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Shadow Detection and Removal in Single-Image Using Paired Regions

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Abstract: 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, and sometimes it degrade the quality of images or it may affect the information provide by them. Thus for the correct image interpretation it is important to detect shadow and restore the information. However, shadow causes problems in computer vision applications, such as segmentation, object detection and object counting. That's why shadow detection and removal is a pre-processing task in many computer vision applications. So we propose a simple method to detect and remove shadows from a single image. The proposed method begins by selecting shadow image and by pre-processing method we focus only on shadow part. In image classification we distinguish between shadow and non shadow pixels. So that we able to label shadow and non shadow regions of the image. Once shadow is detected that detection results are later refined by image matting, and the shadow- free image is recovered by removing shadow region by non shadow region. Examination of a number of examples indicates that this method yields a significant improvement over previous methods.

***Keywords**: Shadow, shadow free image, image classification, matting, pixel*

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I. INTRODUCTION

When the light energy is illuminated on the object there the shadow of that object appears. Detection and reconstruction of shadow areas plays a vital role in the image processing environment. The shadow and non-shadow regions are identified only when the light energy is fallen on the object. If the light energy is fallen less that area is represented as shadow region whereas if the light energy is emitted more, this area is represented as non-shadow region. To separate shadow and non-shadow regions here we are implementing image classification process. This complete process depends on the borders extraction. Shadow detection plays a vital role in digital aerial image processing. Shadows are useful information that can be used in building location recognition, 3-D restoration and height estimation. Shadow can provide semantic and geometric information about the height and shape of its object and the position of the illumination light. The poor visibility in shadow region influences computer operation such as change detection, scene matching, object recognition and true orthophoto generation.Hence shadows need to be properly detected and remove for image interpretation. Yet despite its importance and long tradition, shadow detection remains an extremely challenging problem, particular from a single image.

The main difficulty is due to the complex interactions of geometry, albedo, and illumination. Locally, we cannot tell if a surface is dark due to shading or albedo. To determine if a region is in shadow, we must compare the region to others that have the same material and orientation. For this reason, most research focuses on modeling the differences in color, intensity, and texture of neighboring pixels or regions.[1] In general, shadows can be divided into two major classes: 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. Based on the intensity, the shadows are of two types − hard and soft shadows. The soft shadows retain the texture of the background surface, whereas the hard shadows are too dark and have little texture. Thus the detection of hard shadows is complicated as they may be mistaken as dark objects rather than shadows. Though most of the shadow detection methods need multiple images for camera calibration, the best technique must be able to extract shadows from a single image.

Our goal is to detect shadows and remove them from the images. So existing methodology determine whether a particular region is shadowed or not by comparing it to other regions in the image that are likely to be of the same material. To start, it find pairs of regions that are likely to correspond to the same material and determine whether they have the same illumination conditions. We incorporate these pairwise relationships, together with region-based appearance features, in a shadow/ nonshadow graph. a sparse set of edge potentials indicate whether two regions from the same surface are likely to be of the same or different illumination. Finally, the regions are jointly classified as shadow/nonshadow using graph-cut inference. But this technique gave only 50% accuracy. So develop proposed methodology which leads to good performance on consumer-quality photographs.

Our shadow detection provides binary pixel labels, but shadows are not truly binary. Illumination often changes gradually across shadow boundaries. We also want to estimate a soft mask of shadow coefficients which indicate the darkness of the shadow, and to recover a shadow-free image that depicts the scene under uniform illumination. Specifically, after detecting shadows output of pre-processing phase on which we apply the matting technique of Levin et al. [10], treating shadow pixels as foreground and nonshadow pixels as background. Using surrounding non shadow that is lighting pixel recovered shadow region.

This project consists of:

1. A new method for detecting shadows using a relational graph of paired regions.
2. An automatic shadow removal procedure derived from lighting models making use of shadow matting to generate soft boundaries between shadow and nonshadow areas.
3. Quantitative evaluation of shadow detection and removal, with comparison to existing work.
4. A shadow removal dataset with shadow-free ground truth images.

For reconstructing the image we have to go through some phases like classification, masking, matting etc. Finally, we examine the effects of the reconstructed image on the application of classification by comparing the classification maps of images before and after shadow reconstruction.

