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Shadow Detection: A Review of Various Approaches to Enhance Image Quality

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Abstract— Shadow Elimination is the removal of shadow without disturbing the quality of the image from either indoor and outdoor scenes or any other scenes. This review covers up all the different techniques and algorithms used in shadow elimination process as well as gives a brief description of the advantage and disadvantage of each algorithm used; therefore making an easy platform for the researchers to work more precisely with image processing to yield better growth in science and technology especially in geostatistic.

Index Term— Shadow Elimination; Image processing; Algorithms; Features; Technology

I. INTRODUCTION

Image processing is one unique area of research that has caught interest of many researchers around the world. Any form of signal processing which has image or a video frame as input and the output related to image or histogram of the image or any other image related parameter comes under the category of image processing [1]. Many other aspects off image processing are image segmentation, image enhancement etc. The use of image processing in real life is very important for medical (Cancer detection, MRI etc), image and video compression techniques (JPEG, AVI etc), optical imaging (cameras), computer vision (robots, human tracking), software for commercial (Photoshop, Light room) [1]. Nowadays, surveillance systems are in huge demand, due to their applications in public areas, i.e. at airports, stations, entrance to buildings and in mass events [2]. Detection of moving object is the most critical for any surveillance systems [2]. The main challenge is to identify moving objects from the objects shadows [2]. And in traffic surveillance system they must be able to track the flow of the traffic without misclassification of the object and the shadow. Shadow detection and removal is important for dealing with outdoor images. At times we are not able to recognize the original image from the object. Shadows in images at times remove the quality of the image [3]. High resolution satellite images are being increasingly popular due to the source of detailed information. So when getting the images of the buildings, trees and other objects there can be shadows which make them hard to distinguish between the object and the shadow [4].

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Figure 1. Shadows can be divided into Cast and Self- Shadow

In Figure 1. shows an object with two different types of shadow, self/form-shadow and cast shadow. An objects self shadow is known as self-shadow and the other is cast-shadow [5]. Distinguishing between these types of shadows is very essential for identification of objects and also for removal of cast shadows when it comes to the case of self-shadows should be recognized as part of the object of interest and hence it must be preserved [5]. Both cast and self-shadow has different brightness value. Shadows brightness depends upon the reflectivity of object of which they are cast as well as their illumination from other sources. Self-shadow has more brightness than cast shadow since they get more light from surrounding illuminated objects [5].

II. PREVIOUS WORK

Prati et al in 2003 conducted a study on shadow detection and analyzed the removal techniques and categorized them into shadow detection and removal methods through algorithm – based classification [6]. One algorithm was selected to do the evaluation. They concluded with easy and

simplest method that were suitable to the detection and easily developed its own technique according to the nature of the scene. After this review many methods have been brought up [6].

III. FEATURES

Most of the following features are useful in getting the thorough information on detecting the shadow from the images which has objects or moving shadows. Features such Intensity, chromacity geometry, geometry, textures and temporal features are necessary to improve performance for image processing.

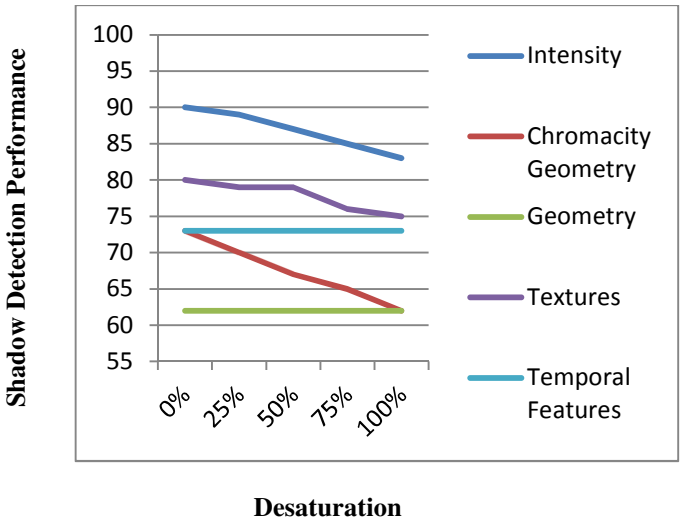

Figure :2 A graph showing the shadow detection performance based on the features

Figure 2. Shows the average performance of each feature across all series of color images. The results illustrate the average between shadow detection and discrimination values. That is, original pixel are used when desaturation is 0% and converted to gray scale when its 100% and the rest are the average of the above two [5]. Many things can be concluded from the graph,

1) The feature which use color will perform better when all color information is available [5].
2) Since chromacity is globally adaptive with higher magnitude than the intensity feature the performance of this feature decreases [5].
3) Without color the intensity based feature depends on texture which is better than temporal feature [5].
4) The intensity feature is far better than any other since it uses the color information even if such is not available the performance is still good [5].

