



Shadowing in Digital Images: Detection & Removal

Jyoti Bala¹, Ritika²¹M.Tech Scholar, Department of ECE SSCET, Badhani, Punjab, India²AP, Department of ECE SSCET, Badhani, Punjab, India

Abstract— A shadow in images occurs when an object partially or totally interrupts direct light from a source of illumination. Hence, a reduction in light intensity is observed in shadow regions. Various techniques attempt to remove shadows by first estimating the amount of intensity reduction in the shadow region and deducing the corresponding shadow scale factors. Hence the performance of the successful object recognition, image analysis and object tracking algorithms would be degraded. In this paper, we propose a method of shadow detection and the shadow removal algorithm to segment the shadow from the foreground.

Keywords— Shadow; Shadow detection; Shadow removal; Digital image processing.

I. INTRODUCTION

A shadow in images occurs when an object partially or totally interrupts direct light from a source of illumination. Hence, a reduction in light intensity is observed in shadow regions. Various techniques attempt to remove shadows by first estimating the amount of intensity reduction in the shadow region and deducing the corresponding shadow scale factors. The shadows are then removed by applying the inverse transformation on the shadow regions according to the shadow scale factors. Shadow in images can be divided into two major classifications: self and cast shadow.

(a) What is Shadow:

Consider a light source L illuminating a scene: 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 if it can not see any part of L , i.e. it does not receive any light directly from the light source. If P can see a part of the light source, it is in the penumbra. The union of the umbra and the penumbra is the shadow, the region of space for which at least one point of the light source is occluded. i.e., shadows are regions in the scene which are not reached by the light source directly. Objects that hide a point from the light source are called occluders. Attached shadows occur when the normal of the receiver is facing away from the light source. Cast shadows occur when a shadow falls on an object whose normal is facing toward the light source. Self-shadows are a specific case of cast shadows that occur when the shadow of an object is projected onto itself [7].

(b) Significance of shadow effects

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

(c) Detecting shadow

Shadows can be detected using the features extracted from three domains: 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:

- Chromaticity: when there is shadow, object chromaticity remains the same.
- Texture: similarly, shadows could only slightly change object texture.
- 246
- Intensity reduction: for a specific scene and a specific lighting configuration, shadows could not reduce too much object luminance.

II. CAST AND SELF 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. However, cast shadows are hard shadows and always have a violent contrast to background

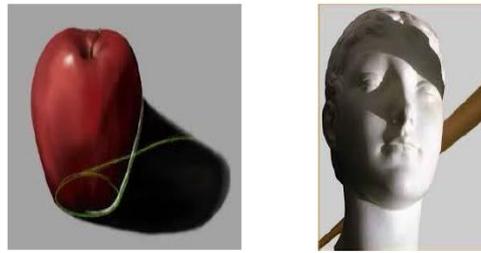


Fig. 1: (a) Cast Shadow (b) Self Shadow

The methods or algorithms to handle these two kinds of shadows are different due to different properties of these shadows. Therefore, techniques to handle shadows, cast by buildings and vehicles in traffic systems, could not deal with the attached shadows on a human face.

The reduction in light intensity yields shadow and there are two possible cases with respect to shadow intensity. The first is where shadow intensity is uniform in the shadow region, resulting in a uniform shadow. The second case is where shadow intensities vary across a shadow region, yielding a non-uniform shadow. The varying shadow intensities occur due to ambient light and is most common in scenes where the interrupting object is close to the shadowed surface. Hence less ambient light reaches the inner regions of the shadow than the outer parts. 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.

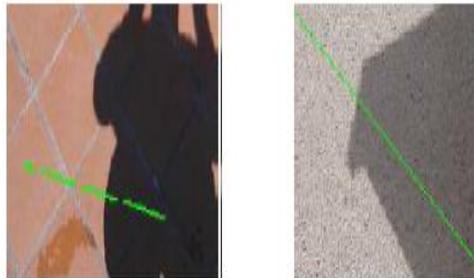


Fig.2: (a) Uniform Shadow (b) Non-uniform Shadow

The umbra (Latin for "shadow") is the darkest part of the shadow [5]. 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.

III. VARIOUS TECHNIQUES OF SHADOW DETECTION & REMOVAL

(a) Model based Technique: The geometry and illumination source of the scene are assumed to be known in this technique. This includes the sensor/camera localization, the light source direction, and the geometry of observed objects, from which a priori knowledge of shadow areas is derived.

