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Hybrid Video Segmentation with Feature Extraction using Anisotropic Diffusion

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Abstract- In recent years, video segmentation is considered as the major research area for digital storage. Video segmentation is different from the image segmentation. Video segmentation is a challenging problem. In video segmentation, for a given image the segmentation achieved should be related to the previous image that belongs to the same shot. In our proposed video segmentation technique, at first the similar shots in the video are segmented by using conversion of frames using shot segmentation. Next for each shot the track frames are collected with the help of the extracted objects in every frame by using anisotropic diffusion. Effective video segmentation results are obtained in the proposed hybrid video segmentation technique by performing intersection on the segmented results provided by both the frame difference method as well as consecutive frame intersection method. Here we utilized the anisotropic diffusion method for the object extraction from the video shots for segmentation. Therefore our proposed technique is evaluated by varying video sequences and also the efficiency is analyzed.

Keywords- *Video segmentation, Anisotropic diffusion, frame difference method, intersection method.*

I. Introduction

One of the main challenges in computer vision is automatic comprehension of complex dynamic content of videos, such as detection, localization, and segmentation of objects and people, and understanding their interactions [27]. Image and video segmentation is very beneficial in several applications for finding the regions of interest in a panorama or annotating the data [28]. MPEG-4 is a promising standard for multimedia communications. MPEG-4 provides standardized ways to encode the video and audio objects, and the scene description, which represents how the objects are structured in a scene [29]. Due to the sudden growth in digital video content, an efficient way to access and manipulate the information in a huge video database has become a difficult and timely issue [4]. Therefore, the need for developing tools and systems that can effectively search and retrieve the desired video content has gained enormous popularity among researchers. Recent development of range-camera technology has the potential to capture the range video in an applicable frame rate and frame resolution [5]. The video segmentation is an imperative technique used for the improvement of video quality on the basis of segmentation [6]. The function of video segmentation is to segment the moving objects in video sequences [7]. Video segmentation is entirely different from single image segmentation [8]. The bad quality segments such as very blurred or shaking clips should be eliminated or recovered, because these clips often irritate the viewer's [9]. Video object segmentation is an important issue in video analysis, and it has several applications namely post-production, special effects, object detection, object tracking, and video compression [10].

In video segmentation, the video is segmented into spatial, temporal, or spatiotemporal regions that are consistent in some feature space [29]. Video segmentation is an important process in image sequence analysis and its results are broadly employed for describing the motion features of scene objects, and also for coding purposes to minimize the storage requirements [11]. Different methods and algorithms have been introduced for video segmentation, where each having its own features and applications [12]. These video segmentation algorithms are classified into three categories: edge information based video segmentation, image segmentation based video segmentation and change detection based video segmentation [13]. The segmentation of each frame of a video into homogeneous regions is an important issue for many video applications [14] such as region-based motion estimation, image enhancement (since different processing may be applied on different regions), and 2D to 3D conversion [15].Scene segmentation has many applications in various domains. For example, in the feature films, scene segmentation provides the chapters that correspond to the different sub themes of the movies [16]. In television videos, segmentation can be used to separate the commercials from the regular programs. In news broadcast programs, segmentation can be used to identify different news stories and videoconferencing application [17]. In home videos, scene segmentation may help the consumers to logically organize the videos related to the different events (e.g., birthday, graduation, weddings, or vacation) [18].

In this work, we proposed dynamic and static foreground and background video segmentation using hybrid technique. The rest of the paper is organized as follows; a brief review of the researches related to the video segmentation is given in Section 2. The proposed video segmentation technique is given in section 3. The experimental results of the proposed approach are presented in Section 4. Finally, the conclusions are given in Section 5.

II. RELATED WORK

Panagiotis Sidiropoulos et al.[19] have proposed a technique, where the low-level and high-level features extracted from the visual and the aural channel have been used jointly. The proposed technique has been built upon the renowned method of the Scene Transition Graph (STG) for overcoming the difficulties of existing scene segmentation techniques. Firstly, a STG approximation has been introduced for reducing the computational cost, and then the unimodal STG-based temporal segmentation technique has been extended to a method for multimodal scene segmentation. The latter has exploited the results of numerous TRECVID-type trained visual concept detectors and audio event detectors using a probabilistic merging process that merges several individual STGs while at the same time reducing the need for selecting and adjusting many STG construction parameters. Their proposed approach has been analyzed using three test datasets, such as TRECVID documentary films, movies, and news-related videos.

