Shadow Detection of Static Outdoor Images using Thresholding Techniques

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Abstract: In applications like traffic surveillance, military surveillance Tracking is one of the services offered. The success of these applications now depend on how successfully the object of interest are tracked. One of the factor which affects the tracking process and lead to false detection is the problem of shadows. These shadows having their shape similar to that of the object and are often mistaken as the object which lead to false tracking. Shadow detection and its elimination is one of the important and pre-processing stages which is introduced in the tracking systems. The images available can be a video sequence called as dynamic image or a set of photos called as static image. More work is done in area of dynamic shadow detection where the object of interest is moving, in this case the method of background subtraction and frame comparison is used for shadow detection. In case of static shadow detection frame comparison and background subtraction is not possible. So shadow detection methods are mostly property based. Static shadow detection is less exposed as compared to dynamic shadow detection. Decomposition of a single image into a shadow image and a shadow-free image is a difficult problem, due to complex interactions of geometry, albedo, and illumination. Many techniques have been proposed over the years, but shadow detection still remains an extremely challenging problem, particularly from a static image viewpoint. Our system detects shadow regions from static Outdoor images. The paper exposes the approach to detect the shadows of object from Outdoor images. Outdoor images which have static background and changing lighting conditions are taken into consideration. The parametric color model so formed has the varying intensities parameter as well as the color information. This is tested with the color outdoor images. We used global and local thresholding for the color images in HSV color space.

Keywords: Preprocessing, Shadow Detection, Static Images, Tracking.

I. INTRODUCTION

Current applications do not offer a single service but a set of services. All such similar types of services are put together and form a single domain which is called as Service Domain. One such service domain is tracking which is used in number of applications like Traffic Surveillance, Navigation, Military application etc. This service should be able to track the object of interest accurately, i.e. there should not be any false detection. There are many reasons of false detection; one of the reasons is the shadow of the object. i.e. the shadow of the object is mistaken as the object itself as the object and its shadow has similar shape. Thus it is necessary to successfully detect these shadows and eliminate them before tracking. Shadow occurs when objects totally or partially occlude direct light projected from a source of illumination. Based on whether shadow is moving or not, shadow can be classified as Static shadow and Dynamic or moving shadow. Based on how the shadow is projected, it is classified as Cast Shadow and Self Shadow.

Computer vision cannot differentiate between object and shadows by itself therefore shadow detection is introduced as a preprocessing stage after image acquisition. The problems addressed in this paper are related to cast shadows as they mainly lead to false detection. Only static shadow detection is addressed as less work is done in that area. The approach of this paper is first defining the shadow types followed by the significance of shadow detection. Then from available methods we are going for Intensity and color based method as these methods are exposed most efficient for outdoor static images.

II. WHAT IS SHADOW

The shadow is an area where direct light from a light source cannot reach due to obstruction by an object. It occupies all the space behind the opaque object. The shadow model consists of a light source L illuminating a scene and the receivers. The receivers are objects of the scene that are potentially illuminated by L. A point P of the scene is considered to be in the umbra region if it cannot see any part of L, i.e. it does not receive any light directly from the light source. If point P can see a part of the light source, then it is in the penumbra region. The union of the umbra and the penumbra is the shadow region.

A. Classification of Shadow at Physical Level

1. Dynamic Shadows

Consider a frame of a video sequence. The shadows given by objects of these frames are called as dynamic shadows.
These shadows can take the advantage of in motion sequence where the motion cues may be exploited to help detect shadows regions in each frame. This makes the shadow detection easier because we get number of frames in the frame buffer so that we get a reference frame and all others frames are compared with respect to it. Dynamic shadow detection work is based on image sequencing with a simple illumination model. This model mapped poorly to realistic conditions of outdoor scenes. Most of these detection methods use background subtraction which are suitable for short indoor scenes but can be problematic for long indoor scenes due to changing illumination conditions. Dynamic shadow detection based on image sequences has received more attention due its application in surveillances. Thus the field of dynamic shadow detection is more exposed.

2. Static Shadows

The images obtained from the camera have object with their shadows, such shadows are called as Static Shadows. Compared with moving shadow detection, there are relatively few methods reported in the literature on static shadow detection. Static shadow detection work is single image it is more complicated in the use of physically based illumination/reflection. It is also difficult for computation. detecting of static shadows is in principle difficult as it is theoretically impossible to definitely determine whether a region In the image is dark object region or dark shadow ,bright surface in image or a very light shadow. Thus single shadow detection and its removal is presented through recent years did gives promising results but with lot of assumptions like very high chromocity, well calibrated camera. More research work is presented on dynamic images, where the object of interest is moving. The method of background subtraction and frame comparison is used for shadow detection. In case of static images there is a single image, so there are no frames for comparison. Our work is to concentrate on static images and is related to only cast shadows.