A. Intensity

Simple way to identify the shadow, the region where shadows are there, the region will be darker. Still there are no methods which has the chief way to differentiate between shadow and objects [7].

B.Chromacity

The region where the image is very dark, but retaining their chromacity is compared to the region of shadow. Example: a green pixel covered by shadow becomes dark-green, which is darker than green but same chromacity [8]. Methods that use this model for detecting shadows often choose a color space with better separation between chromacity and intensity than the RGB color space [9].

C. Geometry

The main advantage of geometry features is that they work directly in the input frame that they don't rely on exact estimation of the background. Methods that use geometry features have some limitations that are specific to object types, standing people or vehicles [10, 31].

D. Textures

Some regions under shadow retain their texture, and there are typically two steps: (1) selection of pixels or regions and (2) classification of pixels or regions as foreground or shadow based on texture [11]. It is a very powerful method to identify the shadows as textures. But is very slow and also has to be analyzed one or more times for each and every pixel [11].

E. Temporal Features

Many of the moving shadows share the same environment and movement so the same temporal filters are used on the objects and to the shadows. Hence enhancing the pixels but there are no methods or temporal feature for shadow detection [10].

IV. SHADOW DETECTION TECHNIQUES

A. Morphology and Edge Subtraction: Background and fore-ground edge is detected by using canny edge method. The difference of both background and foreground edge is calculated by the result edge image [12].

B. Dual-Pass Otsu Method: Pixels are separated and threshold is set to get the shadow. Now the shadow will be replaced by background pixels [13].

C. The Principal Components Analysis (PCA): Gray scale is adjusted to threshold from that usage of dual past Otsu through which detection and removal of shadow is done [4].

D. Susan Algorithm: This algorithm is applied in videos. Video is taken with avi format, edge is detected from Susan method, background is observed by distribution [14].

E. Partial Differential Equations: Different filters are used to smooth the image. Gradient vector used to detect shadow [15].

F. Region Growing: Seed pixels have been selected and set as shadow group. Mean and standard deviation are calculated [16].

G. Harris Algorithm: Neighboring point eliminating method used to detect corner [17].

H. Based on Intensity Information: Standard deviation is calculated for ratio value. Conditions are set for a shadowed pixel [18].

I. Adaboost Classifiers in Co-training Framework: White area indicates foreground and black area indicates the background. The shadow detection and shadow accuracy is done by the comparison of the above results [19].

J. Hierarchical Graph cut: Image is split into super pixels to identify the shadow and non shadow objects in the background [20].

V. ALGORITHM FOR SHADOW REMOVAL

A. Model Based Shadow removal

When there are two types of light such as direct and ambient light, if direct light comes directly from the source while environment light is from reflections of surrounding surfaces, so it results in parts where shadow areas are found, by the help of formula [21].

$$I_i = (T_i COS\theta_i L_d + L_e) R_i$$

I_i represents the value for i-th pixel in RGB space
L_d and L_e represent the lights intensity
R_i is the surface reflectance of that pixel
θ_i is the angle of light and surface norm
T_i is the intensity factor of light if the value is 1 means the object is in sunshine region and if value is 0 then it's in the shadow region.
The shadow region is denoted by $K_i = T_i COS\theta_i$ for the i-th pixel.

$$r = (L_d/L_e)$$

The goal is to relight the pixel and obtain a shadow free image model [22].
And the Removal of shadow and relight the pixel is done by formula denoted below [22].

$$I_i^{\,shadow\ free} = ((r+1)/(K_i r+1))I_i$$

B. Additive Shadow removal

Shadow removal technique and additive correction is for the color intensities in shadow related areas. Here, the average pixel intensities of shadow and bright areas of the images are added and this difference in pixels is the shadow [23].

C. Combined Shadow removal

This is a combination of the above two removal algorithms. Here the images are converted to YCbCR color space, and by the use of the additive correction methods on Y channel and model based correction on Cb and Cr [5].