Kuo Liang chungi et al.[20] have developed a promising predictive watershed-based video segmentation algorithm using motion vectors. The proposed algorithm has much computation-saving merit because the next frame could take over the segmented results of the current frame based on the motion vector information of the next frame. Their proposed algorithm has achieved a better execution-time performance as compared to the existing Chien et al.'s video segmentation algorithm whose input video sequence was assumed to have no motion vector information. Moreover, the mitigation of the over-segmentation problem occurred in both algorithms has been examined.

Chasanis et al. [21] have proposed herein, local invariant descriptors were used to represent the key-frames of video shots and a visual vocabulary was created from these descriptors resulting to a visual words histogram representation (bag of visual words) for each shot. A key aspect of our method was that, based on an idea from text segmentation, the histograms of visual words corresponding to each shot were further smoothed temporally by taking into account the histograms of neighboring shots. In this way, valuable contextual information was preserved. The final scene and chapter boundaries were determined at the local maxima of the difference of successive smoothed histograms for low and high values of the smoothing parameter respectively. Numerical experiments indicate that our method provides high detection rates while preserving a good tradeoff between recall and precision.

III. HYBRID VIDEO SEGMENTATION METHOD FOR DYNAMIC AND STATIC FOREGROUND SEGMENTATION

In video segmentation, the extraction of individual objects from the frame is very crucial issue and therefore our proposed video segmentation method extracts the objects from each frame. Also the proposed technique segments both the dynamic and static foreground objects without considering global motion. The motion segmentation process is carried out by both the frame difference algorithm and intersection method subsequently the most common and accurate segmented objects are retrieved from both the segmented results whereas the static foreground are segmented using the intersection of consecutive frames. Here we use anisotropic diffusion for extracting features from the object. The below figure shows the process used in our proposed method.

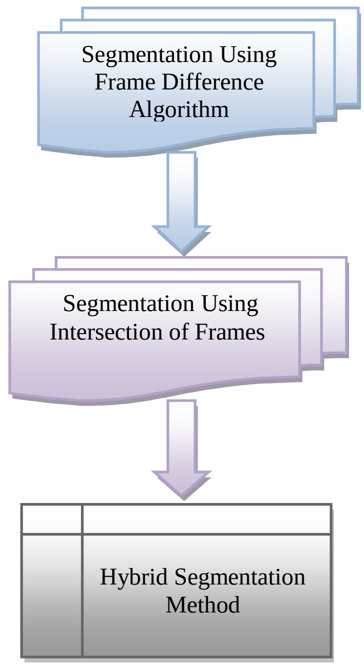


Figure 1: Process of video segmentation method

A. *Frame Difference Algorithm and Anisotropic Diffusion Based Segmentation*

In dynamic and static foreground segmentation using frame difference algorithm the segmentation process is carried out by using conversion of frames using shot segmentation and after extraction of object using anisotropic diffusion frame sequence assortment is used. The below figure 2 shows the process involved in dynamic and static foreground segmentation using frame difference algorithm.

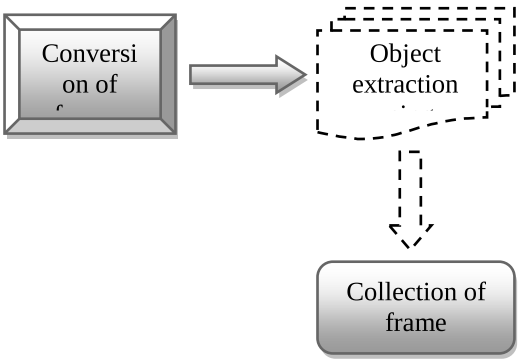


Figure 2: Shows the process of dynamic and static foreground segmentation using frame difference algorithm

1. Conversion of Frames Using Shot Segmentation

The video segmentation algorithm is mainly used for partitioning of each frame into distinct objects. Significant progress has been made on this research topic, although the problem itself is fundamentally ill-posed. The conversion of frames using shot segmentation uses video decomposition techniques which aim to partition a video sequence into shots. The term video commonly refers to several storage formats for storing moving pictures. The video consists of consequent sequence of frames which is a single picture or still shot run in succession to produce what appears to be seamless piece of film or video tape.