B. Classification of Shadow at Application Level

1. Self Shadow

It is that portion of the object which is not illuminated by direct light. It has sub regions of shading and inter reflections. It is not actually a shadow and does not have clear boundary. They are specific case of cast shadows that occurs when the shadow of an object is projected on itself.

2. Cast Shadow

Area projected by object in the direction of direct light. They are hard shadow and have violent contrast to background. Cast shadow regions are further classified into two regions, Umbra and Penumbra. In case of umbra region, within it the source of light is completely concealed by occulting body i.e. there are no inter reflections. Penumbra region is the partial shadow regions where there are inter reflection because only portion of occulting body is occluding the light source partially. Cast shadows occur when a light falls on an object whose normal is facing towards the light source.

3. Attached shadows

In such type of shadows, the normal of the receiver is facing away from the light source. The casts shadow creates more problems in case of tracking. So our work concentrates on cast shadow.

C. Significance of Shadow

Shadows play an important role in our understanding of 3D geometry [3].

1. Shadows help to understand relative object position and size in a scene.
2. Shadows can also help us understanding the geometry of a complex receiver.
3. Finally, shadows provide useful visual cues that help in understanding the geometry of a complex occluder.

D. Properties of Shadow

Common assumptions about shadows are listed in [5, 8]. They are:

1. A shadow darkens the background area on which it falls.
2. A shadow only falls on the ground plane.
3. A shadow changes luminance of an area significantly but does not impact color much.

These properties help us to extract various properties of shadows which can be further used for their detection. These features are domain specific i.e. they are distributed in three domains, viz: spectral, spatial and temporal. Nevertheless, Temporal features are not very reliable because they depend heavily on the object speed and the frame rate of the camera. Hence, this paper mainly focuses on spectral and spatial features. Particularly, the following characteristics are exploited to detect shadow:

1. Chromaticity: when there is shadow, object chromaticity remains the same.
2. Intensity reduction: for a specific scene and a specific lighting configuration, shadows could not reduce too much object luminance.

III. RELATED WORK

Shadow detection has been an active field of research for several decades. Most of the research is focused on modeling the differences in color, intensity, and texture of neighboring pixels or regions in case of dynamic images. In case of static images, Work on shadow detection, published extracts both self shadows and cast shadows from a static image. This is a three level processes approach, viz the low level process extracts dark regions by thresholding input image, the middle level process detects features in dark regions, such as the vertexes and the gradient of the outline of the dark regions and uses them to further classify the region as penumbra (part of the shadow where the direct light is only partially blocked by the object), self-shadow or cast shadow. The third, the high level process integrates these features and confirms the consistency along the light directions estimated from the lower levels.

Existing static shadow detection methods [1, 4, 6, 7, 10, 11, and 12] have the following drawbacks: 1) Failing to present a systematic method, which makes them not scalable.
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IV. SHADOW DETECTION METHODS

Shadow is a mixture of geometry and illumination. To detect shadow it is modeled for difference in color, intensity, and texture of neighbor’s pixels or region. The basic idea is to detect the region of shadows is to classify it based on statistics of intensity, gradient, texture and color. Now by comparing these regions they are classified as shadows or non-shadows. Various shadow detection algorithms are mapped into four methods, which are

- Based on Intensity Information (pixel based): in this only intensity of the shadow changes. This is under uniform light conditions for indoor images.
- Color and Statistical Information: depending on the complexity of lighting conditions, different color models are used.
- Methods based on Geometric Relationship: In this type of images there is a definite geometrical relationship between the object and its shadow.
- Texture based shadow detection: texture difference of the object, shadow and background helps for the detection of the shadows.

V. COLOR BASED METHOD

The required image is taken and color transformations are applied to it to get color models like RGB color model and HSV color model.

A. RGB Color Model

The RGB color model is an additive color model in which red, green, and blue light is added together in various ways to reproduce a broad array of colors. The name of the model comes from the initials of the three additive primary colors, red, green, and blue. The main purpose of the RGB color model is for the sensing, representation and display of images in electronic systems, such as televisions and computers. Consider a scene which is well illuminated. In this the shadow are above some threshold level (dark level). Now RGB color model can be used if the object and its shadow are in low illumination conditions i.e. the object is dark. (below threshold level of dark RGB) then the object will be detected as shadows. In case of RGB model the assumption to be made is the point source is only the single source. So to overcome this limitation a preprocessing step is added in which the RGB color space is changed to normalized log RGB space. This space is brightness and illumination invariant.

