Design of Shadow Detection and Removal System

Bileesh P Babu[1] Shobha G[2]

[1,2]Department of Computer Science and Engineering

[1,2]RVCE, Bangalore

Abstract— Detection and removal of shadow forms a major usage in computer vision application. Presence of shadows causes object distortion. Shadow removal increases the quality of the video surveillance. Shadow detection and removal is carried out in three stages. Foreground image is detected in the first stage using frame differencing technique. Shadow part is detected in the second stage using the hue, saturation, and intensity of the moving object. Shadow removal is done in the third stage by replacing the shadow pixels with the background pixels. All the three modules are collectively implemented in Visual C++. Precision values in the range of 0.9923 to 0.9959 are obtained for different input videos.

Key words: shadow forms, computer vision application, video surveillance

I. INTRODUCTION

Computer vision system is the best way to monitor public spaces. It aims to duplicate the effect of human vision by electronically perceiving and understanding an image. Video surveillance is an application of computer vision system that can be used for scene interpretation, image segmentation, object recognition and tracking. The classical problem in computer vision and image processing is that of determining whether or not the image data contains some specific object, feature, or activity [1]. This task can normally be solved robustly and without effort by a human, but is still not satisfactorily solved in computer vision for the general case of arbitrary objects in arbitrary situations. The presence of shadows adversely affects the performance of these computer vision systems as shadows are misclassified as objects because shadows are typically different from background [2].

Shadow is a region of relative darkness. Shadow occurs when an object totally, or partially occludes direct light from a light source [3]. Shadows can be classified as self shadow and cast shadow. Self shadow occurs on the object occluding the light. Cast shadow is the shadow generated by one object on some other objects [4]. Cast shadows can be further divided into umbra and penumbra part. Umbra is the darkest part of shadow. Within umbra, light source is completely blocked by the object casting the shadow. Penumbra is the part of shadow where light source is partially blocked. Penumbras occur when light source is not a point source.

Cast shadows always move with their corresponding objects such that background subtractions cannot separate them accurately [5]. This might lead to object merging, object shape distortion and object losses. The presence of cast shadows in an image can modify the perceived object shape. The existing methods for dealing with this problem can at best solve it only for specific objects, human faces, or vehicles and in specific situation, typically described in terms of well-defined illumination, background and pose of the object relative to the camera [6]. In order to provide a correct description of the objects, shadows should be identified and removed [7]. Therefore, detecting and eliminating shadow regions are highly desirable and necessary. Shadows can be detected and removed based on any of the features such as color, intensity, texture or geometry. Methods based on a single feature might lead to misclassification for moving cast shadows [8].

II. PROPOSED METHOD

Detecting and tracking of moving objects is required for many of the computer vision applications. Shadows must be detected to avoid object distortion or object loss. The overview of the proposed method is shown in fig 1.

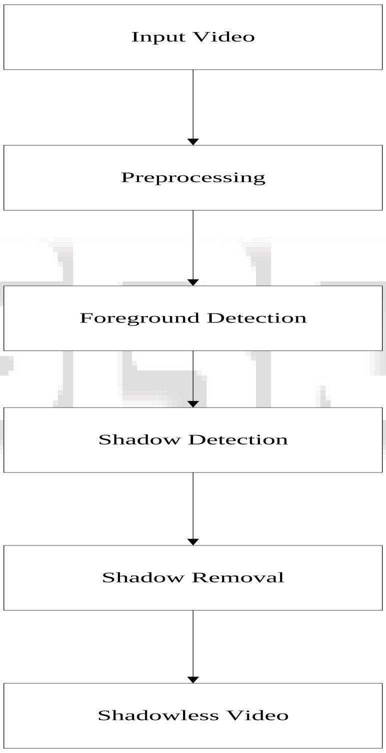

Fig 1 : phases of shadow detection and removal system

A. PRE-PROCESSING

The pre-processing step for the detection and removal of self and cast shadow on a moving object in a video sequence consists of two steps. In the first step, given input video is converted into sequence of image frames. In the second step, image frames are converted into a colour invariant model such as HSV. In HSV color model, color description is in terms of hue, saturation and lightness which are often more relevant.

B. FOREGROUND EXTRACTION

Prior to the shadow detection, foreground image must be detected. Foreground object consists of the moving object along with its shadow. In most of the video surveillance applications, background scene remains constant. Hence the subject of interest comes in detecting the foreground scene. Frame differencing, background subtraction, Guassian method are the different techniques used for foreground extraction. Once foreground is extracted, shadow region can be detected and removed easily.

