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Extraction Of Human Objects Following Gradient-Based Shadow Removal

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Abstract: Video surveillance in dynamic scenes is a great and useful system to meet the current and future challenges of security across the word. Because many forms of inhuman activity, such as terrorism and theft, etc., are beginning to pose a threat to the global community, security in public spaces has become more and more important in recent years. Tracking people in crowded environments is one of the most challenging tasks in a public security system because continuous human object tracking is very essential for public security to reduce human criminal activities. A very basic and critical task in any human object tracking system is the detection of moving objects in captured video sequences. Background subtraction method (BSM) is one of the most popular approaches to detect foreground objects. The key issue is that during foreground segmentation, the shadow merges with moving objects and could be mistaken for a foreground object. The recognition and elimination of shadows is an important pre-processing step to improve the performance of human object tracking systems, because the presence of shadows affects the reliability of human object tracking system. The existing gradient-based shadow removal approaches are discussed in this paper in order to improve the multiple human object tracking system's accuracy.

Index Terms **– Video surveillance system, background subtraction, shadow, Gradient based shadow removal.**

I. INTRODUCTION

Video surveillance system can be used in different areas such as commercial application and public security. The importance of public security in public places is increasing because terrorism and crime activities are increasing. So the video surveillance systems are used as an extensive tool for the observations, supervision and for the law enforcement in public places. Tracking people in crowded environments is one of the most difficult tasks of a public safety system, because continuous tracking of human objects is very important for public safety to reduce people's criminal activities. Many profitable and open source visual surveillance systems are available but these systems need additional resources with human operators to detect the video scenes. A strong automatic surveillance system with affordable cost is very essential since it is very difficult to handle the system by human operators. In a high density crowded environment this system is not feasible because the observation of the behavior and the activities of the people are very difficult and tedious and also it makes error clip. The primary aims of video surveillance systems are to provide an automatic interpretation of scenes to recognize and estimate the movements and interactions of the observed objects based on the information acquired by sensors. The extraction of the foreground item is the crucial and most significant task in any human object tracking system. Background subtraction is a powerful technique for extracting the moving objects. Low visibility, changing lighting, and weather-related disturbances are a few of the difficult problems that might arise while moving object extraction in video sequences, but casting shadows on the extracted foreground object is by far the most difficult.

A shadow occurs when an object partially of fully occludes direct light from light sources so shadow recognition and elimination is a significant pre-processing step for enhancing the performance of such vision tasks. The occurrence of shadows will change the size and shape of the moving objects because the shadow will move along with the moving objects and it will result in incorrect output due to false classification during occlusion detection. So shadow recognition and elimination is a significant pre-processing step for enhancing the performance of such vision tasks. The shadow can be categorized as self-shadow and cast shadow, among these the moving cast shadow cause serious problem in video based applications. The main problem is that the shadow is merging with moving objects during foreground segmentation and the background may be classified as foreground object. The two elementary rules followed for shadow detection are: 1) The shadow will not change the texture of the background 2) The cast shadow falls beyond the boundary of the object but the common boundary between the object and shadow is comparatively very small. Among these the moving cast shadow cause serious problem in video based applications and numerous cast shadow detection methods exist but accurate cast shadow detection and removal is a tedious task. The most common shadow detection methods are: Threshold based detection, Texture based detection, Region growing based detection, classification based detection, and Geometric property based detection

II. LITERATURE REVIEW

The important problem in foreground detection is the misclassification of shadow pixels as foreground object. So shadow detection and removal is a vital task in image processing when dealing with the outdoor environments. Shadow is an area that occurs only when objects occlude light coming from light sources .Presence of shadow degrades the performance of many surveillance applications due to the misclassification of object points. Shadow in an image reduces the working reliability of many computer vision algorithms. It often alters the visual quality of images. In outdoor environment, the effect of shadow will change the geometrical properties of the original image in some extent. Therefore the shadow should be detected and removed accurately and precisely because the shadows will degrade the performance of the foreground object detection when dealing with outdoor environment. Recognition of shadow is a tedious work in outdoor video surveillance and several algorithms exist to differentiate between moving object and its shadow.