Let $V_{M\times N}$ be the video to be segmented where $'L'$ is the total no of frames present in the video.

$$V_{M\times N} = f_{(i)}(x,y) \quad ; \qquad i=1,2,......L$$
$$x=0,1,2,....M-1$$
$$y=0,1,2,....N-1$$

The shot is defined as a sequence of frames which are captured from a single image. In video segmentation the conversion of frames using shot segmentation is necessary for grouping the similar shots. In this shot segmentation similar shots are grouped together for improving the performance of the segmentation. To accomplish this task initially all the frames are partitioned into $m\times n$ patches and every patch are converted to its equivalent frequency coefficients by means of Discrete Cosine Transform (DCT) (i.e.) DCT is applied to every patch in the frames as follows.

$$T_{ik} = D_{ik} \times f_{ik} \times D' \qquad (1)$$

Where

$$D_i(a,b) = \left(\frac{2}{(m\times n)^{1/2}} \right) \eta_a \eta_b \sum_{p=0}^{m-1}\sum_{q=0}^{n-1} f_{i,k}(p,q) \cos\left(\frac{\pi.a}{2m}(2p+1)\right) \cos\left(\frac{\pi.b}{2n}(2q+1)\right) \qquad (2)$$

$$\eta_a = \begin{cases} \left(\frac{1}{2}\right)^{1/2} & if \;\; a=0 \\ 1 & if \;\; 1\le c\le m-1 \end{cases} \qquad (3)$$

$$\alpha_c = \begin{cases} \left(\frac{1}{2}\right)^{1/2} & if \;\; b=0 \\ 1 & if \;\; 1\le c\le n-1 \end{cases} \qquad (4)$$

$1\le k\le P_{(i)}$ Where P_i is the number of patches present in the i[th] frame. Thus all the patches are transformed to transform domain subsequently the Euclidean distance of every patches of consequent frames and their total mean are calculated as follows.

$$D_j = \frac{\sum_{i=1;k=1}^{L;P_i} \sqrt{(T_{i,k} - T_{i+1,k})^2}}{P_{(i)}} \qquad (5)$$

Where $1<i, j\le L$ and $1\le k\le P_{(i)}$. The frames belongs to the similar shots are identified based on the mean distance. Hence the segmentation is carried out in dynamic and static foreground segmentation using conversion of frames in to shot segmentation.

2. Object Extraction Using Anisotropic Diffusion:

The objects in every frame are identified for segmentation. Let $\delta = \{\delta_a \mid 1 < a \le \mathbf{A}\}$ be the result of shot segmentation where 'A' is total no of shots and $\delta_a = \{ f_{aj} \mid 1<a\le \mathbf{A}; 1<j\le |\delta_a| \}$ be the set of similar shots where '$|\delta_a|$' are the total no of frames in a[th] shot in the segmented results. The initial frames in every shot are taken as key frame for object extraction for example the f_{11} is key frame for shot δ_1 which is known as $f_{key(1)}$. Likewise each shot having its own key frames.

$$\hat{f}_{aj} = 0.2989 * f_{aj}^{(r)} + 0.5870 * f_{aj}^{(g)} + 0.1140 * f_{aj}^{(b)} \qquad (6)$$

It is a great deal of interest in anisotropic diffusion since it was first proposed by Perona and Malik as a useful tool for multi scale description of images, image segmentation, edge detection, and image enhancement. The basic idea behind anisotropic diffusion is to extract features from an original image derived from the solution. The anisotropic diffusion coefficient c is a non-negative function of the magnitude of a image gradient also by using this the edges were sharpened. Edge detection is a problem of fundamental importance in image analysis. In typical images, edges characterize object boundaries and are therefore useful for segmentation, registration and identification of objects in a scene. Therefore here in anisotropic diffusion edge detection is used and carried out the method. Using edge operators the edge point set extracted and also some edge points in the edge point set are removed and the obtained edge points are connected to be a line. Therefore edge detection is used and therefore as $E(r,g,b)$ be a vector value function and it says that the $E(r,g,b)=o$ in the interior part of each region and $E(r,g,b)=Ke(r,g,b)$ at each edge point, where e is a unit vector to the edge at the point and K is the local contrast of the edge.

3. Collection of Frame Sequence

In collection of frame sequence, after the shot segmentation, the track frames of the every shot are identified using the objects of their key frame. Therefore the objects that appear simultaneously in at least two consecutive frames can be compared directly in terms of their motion so the assortment of the track frames is a required pre-processing step for segmentation this track frame selection process reduces the computational time of segmentation. The objects of the key frame are compared with the other frames of the shot for their presence in the frame. If the object is present in any of the frame then its frame index is stored in $T_j^{\,i}$. For example if the object of key frame $f_{key(1)}$ is presented in the k^{th} index of shot then the index is stored in $T_1^{\,1}$. Likewise all the track frames of the every shot are identified.

