Detection and Removal of Cast and Self Shadow in Images
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Abstract—Shadow is an area where direct light from a light source cannot reach due to obstruction by an object. It can reduce the successful rate of edge extraction, object recognition, image matching, change detection and other processing for the corresponding ground objects in the shadow. This paper aimed to give a survey and analysis of current shadow detection methods. An algorithm of shadow detection is proposed and performance is verified in this paper.

Keywords—Umbra, Penumbra, Cast Shadow, Self Shadow

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 general, shadows can be divided into two major classes: Self shadow and Cast shadow.

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. Fig 1 shows some examples of different kinds of shadows in images. Cast shadows can be further classified into umbra and penumbra region, which is a result of multi-lighting and self shadows also have many sub-regions such as shading and inter-reflection. Usually, the self shadows are vague shadows and do not have clear boundaries. On the other hand, cast shadows are hard shadows and always have a violent contrast to background. Because of these different properties, algorithms to handle these two kinds of shadows are different. For instance, algorithms to tackle shadows cast by buildings and vehicles in traffic systems could not deal with the attached shadows on a human face. Accordingly, this survey attempts to classify various shadow removal algorithms by the different kind of shadows they focus on and in fact, by the different assumptions they made to the shadows.
The penumbra (from the Latin paeans "almost, nearly" and umbra "shadow") is the region in which only a portion of the light source is obscured by the occluding body. An observer in the penumbra appears like a partial eclipse. The umbra (Latin for "shadow") is the darkest part of the shadow. In the umbra, the light source is completely occluded. So in the umbra it is said shadows experience total eclipse. Hence it is a complete or perfect shadow of an opaque body, where the direct light from source of illumination is completely cut off.

The antumbra is the region from which the occluding body appears entirely contained within the disc of the light source. If an observer in the antumbra moves closer to the light source, the apparent size of the occluding body increases until it causes a full umbra. So it appears like an annual eclipse.

II. VARIOUS ALGORITHM OF SHADOW DETECTION

Yung, N.H.C.; Pang, G.K.H.; Lai, A.H.S. in 2001[10] proposed the shadow confidence score and the bounding hull, the cast shadow is identified as those regions outside the bounding hull and with high shadow confidence score. A number of typical outdoor scenes were evaluated and it is shown that our method can effectively detect the associated cast shadow from the object of interest.

Andrea Cavallaro, Elena Salvador, Touradj Ebrahimi [11] in 2002 presented an algorithm for the de-diction of local illumination changes due to shadows in real world sequences. The algorithm was designed to be able to work when camera, illumination and scene’s characteristics were unknown. First colour information was exploited, and then multiple constraints from physical knowledge were embedded to define the shadow detection algorithm. Colour information is exploited by means of the RGB colour space and by means of photometric invariant features. After colour analysis, a spatio-temporal veri-fication stage was introduced to refine the results. Experimental results show that the proposed algorithm outperforms state-of-the-art methods and can be applied on both indoor and outdoor image sequences.

Wang [12] in 2004 suggested a three step process to remove shadows from a foreground object obtained after subtraction of an image from a background image. The first step was illumination assessment, in which the foreground region is analyzed to determine if it contains any shadow based on pixel intensity and energy. If a shadow was suspected to exist on aggregate statistics of bright and dark pixels, the shadow detection step was performed. In the final step, the object is recovered by using information from the object area and shadow attributes to construct the object.

Yasuyuki Matsushita, Member, K. Nishino 2004 proposed an illumination normalization scheme which can potentially run in real time, utilizing the illumination eigen space, which captures the illumination variation due to weather, time of day, etc., and a shadow interpolation method based on shadow hulls. This paper described the theory of the framework with simulation results and shows its effectiveness with object tracking results on real scene data sets.

Beril Sırmacek and Cem Ursalan in 2007 recommended a novel approach for building detection using multiple cues. We benefit from segmentation of aerial images using invariant color features. Besides, we use the edge and shadow information for building detection. We also determine the shape of the building by a novel method.

Yue Wang, Shugen Wang in 2008 preferred an edge detector. The general principle of the
partial differential equations used in image restoration, a new shadow detection algorithm based on the PDES was presented, which uses the gradient values to be the parameter of edge detector. After the experiments with several urban color aerial images, it shows that the presented algorithm is effective for shadow detection, and no additional information is required except for the image itself.

Ruqi Guo, Qieyun Dai Derek Hoiem in 2011 predicted relative illumination conditions between segmented regions from their appearances and perform pair wise classification based on such information. Classification results were used to build a graph of segments, and graph-cut is used to solve the labeling of shadow and non-shadow regions. Detection results were later refined by image matting, and the shadow free image was recovered by relighting each pixel based on our lighting model. We evaluate our method on the shadow detection dataset; In addition, we created a new dataset with shadow-free ground truth images, which provides a quantitative basis for evaluating shadow removal.