According to the classification described in (Jiang et al., 1992), shadows are classified in to two categories: one is cast shadow and the other is self-shadow .A self-shadow happens only in the portion of an object which is not illuminated by the direction of light. That is, some part of object does not receive proper light from light source. A cast shadow is the area of object is projected by illumination of direct light. A cast shadow is further classified into umbra that corresponds to the area where the direct light is fully blocked by the object and the penumbra means area it is partially blocked. Umbra is a hard shadow region and the penumbra is a soft shadow region. In outdoor images, presence of cast shadow modifies the actual object shape and makes problems in obtaining and analysis of the accurate silhouettes. The presence of self-shadow modifies the actual shape of object and its color and the self-shadows have higher brightness than cast shadow but these are unclear shadows that do not have clear boundaries and so only cast shadow can be removed by using shadow detection and removal methods.

Various moving cast shadow detection techniques classified by the authors (Wei Zhang et al., 2007) are color based, texture based and geometry based methods. The authors (Habib Ullah et al., 2010) categorized the moving shadow detection based on intensity, color and statistical information and the authors (Andres Sanin et al., 2013) categorized the shadow removal methods according to chromaticity based, texture based and geometrical based methods. The authors (Horprasert et al., 1999) categorize each pixel into four different categories such as background, shadow, tinted background and moving foreground item by computing the distortion of brightness and chromaticity between background pixel and current image pixel. (H.T. Chen et al., 2001) adopt two things about shadow detection scheme: one is that the pixel intensity within shadow regions is likely to decrease in most cases when compared with background image and the second one is that the intensity reduction rate changes smoothly between neighboring pixels and shadow edges. A Coarse to fine approach is proposed by (Chia-Jung et al., 2002) for shadow elimination. In this method they have used static background through Gaussian shadow modeling to eliminate unwanted shadow and the information of vertical edge is used to separate multiple pedestrians from the background .Then coarse-to-fine approach is used to remove shadow from each extracted pedestrian. (Finlayson et al., 2002) proposed a method which uses illumination invariant image with the unique color image to find the shadow edges. (Kavitha Nagarathinam et al., 2017) employing stationary wavelet transform (SWT) based on a threshold established by wavelet coefficients to detect and eliminate moving shadows. The stationary wavelet transform's multi-resolution feature allows for the subdivision of the frames into four distinct bands without losing any spatial information.(Bingshu Wang et.al., 2016) proposed a method to extract shadows by jointly using three components of HSV chromaticity, improved local ternary pattern and the gradient for each pixel. Another shadow detection method is region growing and in this method, the seed pixels have been selected and set as shadow groups. When the pixel intensity is varied in the shadow region, the region growing algorithm will not provide better results. So the region growing algorithm cannot perform well in the penumbra part of shadow. The next shadow detection method is Gradient based shadow detection proposed by (Muhammad et al., 2009) and a fixed threshold is set and the neighborhood ratio of object boundary is calculated to detect shadow region. This method provides better results in real time applications. (Akmalbek Abdusalomov et.al, 2019) geometry and color information are utilized to remove detected shadow pixels that incorrectly include the foreground mask. The advantage of intensity based shadow removal technique is that the function for intensity is estimated directly from the data without any other assumption. But the problem is that, the intensity value of pixel is affected to illumination changes. In texture based method, similarity between background and shadow texture as well as the difference between foreground and texture are calculated to extract shadow and this method is applicable for indoor environment and it is very difficult to implement and also difficult to work it with outdoor environment. The color tune value of background and shadow are same but intensity is different. In the color based shadow detection methods, the color difference of shadow pixel and background pixels as well as illumination invariance are used for shadow removal.

The choice of the best shadow detection and removal method depends on the characteristics of data set being used. Colour based method is applicable for any coloured image but may fail when intensity of shadow and background is same and the colour of objects is same or darker than background. In the proposed system Gradient based method is chosen because this method well performed in real time system to extract cast shadow region.