C. SHADOW DETECTION

For effective shadow detection, features in which shadows differ from their moving objects must be extracted. According to assumptions of shadows, several types of features including intensity, color and texture are employed adequately. Shadow region can be detected using any of these features. Shadow region have lower intensity when compared to non-shadow region. Shadows doesn't change the texture of the object on which it is falling. These all features can be used for the detection of the shadow. Each feature has its own advantages and disadvantages. Sometimes a combination of two or more features is also using to detect the shadow region. In the proposed system, shadow detection is done using the features such as hue, saturation, and intensity. The pseudo-code for the detection of shadow region is as follows.

Step 1: start

Step 2: If all foreground images are processed, goto step 14.

Step 3: Read foreground image

Step 4: Extract Hue, Saturation, and Intensity of foreground image

Step 5: Extract Hue, Saturation and Intensity of background image.

Step 6: $Hue = | Hue_{foreground} – Hue_{background} |$

Step 7: $Saturation = | Saturation_{foreground} – Saturation_{background} |$

Step 8: $Intensity = Intensity_{foreground} / Intensity_{background}$

Step 9: If $Threshold_1 > Intensity > Threshold_2$, goto step 13

Step 10: If $Saturation > Threshold_3$, goto step 13

Step 11: If $Hue > Threshold_4$, goto step 13

Step 12: Spoint(x, y) = 1. Goto step 2

Step 13: Spoint(x, y) = 0. Goto step 2.

D. SHADOW REMOVAL

Once shadow has been detected, next step is to remove it. The normal way of removing shadow is by replacing the shadow region pixels with the corresponding background pixels. The psedocode for shadow removal is as follows.

Step 1: Start

Step 2: If all shadow regions are processed, then goto step 7.

Step 3: For every shadow region Spoint (x, y) = 0 , goto Step 5

Step 4: Frame (x ,y) = Background (x, y)

Step 5: Goto Step 2.

Step 6: Stop

III. EXPERIMENT DESIGN AND ANALYSIS

Evaluation metrics are the criteria under which different algorithms are tested. The metrics are used to determine the behavior of the algorithms and techniques. The different metrics used in the evaluation of shadow detection and removal system are True Positive (TP), True Negative (TN), False Positive (FP), False Negative (FN), and precision. The metrics values for three different kinds of input videos are shown in Table I.

Videos	True Positive	False Positive	True Negative	False Negative	Precision
Video 1	1562	12	756	35	0.9924
Video 2	2329	18	808	29	0.9923
Video 3	3932	16	846	47	0.9959

TABLE 1 : METRIC VALUES FOR DIFFERENT VIDEOS

Three different types of videos are used for the analysis of the shadow detection and removal system. First video is an outdoor real time video which is captured in a static camera. The background is set as static. In this video, only one moving ball with uniform color. The second video is an indoor laboratory video. In this video, two moving objects are there of different type in which only one is moving in the frame at a time. In third video, multiple moving objects are moving simultaneously in a laboratory.

Using ImageSeek tool, performance analysis of shadow detection and removal is done. The video frames from which shadow part removed manually are considered as groundtruth frames. Frames in the output video are compared with these groundtruth frames. ImageSeek tool displays a percentage for each of the groundtruth frame. This percentage is displayed in comparison with the groundtruth frame. The accuracy of shadow detection and removal for three different videos are tabulated in table II.

TABLE 2 : ACCURACY OF SHADOW DETECTION AND REMOVAL SYSTEM

Videos	Accuracy
Video 1	93.8975
Video 2	89.42
Video 3	91.84

IV. CONCLUSION

Detection and removal of shadows forms a major usage in computer vision. It covers many areas such as video surveillance to medical imaging. The proposed method effectively detects and removes shadow from video sequences. The shadow part of the foreground image is detected using the features such as hue, saturation, and intensity. Precision of the proposed system was calculated using the evaluation metrics such as true positive, false positive, true negative, and false negative. Precision value for video 1, video 2, video 3 are 0.9924, 0.9923, and 0.9959 respectively. Accuracy of the system is compared using ImageSeek tool. Accuracy for video 1, video 2, and video 3 are 93.8975, 89.42, and 91.84 respectively.

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