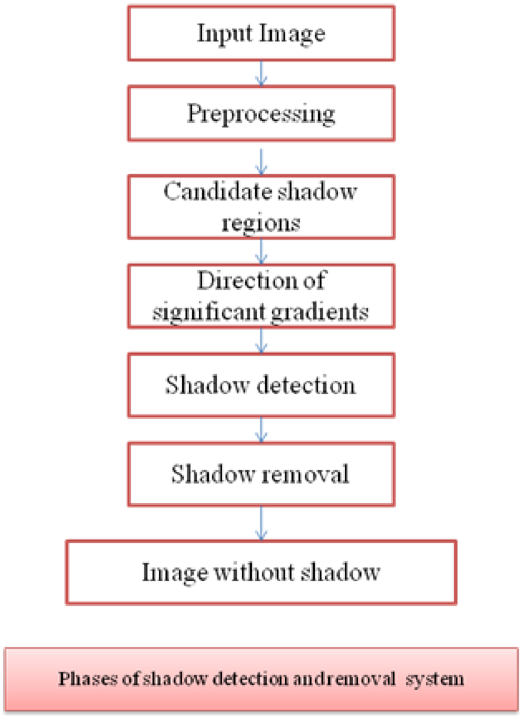

Fig. 3: Block Diagram of our method

Shadow removal

Our shadow removal approach is based on a simple shadow model where lighting consists of directed light and environment light [11]. We try to identify how much direct light is occluded for each pixel in the image and relights the whole image using that information. First, we use a matting technique to estimate a fractional shadow coefficient value. Then, we estimate the ratio of direct to environmental light, which together with the shadow coefficient, enables a shadow-free image to be recovered.

IV. Experimental Results

The shadow detection and removal module was implemented in Visual Studio 2013 C++. The entire process was tested over real images obtained from a data set proposed in [12]. No assumption is made on the lighting conditions. The time for an RGB image of the size of 256×256 is less than 5 s. The shadow region is almost of the same illumination as the non-shadow areas. The proposed approach gives good detection results for outdoor images and overcomes the disadvantage of the method proposed in [13]. Some of the shadow removal results are shown in Fig. 4.

(a) (b) (c)

Fig.4. Results of the shadow detection and removal algorithm: original images containing a shadow (a); shadows detected shown in white (b); output of the proposed method (c).

Dataset
Standard datasets for shadow detection research is available from University of Central Florida's database created by Zhu et al.[14]. This dataset consists of 245 images, with manually labelled ground truth shadow masks useful for detection evaluation. In our paper we used shadow boundary dataset which contains 135 images in which the ground shadow boundaries are labelled. These images were used in our paper for the training and testing of our shadow detection algorithm. Other images have been borrowed from Zhu et al., but annotations have been updated such that only ground shadow boundaries are labelled. In the case where the original images were high dynamic range (HDR), these images were cropped at 8 bits, and saved as jpegs.

V. Conclusion And Future Directions

In this paper an efficient method for shadow detection and removal from single image is proposed. The method works in RGB and HSV space to detect shadows and then uses Otsu's thresholding method to detect shadows. After the shadows are detected they are removed by using the mean and variance value of the buffer area around each shadow. The results are quite effective and it is seen that shadows are detected correctly. The shadow free image is also quite effective and the areas under the shadow are illuminated.

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