II. LITERATURE REVIEW

A shadow is an area where direct light from a light source cannot reach due to obstruction by an object. There have been few studies concerning shadow removal, and the existing approaches cannot perfectly restore the original background patterns after removing the shadows. Here are our basic assumptions as follows

- The illumination image is spatially smooth.
- There is no change in the texture inside the shadow region.
- In the shadow regions, the illumination image is close to being constant.

A brief literature review is needed in order to understand work done by various scholars in this field. On the one hand, these shadows may be utilized as a valuable cue for inferring 3-D scene information based on their position and shape, for example, for building detection and building height estimation.[11] On the other hand, existence of shadows may cause serious problems while segmenting and tracking objects: shadows can cause object merging. For this reason, shadow detection is applied to locate the shadow regions and distinguish shadows from foreground objects. In some cases, shadow detection is also exploited to infer geometric properties of the objects causing the shadow ("shape from shadow" approaches). In spite of the different purposes, invariably the algorithms are the same and can extend to any of these applications.

A. Existing Method for Shadow Detection and Removal

There are various approaches proposed by various researchers for shadow detection and removal. In this chapter a brief description of these approaches and a comparison between them are given.

B. An Object Oriented Shadow Detection and Removal Method

Hongya Zhang et al. [3] put forward an object oriented shadow detection and removal method. In this method, shadow features are taken into consideration during image segmentation, and then, according to the statistical features of the images, suspected shadows are extracted. Furthermore, some dark objects which could be mistaken for shadows are ruled out according to object properties and spatial relationship between objects. For shadow removal, inner–outer outline profile line (IOOPL) matching is used. First, the IOOPLs are obtained with respect to the boundary lines of shadows. Shadow removal is then performed according to the homogeneous sections attained through IOOPL similarity matching. Here he provided a comprehensive survey of shadow detection and removal in indoor and outdoor scene, traffic surveillance images etc. survey is done on various types of images real time application or traffic images. A survey on various shadow detection and removal method and algorithm.

C. An Object Tracking Method

Huazhong et al. [4] present a novel method for object tracking in surveillance scenes. There are three components of object tracking process according to the time sequence of object detection and tracking. Bottom-Up process, Top-Down process and process of their combination. Bottom-Up process detects the object and associate with the video frame. Top-Down process create model for object and involve incorporating prior information about scenes or object .The combination process improve the accuracy and reduce complexity of object tracking by combine information of detection and tracking. This Object Tracking Method improve the 'ViBe' background subtraction algorithm by adding the scale invariant local ternary pattern operator 'SILTP' so as to detect moving shadow and increase the accuracy of segmentation. An object tracking method based on Compressive Tracking and Kalman filter by using the result of background subtraction is presented, improve the accuracy and robustness of the tracking system in surveillance scenes.

D. Regional Growth to Detect Moving Cast Shadow Approach

YAN Jinfeng et al. [5] proposes an approach based on regional growth to detect moving cast shadow. Firstly, the pixel distribution histogram in RGB color space or the luminance ratios in HSV color space is used to detect the possible shadow area, which can produce a possible shadow area to reduce the calculation of subsequent processing. Secondly, we implement the regional growth approach based on the Breadth-First Search algorithm to get a relatively accurate shadow area. This approach considers both the color information and the edge features of images, which yields accurate detection of moving cast shadows as shown by experiments.

E. Extracting the Object from the Shadows like Object/Shadow Discrimination

Kanouivirach et al. [6] propose and experimentally evaluate a new method for detecting shadows using a simple maximum likelihood formulation based on color information. We first estimate, off line, a joint probability distribution over the difference in the HSV color space between pixels in the current frame and the corresponding pixels in a background model, conditional on whether the pixel is an object pixel or a shadow pixel.

Given the learned distribution, at run time, we use the maximum likelihood principle to classify each foreground pixel as either shadow or object. In an experimental evaluation, we find that the method outperforms standard methods on three different real-world video surveillance data sets. We conclude that the proposed shadow detection method would be an extremely effective component in an intelligent video surveillance system.

F. Detect the Events by Using Color Camera with a Depth Camera

Yu-Jen Chou et al. [7] uses a color camera to combine with a depth camera to detect the events. Depth information can resolve the light and shadow change condition problem and complicated color background. It divides up the foreground object easier and more completed, and the foreground object is used to detect events.