Andres Sanin, Conrad Sanderson, Brian Lovell in 2011 proposed physical method improves upon the accuracy of the chromacity method by adapting to local shadow models, but failed when the spectral properties of the objects were similar to that of the background. The small-region texture based method was especially robust for pixels whose neighbourhood is textured, but may take longer to implement and is the most computationally expensive. The large-region texture based method produces the most accurate results, but has a significant computational load due to its multiple processing steps.

Nijad Al-Najdawi a, Helmut E. Bez Jyoti Singhai c, Eran.A. Edirisinghe in 2012 presented a comprehensive survey of shadow detection methods, organized in a novel taxonomy based on object/environment dependency and implementation domain. In addition a comparative evaluation of representative algorithms, based on quantitative and qualitative metrics was presented to evaluate the algorithms on a benchmark suite of indoor and outdoor video sequences.

Q. YE a, H. XIE b, Q. XU in 2012 proposed a method to remove tall building shadows in true colour and colour infrared urban aerial images based on the theory of colour constancy. The specthem ratio and Otsu threshold segmentation methods were used to detect building shadows on urban aerial true color and color infrared aerial images. Then, based on the shadow detection result, one of the color constancy algorithms SoG (Shades of Gray) was used to remove the shadows in aerial images with different p values of the Minkowski norm. Finally, the shadow removal results with different p values have been compared by brightness, contrast and average gradients. The experiments shown that the result of this method based on color constancy has a good visual effect, and different from general scene image shadow removal, the aerial images get the best shadow removal result when p is 2. It means the two types of aerial images should not be simply regarded as gray world images.

G.Lloyds Raja,Maheshkumar H.Kokkar in 2012 presented a novel method of illumination normalization based image restoration. A modified retinex algorithm was proposed to remove the shadow and restore the image. First, image was split into illumination (L) and reflectance (R) components. The Reflectance component was subjected to threshold filtering while the illumination component was subjected to modified retinex algorithm and the resulting reflectance component was combined effectively with the output of threshold filter for obtaining the shadow-free image. Illumination normalization was performed on both small-scale as well as large-scale features. Using this approach, face images with cast shadows were normalized efficiently. The quality of the illumination normalized image was evaluated by means of JPEG quality score and PSNR values. We observed very good quality score for illumination normalized images in comparison with original images. The proposed method has a great potential in real-time face recognition systems, especially under harsh illumination
III. ALGORITHM OF SHADOW REMOVAL

The first step is to remove noise of image with shadow by applying contra harmonic filter. To remove shadow properly, average frame is computed to determine effect of shadow in each of the three dimensions of colour. So the colours in shadow regions have larger value than the average, while colours in non-shadow regions have smaller value than the average values.

Images are represented by varying degrees of red, green, and blue (RGB). Red, green, and blue backgrounds are chosen because these are the colors whose intensities, relative and absolute, are represented by positive integers up to 255.

Create a threshold piecewise function to remove shadow regions. The results of the threshold function is a binary bitmap where the pixel has a value of zero if the corresponding pixel is in the shadow region and it has a value of one if the corresponding pixel is in the non-shadow region. Finally, convolute the noise-free binary image with the original image to separate the shadow from the non-shadow regions. By testing the effects of shadow on specific pixels located in the solid backgrounds, the effect of shadow can be derived for different pixel value combinations by applying binary and morphological function.

Solid colours are utilized as a background in order to remove as many variables as possible from the experiment. Pixels with wide variations in colour may reside next to each other giving skewed results. The separate analyses of these three solid backgrounds showed a correlation utilized to predict the effect of shadow in a multitude of situations. Finally energy function is applied to remove shadow.

IV. EXPERIMENTAL RESULTS

The effects of shadow on different combinations of colours are represented. The shadow pixels that belong to a corresponding colour are isolated and removed. In this work first pre-processing of image is done by filtering the image using contra-harmonic filter where pepper noise is removed. Then, average colour values of red, green, blue (primary) components in image are obtained which are considered dark pixels as of shadow regions.

The hypothesis test is used to detect the shadow and shadows are detected by comparing average R, G and B values with original R, G and B values of image. After shadows are detected then shadow removal is done by using energy function. The algorithm of shadow removal is applied to various colour images and the results are shown in figures 2 (a) to 2(c).

The table 1 below shows the PSNR values of original and enhanced image.
TABLE 1: PSNR AND MSE VALUE OF ORIGINAL AND ENHANCED IMAGE

<table>
<thead>
<tr>
<th>Pictures</th>
<th>PSNR and MSE value of original and enhanced image</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PSNR</td>
</tr>
<tr>
<td>Person</td>
<td>41.90</td>
</tr>
<tr>
<td>Bricks</td>
<td>39.22</td>
</tr>
<tr>
<td>Grass</td>
<td>46.66</td>
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</tbody>
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V. CONCLUSIONS

This paper represents the study and analysis of shadow removal in images. This paper proposed a shadow removal algorithm based on morphological operation. The performance of the algorithm is evaluated in terms of PSNR and MSE. The algorithm allows for the removal of a large percentage of shaded colours. This shows that it is possible to remove shadow from image without losing a large amount of pertinent data.

REFERENCES