III. GRADIENT BASED SHADOW REMOVAL

The first step of any human object tracking system is to capture the video. To capturing of video images, monocular approach is adapted. In monocular approach, only one camera is used to capture the video. The initial process of the object tracking algorithms is moving object segmentation and the background subtraction is the most foreground extraction method if the captured video is from static camera. The adaptive Gaussian Mixture Model is used in the system which represents each pixel in the image as a mixture of K Gaussian distribution of the pixel intensity. Once the foreground object is identified using GMM, each foreground pixel is checked whether it is the part of the object or shadow. Shadow detection is very significant because, shadow of the background object may get combined with the foreground object. In such situation tracking of occlusion detection is a tedious task. Generally two types of shadows occur in a scene while capturing a video sequences. First one is static which does not move with the moving objects while the second one is reflected as cast shadow. The cast shadow is generated due to occlusion of light by moving objects. The intensities of pixels related to the cast shadows are relatively different from the corresponding background pixels. The background estimation algorithms cannot differentiate the shadows from actual moving objects. So, shadow is projected along with moving object and these pixels will be misclassified as foreground objects during moving object extraction. The presence of cast shadow makes inaccurate silhouette i.e. Separate objects are seem to be combined together due to shadows. It will affect the performance of human or human group classification. In real time outdoor environment, gradient based shadow detection methods provide better results to remove cast shadow. So in the proposed system, the existing gradient based shadow removal method (Muhammad Shoaib et al., 2009) is used in outdoor environment. The Figure 1 shows the Block diagram of Gradient based shadow detection and Removal.