G. Detection of Salient Shadow and Object Regions in Uderwater Acoustic Images

Trevor Beugeling et al. [9] present novel methods for detection of salient shadow and object regions in underwater acoustic images. Both methods are based on the watershed transform. The methods exploit shape and appearance characteristics of salient shadows and objects. Experimental evaluation shows satisfactory results for the shadow detection algorithm.

H. A New Approach by Using Black Body Radiator Model

AliakseiMakarau mentions a method which uses black body radiator model for the description of the illumination model. Its results are robust and accurate [6]. A method to choose a threshold value from a grey level histogram is suggested by Noboyuki Otsu. This method is acquired from the perspective of discriminate analysis.

I.Classification Method by Using SVM Approach

Nishna Soman specifies a method based on classification which is accomplished by using state of the art SVM approach [10].Paper dispenses a productive and robust approach for shadow segmentation and compensation in color satellite images with high spatial resolution. The approach employ normalized saturation-value difference index (NSVDI) in Hue-Saturation-Value (HSV) color space to detect shadows and utilize histogram matching to recuperate the information under shadows[11].A technique to recover secular series of low-resolution images affected by clouds and associated shadows has been proposed in this paper. This nonparametric algorithm, which is based on Kohonen's SOM, does not need any statistical model to suitable the data. The training phase based on data issued from the scene to be processed for a thematic analysis. An optimal threshold is pick by the differentiate criterion, namely, so as to maximize the separability of the resultant classes in grey levels. The method is very simple, utilizing only the zeroth and the first-order accumulative moments of the grey-level histogram [12].