B. HSV color Model

HSI and HSV are the two most common cylindrical-coordinate representations of points in an RGB color model, which rearrange the geometry of RGB in an attempt to be more intuitive and perceptually relevant than the Cartesian (cube) representation [9]. HSL stands for hue, saturation, and lightness, and is often also called HLS. HSV stands for hue, saturation, and value, and is also often called HSB (B for brightness). A third model, common in computer vision applications, is HSI, for hue, saturation, and intensity. For all light conditions, we convert RGB model to HSV model where H: hue position of colour in spectrum, S: saturation in colour purity, V: Value, extent of colour brightness shadow, objects covered with shadow and object all have different HSV value [8].

The colour independent property of the HSV colour space is used to detect shadows. In this the logic is, if a pixel is covered by shadow then the hue(H) and saturation component (S) of that pixel only changes within the certain limits.

VI. PROPOSED ALGORITHM

We have concentrated on following two algorithms:

- Method 1: It basically concentrates on color Outdoor image. Shadows are detected from color outdoor images using global thresholding.
- Method 2: It basically concentrates on color Outdoor image. Shadows are detected from color outdoor images using local thresholding.

A. Algorithm for Color Images using Global Thresholding

1. Read image as HSV
2. Compute the average color
3. Compute the ratio map using H and V values of HSV where r value for each at coordinates (i,j) will new
   (H(i,j)/V(i,j)+1).
4. Find the global image threshold using Otsu's method and use it to obtain binary image from ratio map.
5. Get the gradient map using sobel operator got V of HSV.
6. Use global image threshold found in step 4 on the gradient map to get shadow area.

B. Algorithm for Color Images Using Local Thresholding

1. Select RGB outdoor color image
2. Convert it into HSV image.
3. Scale I to the range of [0,1] where Ie=intensity equivalent image Scale H to the range of [0,1] where He=hue equivalent image
4. Construct the ratio map R, where R=He(xy)+1/Ie(xy)+1.
5. Scale R(xy) in the range of [0 to 255].
7. Use threshold on image to get binary image.
8. Perform Region Labeling on B and eliminate any smaller regions as per requirement.
9. Get the endpoints for each region i.e xmin, xmax, ymin, ymax.
10. Use these endpoints as reference to get the local threshold using otusu.
11. Use local threshold to get shadow area of particular.
12. Repeat steps 9-11 for all regions to get combined shadow area for local.
VII. EXPERIMENTAL RESULTS
In the proposed method experiments are performed under different conditions. The first image represents the capability of the proposed method to detect the shadow from the well illuminated and clear image of the static pedestrian. The proposed method indeed works and detects the object from the shadow and differentiates it. Input images intermediate output as well as final output after applying algorithms are as shown below. Image (a) and (b) are the input images and (c) and (d) are intermediate output images which shows only shadows and (e) and (f) are the final output after applying above algorithms on it.

![Input Image for Global thresholding Algo (a), Local thresholding Algo (b), Intermidiate Output after Shadow Detection for global thresholding Algo (c) Local Thresholding Algo (d), Output after Shadow removal for global thresholding Algo (e) Local Thresholding Algo (f).]

VIII. ALGORITHM EFFICIENCY
We have evaluated the same images using local and global thresholding and we got following results in terms of User accuracy, producer accuracy and combined accuracy. We have mentioned it in terms of table as shown below.

1. Producer Accuracy

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2. User Accuracy

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3. Combined Accuracy

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Evaluation using Color (HSV) based shadow detection method using local threshold.

3. Producer Accuracy

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4. User Accuracy

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5. Combined Accuracy

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IX. CONCLUSION

In this paper, we have implemented a method to effectively detect the shadow of the static Outdoor image. The approach detects the unwanted shadows from an image. We basically used the two different techniques to detect shadows. In first technique we used global thresholding. Firstly we compute the ratio map using H and V values of HSV. Then we found the global image threshold using Otsu's method and used it to obtain binary image from ratio map. We computed gradient map using sobel operator and got V of HSV. Global image threshold is used to draw gradient map to get shadow area. In second technique RGB outdoor color image is converted into HSV image. Ratio map R is constructed. Then threshold is calculated using otsu method. Then used threshold on image to get binary image. Region Labeling is performed and eliminate any smaller regions as per requirement considering endpoints as reference to get the local threshold using otsu and used use local threshold to get shadow area of particular. The experimental results have shown the proposed methods are superior in terms of efficiency, effectiveness of shadow detection from the static outdoor image. The proposed algorithm detects the shadow from the static outdoor image. Among global and local thresholding technique it is proved that we got better results using local thresholding technique for shadow detection.

X. REFERENCES