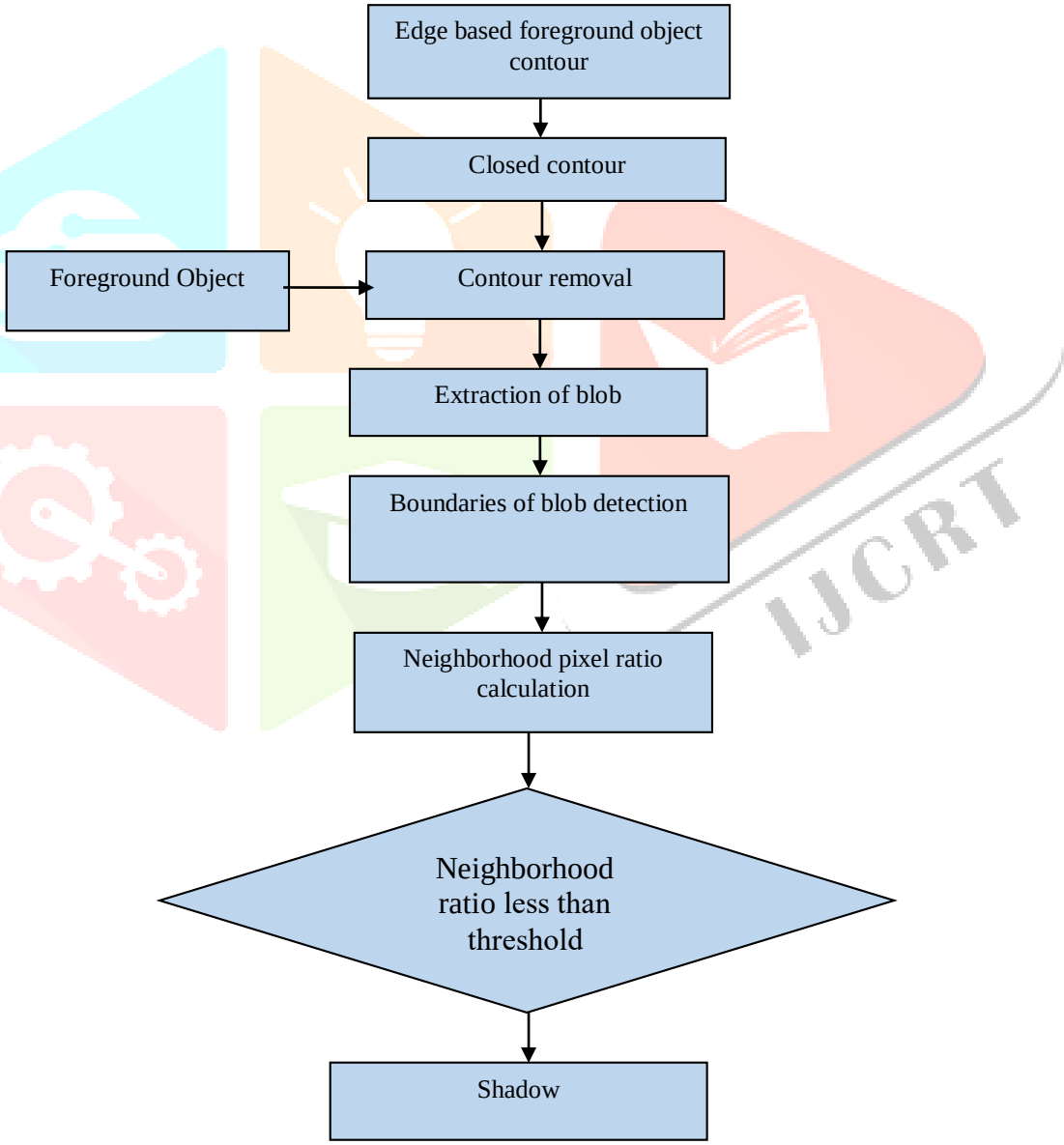
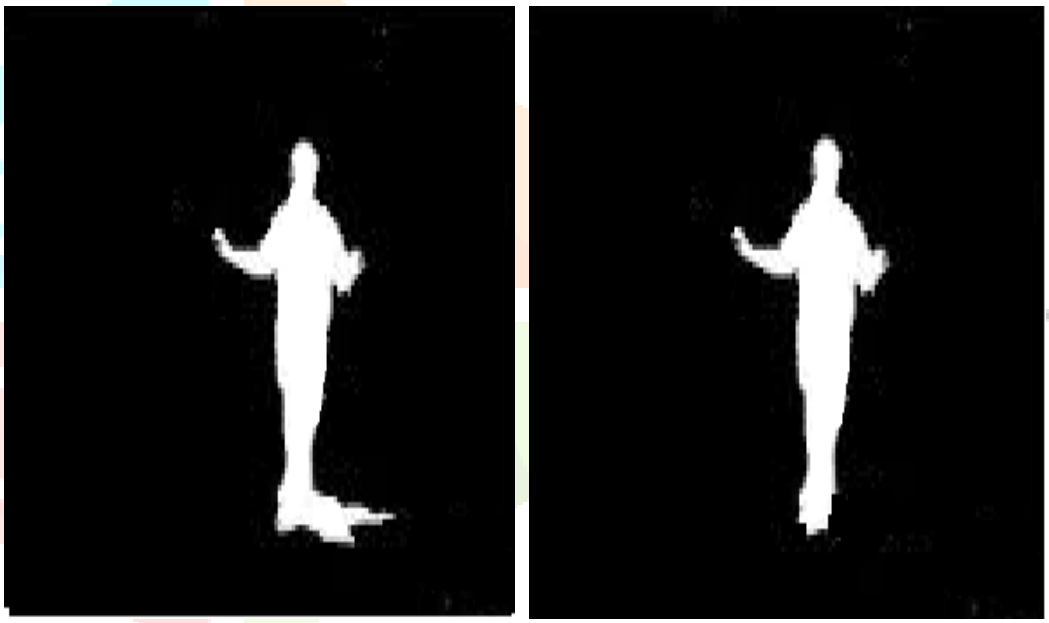


Figure 1. Functional Block Diagram of Gradient Based Shadow Detection& Removal

In the gradient based shadow detection method, the pixels lying outside of the object contour is considered as shadow. In this method, the location of shadow is determined on the basis of its connectivity with the contour. Any pixels lying inside a closed object contour has greater connectivity and that pixels are considered as parts of the human body. The shadow has both internal and external boundaries and the internal boundary is placed near to the object contour. This method can successfully remove the pixels due to shadow and sudden illumination changes in the foreground objects which is applied in the extracted foreground object using Gaussians mixture model .The first step is to detect contour cntr(x,y) of each foreground object. The detected contours are not always completely closed and it will affect the performance of the algorithm. So the contour closer $cntr^{cr}$ (x,y) should be performed after contour pixel detection. For every foreground pixel, the pixels in right and bottom are checked to detect the foreground neighbor, if this pixel is present, the procedure moves to the next foreground pixel. If not found the pixel, then the searching continued in the same direction until it reaches to the limit T_{vert} or T_{horz}. The pixels within these limits are connected by changing the intensity in between background to foreground pixels. Gradient based contour pixels are connected and the number of blobs generated are identified by connected component analysis may place inside or outside of the object contours are extracted. Then boundaries around each blob are calculated. A neighborhood ratio for every blob is calculated to extract shadow region. For each boundary pixel in a blob, its eight neighbors are tested to check whether they overlap with the contour of object. The count of match M_{count} is incremented if any of the 8 neighbors exists. Finally the neighborhood ratio N_{ratio}, for a blob is calculated by dividing its count of match C, by its total number of boundary pixels , B_{count},