III. PROPOSE MEHODOLOGY

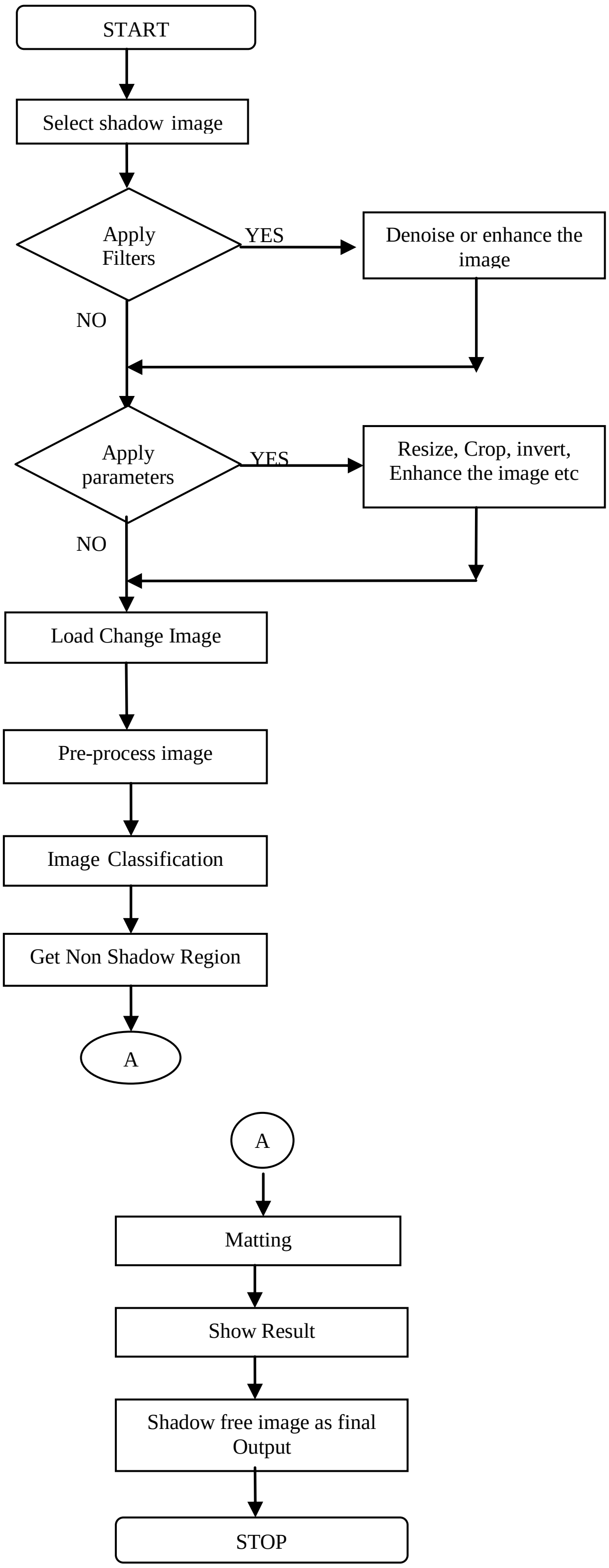


Figure 1. Dataflow of shadow detection and removal

Above figure 1 shows the dataflow of shadow detection and removal. Now we consider each phase in detail.

A. Select Shadow Image

For our Shadow detection and removal project we are taking image as an input. Select shadow image is a first phase in shadow detection and removal project. Different images are stored in a folder name as images as a database for choosing input for shadow detection and removal. Here we can take any type of image as an input for example shadow image, non-shadow image or any type of image format for example .jpg, .bmp, .png etc. It will work for all type of images.

1) Image Processing:

In imaging science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. The most requirements for image processing of images is that the images be available in digitized form, that is, arrays of finite length binary words. For digitization, the given Image is sampled on a discrete grid and each sample or pixel is quantized using a finite number of bits.

2)Types of Images:

Image file formats are standardized means of organizing and storing digital images. Image files are composed of digital data in one of these formats that can be rasterized for use on a computer display or printer. An image file format may store data in uncompressed, compressed, or vector formats. Image file size is positively correlated to the number of pixels in an image and the color depth, or bits per pixel, of the image.

JPEG (Joint Photographic Experts Group) is a compression method. JPEG compression is lossy compression. The JPEG filename extension is JPG or JPEG. Nearly every digital camera can save images in the JPEG format, which supports 8-bit grayscale images and 24-bit color images (8 bits each for red, green, and blue). JPEG applies lossy compression to images, which can result in a significant reduction of the file size.

The TIFF (Tagged Image File Format) format is a flexible format that normally saves 8 bits or 16 bits per color (red, green, blue) for 24-bit and 48-bit totals, respectively, usually using either the TIFF or TIF filename extension. TIFFs can be lossy and lossless; some offer relatively good lossless compression for bi-level (black & white) images.

The BMP file format (Windows bitmap) handles graphics files within the Microsoft Windows OS. Typically, BMP files are uncompressed, hence they are large; the advantage is their simplicity and wide acceptance in Windows programs.

The PNG (Portable Network Graphics) file format was created as the free, open-source successor to GIF. The PNG file format supports 8 bit paletted images and 24 bit true color (16 million colors) or 48 bit true color with and without alpha channel - while GIF supports only 256 colors and a single transparent color.

B. Apply Filter

Apply Filter is an optional phase. In which we can enhance image by using Daubechies Wavelet, Gausian filter, we can denoise the Image Using Gabor Filter. So take a look for these filters.

1) Image enhancement:

It refers to accentuation, or sharpening, of image features such as boundaries, or contrast to make a graphic display more useful for display & analysis. This process does not increase the inherent information content in data. It includes gray level & contrast manipulation, noise reduction, edge sharpening, filtering, interpolation and magnification, pseudo coloring, and so on. Edge enhancement is an image processing filter that enhances the edge contrast of an image or video in an attempt to improve its acutance. The filter works by identifying sharp edge boundaries in the image, such as the edge between a subject and a background of a contrasting color, and increasing the image contrast in the area immediately around the edge. There are following Image Processing techniques used in this thesis for Image Enhancement i.e. Gabor filter [13] which is used to denoising the image, Gaussian Wavelet, Daubechies wavelet [14] which are used for image enhancement.

2)Denoise Image Using Gabor Filter:

In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. The Gabor filters are self-similar: all filters can be generated from one mother wavelet by dilation and rotation. The filters are convolved with the signal, resulting in a so-called Gabor space. The Gabor space is very useful in image processing applications such as optical character recognition, iris recognition, human face recognition and fingerprint recognition. Relations between activations for a specific spatial location are very distinctive between objects in an image. Furthermore, important activations can be extracted from the Gabor space in order to create a sparse object representation [13].