IV. Frame Difference Algorithm for Dynamic Foreground Segmentation

In the background subtraction method the key frame of every shot is consider as background. Also at each $\hat{f}_{aj}$ frame, the $\hat{f}_{aj}(p,q)$ pixel's value can be classified as foreground pixel if the following inequality:

$$\hat{f}_{aj}(p,q)-\hat{f}_{a1}(p,q)>\lambda \tag{7}$$

The $\hat{f}_{aj}(p,q)$ will be classified as background pixel value. Where $\hat{f}_{aj}(p,q)$ is the current frame pixel value, $\hat{f}_{a1}(p,q)$ is the key frame value and 'λ' is the threshold pixel value in foreground. The pseudo code 2 details the background subtraction method.

A. Hybrid video segmentation using Intersection of frames

The dynamic and static object segmentation using intersection of frames yields to conversion of gray scale to binary image operation and therefore it is as follows

B. Conversion of gray scale to binary Image:

The conversion of gray scale to binary image is said to be binarization. Therefore the binarization separates the foreground (text) and background information. The most common method for binarization is to select a proper threshold for the intensity of the image and then convert all the intensity values above the threshold to one intensity value ("white"), and all intensity values below the threshold to the other chosen intensity ("black").

$$\hat{\hat{f}}_{aj} = \begin{cases} 1 \ ; \ if \quad \hat{f}_{aj} > \Gamma \\ 0 \ ; \ otherwise \end{cases} \tag{8}$$

Where, 'T' is a global threshold value for binarization. After performing the binarization the consecutive frames are intersected to segment the dynamic and static objects. Let $\hat{\hat{f}}_{11}$ and $\hat{\hat{f}}_{12}$ be the binarized form of frame1 and frame2 in shot1 respectively. The dynamic motion objects are found as follows

$$G2_{aj} = \hat{\hat{f}}_{11} - f'_{aj} \tag{9}$$

Where, as the static foreground are segmented as follows

$$f^{i}_{aj} = \hat{\hat{f}}_{11} \cap \hat{\hat{f}}_{12} \tag{10}$$

Likewise all the consecutive frames are intersected to achieve the static and dynamic object segmentation. Then dynamic and static object based on hybrid methods are used

C. Hybrid video segmentation method

Let $G1=\{S_i \ |1<i\leq n\}$ and $G2=\{S_i^{'}|1<i\leq n\}$ be the segmented results of dynamic objects using frame difference algorithm and frame intersection techniques respectively. In this technique by subtracting the background of segmented motion objects and the later segmentation technique yields the motion object by intersection method. Therefore by using the below equation (13) segmentation results were obtained. The 'G' consists of final segmented motion objects.

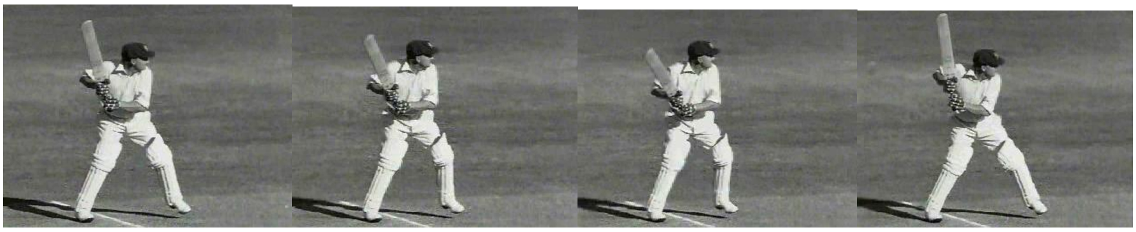
$$G = G1 \ \cap G2 \tag{13}$$

D. Linguistic image operation:

The four most basic operations in mathematical operations are dilation, erosion, opening and closing. The segmented motion objects are subjected to dual morphological operations for getting the improved segmentation results. Morphological processing is constructed with operations on sets of pixels. The process is functioned by placing the constructing element on the image and descending it transversely to the image in a routine related to complexity. Output image is acquired by utilizing a structuring element to the input object. The value of each pixel in the output image is constructed by measuring the conformed pixels in the input image with it are abutted. By adjusting the contrast and intensity parameters of the image I is converted in to binary form I_b .