$$N_{ratio} = M_{count} / B_{count} \quad (1)$$

If N_{ratio} of a blob is less than a predefined threshold Th , then that region is considered as a shadow and is discarded from the color based background result. The example of shadow removed image using Gradient based algorithm is shown in Figure 2.



(a) Foreground Object with Shadow (b) Results after Shadow Removal

Figure 2. Gradient Based Shadow Removed Image

IV. EXPERIMENTAL RESULTS

In this section we shows the performance of Gradient based shadow removal method for different video samples. The following video sample #1 shown in figure 3 has the dimension 320X240 is captured from a Railway station to test the competence of the Gradient based shadow removal system in real time scenarios. This video sequence contains a number of waving tree leaves in the background and all the moving regions in a particular video frame are segmented by the Gaussian Mixture Model is shown in figure 4.

Figure 3. Video Sample # 1 Captured from Railway Station

It is clear that using GMM based background subtraction all small moving particles are segmented from the background but the extracted foreground objects have the effect of cast shadow and it will affect the performance of occlusion detection process. So shadow detection and object classification are the very important steps after morphological processing in the extracted foreground object.

Figure 4 .Result of GMM with Non Stationary Background

The Gradient based shadow detection algorithm is used in the proposed system and the working process results are shown in figure 5. In the Gradient based shadow detection method the pixels lying outside of the object contour is considered as shadow.