3) Gaussian filter:

Gaussian filtering is used to blur images and remove noise and detail. In one dimension, the Gaussian function is:

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

Where σ is the standard deviation of the distribution The distribution is assumed to have a mean of 0.

Standard Deviation:

The Standard deviation of the Gaussian function plays an important role in its behavior. The values located between +/- σ account for 68% of the set, while two standard deviations from the mean (blue and brown) account for 95%, and three standard deviations (blue, brown and green) account for 99.7%.

The Gaussian function is used in numerous research areas:

- It defines a probability distribution for noise or data.
- It is a smoothing operator.
- It is used in mathematics.

The Gaussian function has important properties which are verified with respect to its integral In probabilistic terms, it describes 100% of the possible values of any given space when varying from negative to positive values Gauss function is never equal to zero. It is a symmetric function. The Gaussian filter is a non-uniform low pass filter. Gaussian filtering is used to remove noise and detail. It is not particularly effective at removing salt and pepper noise. This is achieved by using the median filter.

4) Median filter:

Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. It is particularly effective at removing 'salt and pepper' type noise.The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels. The pattern of neighbours is called the "window", which slides, pixel by pixel over the entire image pixel, image.

The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value. Thresholding and image equalization are examples of nonlinear operations, as is the median filter.

5) Daubechies Wavelet Method:

The most commonly used set of discrete wavelet transforms was formulated by the Belgian mathematician Ingrid Daubechies in 1988. Daubechies derives a family of wavelets, the first of which is the Haar wavelet. Daubechies wavelets are widely used in solving a broad range of problems, e.g. self-similarity properties of a signal or fractal problems, signal discontinuities, etc. Daubechies orthogonal wavelets D2-D20 (even index numbers only) are commonly used. The index number refers to the number N of coefficients. Each wavelet has a number of zero moments or vanishing moments equal to half the number of coefficients. For example, D2 (the Haar wavelet) has one vanishing moment, D4 has two, etc. A vanishing moment limits the wavelet's ability to represent polynomial behavior or information in a signal. For example, D2, with one moment, easily encodes polynomials of one coefficient, or constant signal components. D4 encodes polynomials with two coefficients, i.e. constant and linear signal components; and D6 encodes 3-polynomials, i.e. constant, linear and quadratic signal components. This ability to encode signals is nonetheless subject to the phenomenon of scale leakage, and the lack of shift-invariance, which arise from the discrete shifting operation (below) during application of the transform [1s4].

C. Apply Parameter

Second optional phase is Apply Parameter in which we can resize, crop, invert, enhance, shear and scaling the image. Then also shadow region will be detected and remove. Whatever the changes done in image that will load by next step that is load change image.

D. Load Change Image

Load change image will load the image with change, if we apply any filter like Gabor filter for denoise the image, wavelet db filter to enhance image, Gausian filter for enhance image or if we change the parameter of image by resize, crop, invert, enhance, share or scaling the image then also shadow will detected and remove. Apply filter and Apply parameter are the optional steps .If we don't used this optional steps then load change image will be same as that of the input image. We will discuss this optional stage later

E. Pre-process image

After load change image, pre-processing image phase will be occurs. In this phase we will highlight only shadow part that is only shadow part will appeared and remaining non shadow part will be disappear. If the input image is non shadow image then no change will be done in image it remain same because of no shadow will be there. Such highlighted shadow output is given input to the next image classification phase. Our shadow detection provides binary pixel labels, but shadows are not truly binary. We also want to estimate a soft mask of shadow coefficients which indicate the darkness of the shadow, so that we remove that shadow from image. So we make background pixel as in white color of image.

F. Image classification

Image classification taking input from pre-processing image, making that dark shadow pixel as white and remaining portion of image as black. Here we are going to apply one logic that is, shadow means dark pixels and single pixel never be a shadow. So if we get continue 10 pixels in a range from 50 to 220 then we consider it as shadow and make that pixel as white in image classification. Here we apply a masking technique that treating shadow pixel as foreground and non shadow pixel as back ground, and gives whites soft mask image as output

G. Register Shadow

This Register shadow phase will locate the shadow position in image by taking input of image classification. Now we have to remove this shadow portion by matching surrounding image pixel which should be non shadow pixels. For this purpose we develop new phase that is get non shadow region.