V. RESULTS AND DISCUSSION

In our proposed video segmentation approach has been validated by experimenting with variety of video sequences. The proposed system has been implemented in Matlab (Matlab7.10). The performance of the proposed approach is compared.

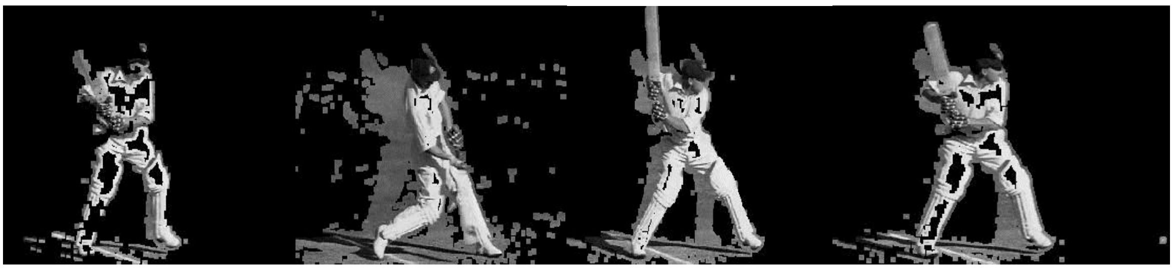


(a)

(b)

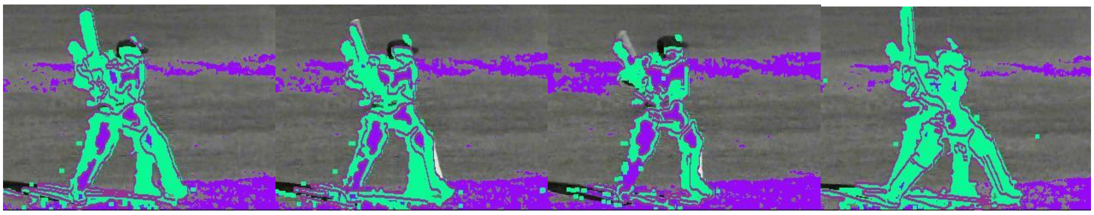
Figure 3: (a) Sample frames, (b) Extracted Objects
figure 3 shows the sample frames 2, 5, 8, and 15 are the sample frames we used here and the extracted objects using anisotropic diffusion is shown in fig 3.b

(c)

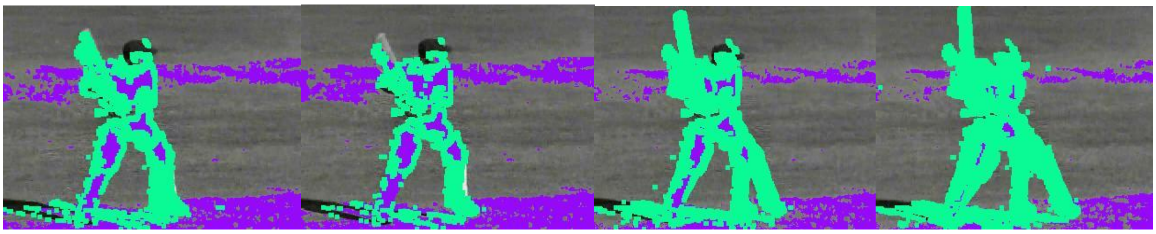


(d)

Figure: 4 (c) Segmented static objects using frame difference method (d) segmented dynamic objects using frame difference method



(e)



(f)

Figure: 5 (e) Shows the Segmented static and dynamic objects using intersection method, (f) Shows the Segmented static and dynamic objects using hybrid method

Figure: 6 shows the objects for morphological operation

The figure 4 shows the segmented static and dynamic objects using frame difference method and the figure 5.(e) shows the Segmented static and dynamic objects using intersection method and the figure 5.(f) shows the Segmented static and dynamic objects using hybrid method. The figure 6 shows the morphological operation of the object for the corresponding sample frames.

5.1. Performance Evaluation

The performance of the proposed system is evaluated by the statistical measures like sensitivity and specificity. The output of the proposed system may be positive (Segmenting the objects) or negative (non-segmenting the objects). The output of the proposed system may or may not be match with the original status of the image. Consider the following setting for the statistical measures.