Y represents the luminance/ light intensity

Cb represents blue-difference chrominance

Cr represents red-difference chrominance

Technique	Advantages	Disadvantages	Reference
Morphology and Edge Subtraction	Good when scenes contain dark and light vehicles.	Expensive	[12]
The principal Components analysis (PCA)	Image clarity is increased	Chance of improvement in shadow occurred areas	[4]
Dual-Pass Otsu Method	Cheap	Poor performance	[13]
Susan Algorithm	Speed and accuracy is obtained. Detection is very good	----------	[14]
Geometry-Based Shadow Detection	This method revolves around the objects change in model leads to Ineffective results.	If geometric of object is changed then method is ineffective	[5]
Partial Differential Equations	Shadow detection is Effective.	----------	[15]
Spectrum based shadow Detection	Color feature is extracted	Not reliable because only color information is used.	[5]
Texture-based Shadow Detection	----------	Due to textural information of scenes other methods Doesn't work effectively.	[24]
Reliability of the color Property	Very effective for indoor and outdoor scenes and also for humans and vehicles. Works on Moving Shadow.	Not that much reliable	[25]
Region Growing	Orientation based technique	Region growing, failed When the pixel intensity varied widely in the Shadow	[16]

		region.	
Harris Algorithm	More efficient then Susan Algorithm.	----------	[17]
Based on Intensity Information	----------	The pixel intensity value is susceptible to Illumination changes.	[18]
Gradient-based background subtraction	Shadow detection is done precisely. Real time applications have a very good use of this algorithm	----------	[26]
Adaboost Classifiers in a Co-training Framework	Algorithm is very good for indoor and outdoor scene	Lack of good features	[19]
Pyramid-Based Shadow Removal	Avoiding loss of texture, contrast and introduction of noise	Low quality shadow-free image as well as shadow to become transparent	[27]
Model Based shadow elimination	Finds the lower intensity of the image and the smoothening of the image is can also be done	Usage of C++ code and Matlab is a likely complicated	[28]
Background Subtraction in grayscale videos	----------	It's done in gray scale video hence identifying the shadow is very difficult	[29]
Hierarchical Graph cut	Faster with better image restoration and shadow removal	Only single image is taken to remove the shadow	[20]

Table 1: Advantages and Disadvantages of the Techniques

VI. EASE OF WORK

The Table 1 consists of different methods with their advantages and disadvantages. So we can conclude various processes can be used for shadow detection and elimination and similarly can be improved by developing new algorithms to introduce new methods. The following criteria should be given importance for discovering new methods

1) Shadow detection and removal should be sturdy, fast and automatic.
2) The algorithms/methods should reduce or completely remove the shadow from images and improve its image quality.
3) While removing the shadow without removing or losing the information or data is a major criteria to be taken in mind [30]. These recommendations may also assist in improving the shadow removal algorithm; they are as follows

   a. The shadow occurred areas can be uncommon area within the image. So an appropriate way should be handled to get the shadow covered regions other than applying threshold [30].
   b. There are numerous ways to develop shadow detection but very few techniques in removing the cast shadow. So future research should concentrate on detecting accurately the shadow regions [30].
   c. Focus is usually given importance in improving the images of the shadow only but it becomes tough based on different situations. Hence more research should be done is correcting them also [30].

VII. CONCLUSION AND FUTURE WORK

In this study we have given a survey of shadow detection and removal techniques adopted for indoor and outdoor scenes, as well as in traffic surveillance images and satellite images. Among variety of methods discussed, Pyramid-Based detection is the finest method best suited to remove shadows from indoor and outdoor and introduces the noise in the scenes; it uses the illumination invariant technique to avoid the loss of texture contrast similarly for the traffic surveillance image scenes. Susan algorithm is also very efficient among all algorithms and likewise for the satellite images due to the edge detection and its perfection of accuracy. Region growing is suited for the removal of shadows from satellite images since it uses the mean and standard deviation which is done using the oriented based technique. The ability to correct shadow regions depends on both the detecting of the shadow and removal of the shadow. Other than that, future research work has to be steadily boosted on implementing the shadow detecting techniques in various fields as well as in geostatistics, in order to identify the shadow regions. Therefore, a push in developing new algorithms has to be originated which can build a user friendly platform for the users to handle technology to easily tackle removal of shadows from images,

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