H. Get Non Shadow Region

In Get Non Shadow Region stage there are four frame decomposition levels that are level 0, level 1, level 2, and level 3. In these levels we get different frames or different part of images and we have to choose the frame according to the surrounding pixels. But this process is handy process.

I.Image Matting

In this stage we replace the shadow region by non shadow region output. Such a way we remove shadow region from images. After image matting result will display by using next show result step.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

In our experiments, we evaluate both shadow detection and shadow removal results. Image classification stage classify shadow and non shadow region and make shadow region as white in color that means it treat shadow pixel as foreground and non shadow pixel as background.

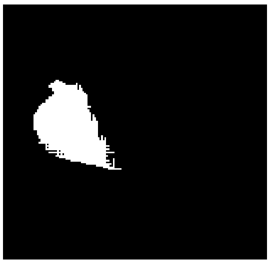
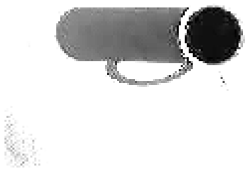
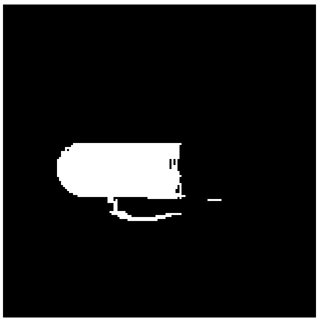
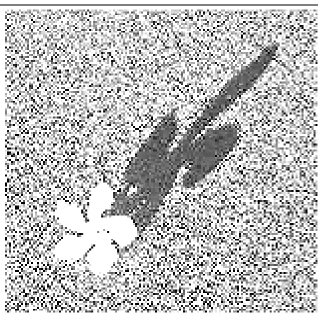
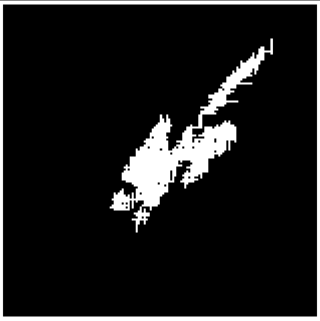
Sr.No.	Shadow Image	Pre-Process Image	Image Classification	Shadow Removal Result
1				
2				
3				
4				

Table I: Comparison of Shadow Detection and Removal result of images

.Above table illustrate the comparison between shadow images and its result as shadow removal. But boundary shadow pixel is not get remove properly. It is future scope of paper.

V. APPLICATION

The presence of shadows has been responsible for reducing the reliability of many computer vision algorithms, including segmentation, object detection, scene analysis, stereo, tracking, etc. Therefore, shadow detection and removal is an important pre-processing for improving performance of such vision tasks. Here we use median filter which play important role in reducing noise from shadow image. Our algorithm can be used to recover scene illumination for applications of image manipulation.[1]

VI. LIMITATION AND FUTURE SCOPE

There are some problems in shadow detection and removal process like when image is giving input then sometimes shadow will not get detected 100% and after removal process some shadow pixels remain in output image. So it will be our future scope of this project. The boundary pixel of shadow is not get clearly remove from image so that it is another limitation of paper. Another challenge comes from the get non shadow region phase that is, we have to choose the surrounding non shadow region frame to replace shadow region that means it is a handy process but in future improvement will defiantly happen in this process.

VII. CONCLUSION

Shadow detection and removal in single image is a complex and mutable subject. In addition to algorithms, there are more things to think about. The study of shadow detection reveals many conclusions, issues and thoughts. This conclusion explains it and sorts them; hopefully to be useful is future research. We proposed a novel approach to detect and remove shadows from a single still image. This shadow detection approach is better as compared with other existing appearance-based models. We also show that by applying soft matting to the detection results, the lighting conditions for each pixel in the image are better reflected, especially for those pixels on the boundary of shadow areas.

Our conclusions are supported by quantitative experiments on shadow detection and removal which is shown in table format in experimental result and discussion topic. This conclusion summarizes that after testing with all techniques, this implemented method of shadow detection and removal gives appreciable result.

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