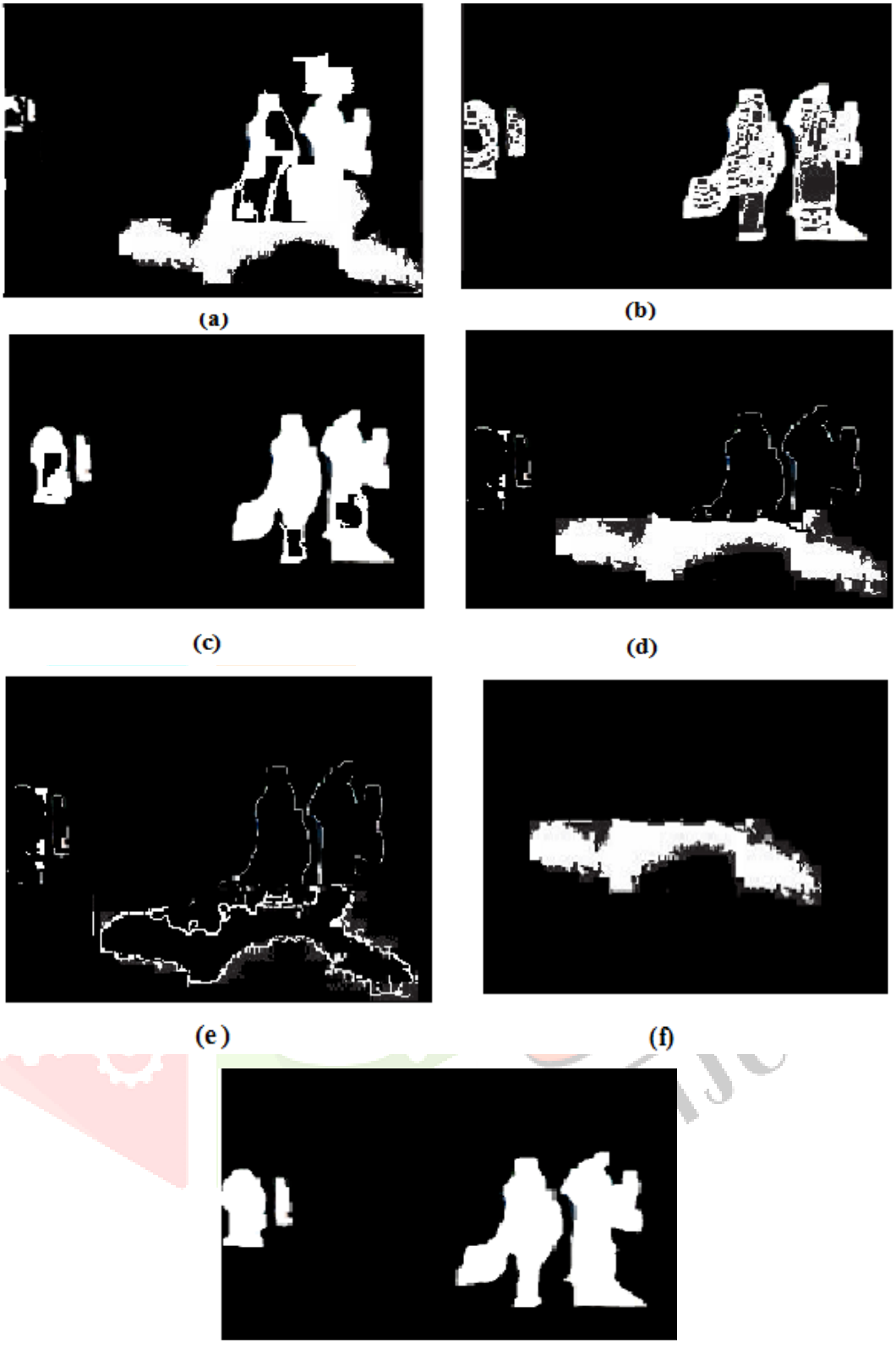
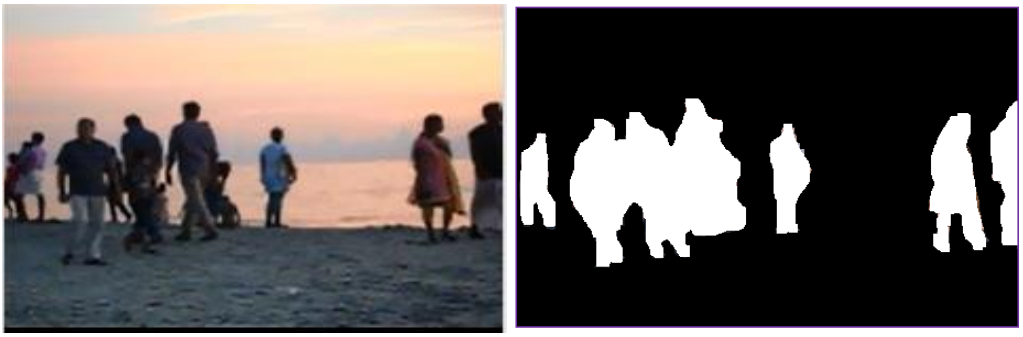


Figure 5. Shadow Removal Process. (a) Foreground Object Segmentation using GMM (b) Contour of Foreground Image (c) Contour Closer of Objects (d) Part of objects as Shadow (e) Boundary of Shadow (f) Shadow after Neighborhood Ratio (g) Binary Foreground Object after Shadow Removal.

The shadow removal using Gradient based method is perfectly working with Multi human tracking environment .Figure 6 shows the result of shadow removed foreground object sample with multiple human objects. The sample #2 is a crowded atmosphere collected from the Alappuzha Beach and the second video sample #3 is collected from the Govt. Medical College, Alappuzha.



Video Sample #2: (a) Input Frame (b) Shadow Removed Foreground

Video Sample #3: (a) Input Frame (b) Shadow Removed Foreground

Figure 6. Results of Gradient based Shadow Removal in Multiple People Sites

CONCLUSION

The influence of shadow makes it difficult to extract human objects in any human object tracking system. In this study, a monocular method is employed to record video in various outdoor settings. After frame conversion, the foreground object is extracted using the straightforward Background subtraction method (BSM). The foreground objects that were extracted are combined with shadow in various climatic conditions. Any human object tracking system's performance will suffer as a result. The current gradient-based shadow removal method produces better results in this paper. However, the difficult issue we have is that by using the background removal method, all objects other than human objects are likewise incorrectly identified as human. Future efficiency improvements will also require an effective human object classification algorithm.

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