(b) Image based Techniques: In these techniques, certain image shadow properties such as colour/intensity, shadow structure and boundaries etc. are used. Nevertheless, if any of that information is available, it can be used to improve the detection process performance.

Some common ways of exploiting image shadow characteristics are:

- The value of shadow pixels must be low in all the RGB bands. Shadows are, in general, darker than their surrounding, thus it is delimited by noticeable borders (shadow boundaries).
- Shadows do not change the surface texture. Surface markings tend to continue across a shadow boundary under general viewing conditions [40].
- In some colour components (or combination of them) no change is observed whether the region is shadowed or not i.e this is invariant to shadows [41].

(c) Colour/Spectrum based Shadow Detection: The colour/spectrum model attempts to describe the colour change of shaded pixel and find the colour feature that is illumination invariant. The shadows are then discriminated from foreground objects by using empirical thresholds on HSV colour space.

(d) Texture based Shadow Detection: The principle behind the textural model is that the texture of foreground objects is different from that of the background, while the texture of shaded area remains the same as that of the background. The several techniques have been developed to detect moving cast shadows in a normal indoor environment.

(e) Geometry based Shadow Detection: Geometric model makes use of the camera location, the ground surface, and the object geometry, etc., to detect the moving cast shadows.

IV. VARIOUS ALGORITHM OF SHADOW REMOVAL

The shadow detection and removal algorithms are classified as:

(a) Chromacity-based method

Among the chromacity methods, the most important factor is to choose a colour space with a separation of intensity and chromacity. Several colour spaces such as HSV, c1c2c3 and normalised RGB have proved to be robust for shadow detection.

(b) Physical method

The basic idea behind this is when the sun's light is blocked; the effect of sky illumination increases, shifting the chromacity of the region under shadow towards the blue component. Therefore this method create more general non-linear attenuation models accounting for various illumination conditions in both indoor and outdoor scenarios Research in physical models for cast shadow removal has been done incrementally. The more recent papers are extensions of previous physical models, typically removing some assumptions and improving on previous results

(c) Geometry-based method

In this method, the orientation, size and even shape of the shadows can be predicted with proper knowledge of the illumination source, object shape and the ground plane. Most geometry methods assume that each foreground blob contains a single object and shadow, which is not, guaranteed in many computer vision applications

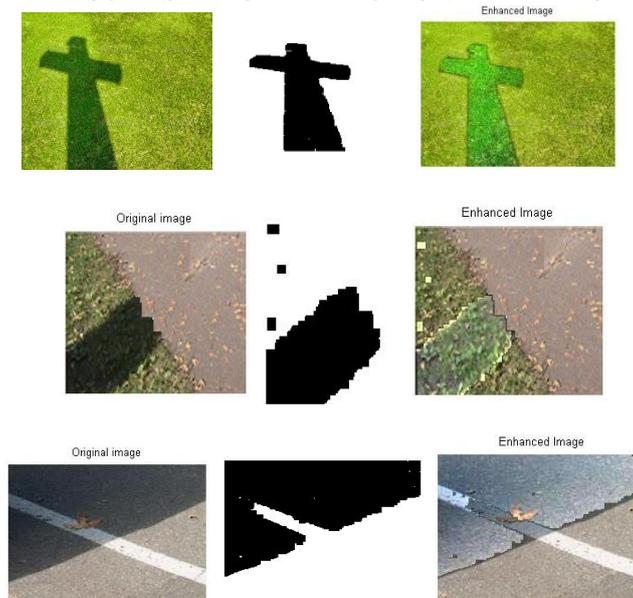
(d) Small region (SR) texture-based method

These methods exploit the fact that regions under shadow retain most of their texture. 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. Texture-based methods present the greatest diversity among the various categories.

(e) Large region (LR) texture-based method

The problem of using small regions is that they are not guaranteed to contain significant textures. So a method proposed using colour features to first create large candidate shadow regions (ideally containing whole shadow areas), which are then discriminated from objects using gradient-based texture correlation.

V. RESULT SHADOW DETECTION AND REMOVAL



VI. CONCLUSION

This paper represents the study and analysis of shadowing in images. We proposed a shadow detection and enhancement algorithm. The algorithm detects and enhances the shadow portion of image effectively and accurately.

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