- **True Positive (TP):** Valid objects correctly segmented.
- **False Positive (FP):** Invalid objects incorrectly segmented.
- **True Negative (TN):** Invalid objects correctly non-segmented.
- **False Negative (FN):** Valid objects incorrectly non-segmented

The sensitivity value represents the percentage of recognition of actual values. Specificity value represents the percentage of recognition of actual negatives.

Accuracy is degree of closeness of measurements of a quantity to its actual (true) value. The performance is also analysis by the kappa coefficient which is as below. The table 1 represents the statistical measures of the proposed system for the different frames in a video sequence-I.

TABLE 1: SHOWS THE PERFORMANCE ANALYSIS OF TP, TN, FP, FN AND KAPPA-COEFFICIENT AND THEREFORE IT IS PROVED TO BE BEST WHILE COMPARING TO THE EXISTING METHOD.

TP	TN	FP	FN	KappaCoff
25049	67021	4730	1323	0.946722
24912	67266	4622	1817	0.949664
25302	67015	4483	1540	0.964804
37096	66080	3624	2048	0.969907

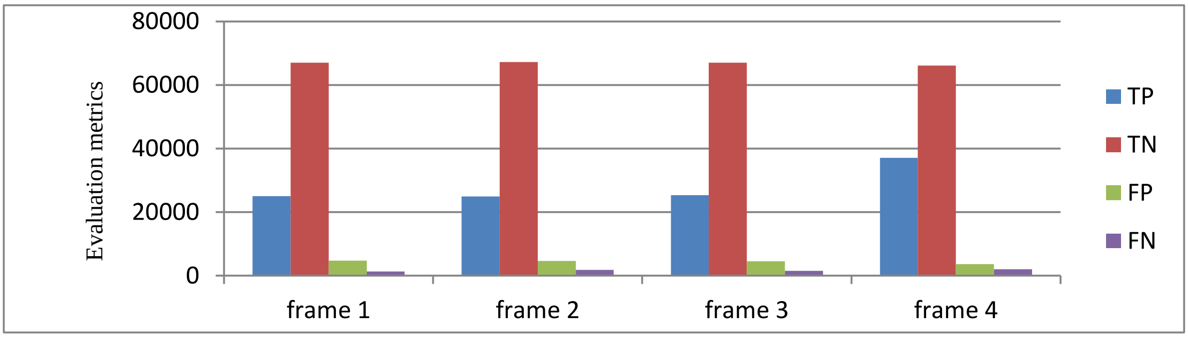


Figure 7: shows the performance analysis of TP, TN, FP, FN and kappa-coefficient

5.2 Performance analysing with existing methods:

The comparison analysis is given here for the three videos. Hence the measure is taken for segmented areas of all the three videos and therefore the table and graph for all the three videos were shown below as follows:

TABLE: 2 COMPARISON TABLE FOR STATISTICAL MEASURES OF VIDEO-I

Fuzzy k-means clustering based segmentation	Fuzzy C-Means Clustering based video segmentation	Anisotropic diffusion based segmentation
3308	3878	7403
3954	5890	7788
10419	16713	20145
5225	7058	8067

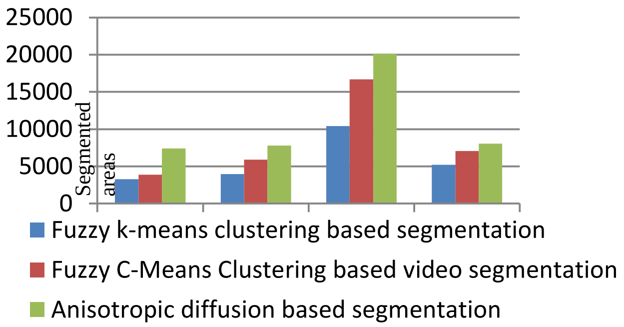


Figure: 8 Comparison graph for statistical measures of video- I

TABLE 3: HERE THE IMPROVED ACCURACY IS SHOWN FOR ALL THE THREE WORKS AND HENCE THE ABOVE THREE GRAPHS SHOWS THAT OUR FINAL PROPOSED TECHNIQUE TO BE BEST AND EFFICIENT METHOD FOR VIDEO SEGMENTATION.

Fuzzy k-means clustering based segmentation	Fuzzy C-Means Clustering based video segmentation	Anisotropic diffusion based segmentation
21917	32693	39294
21072	31385	38445
21925	31503	38564
40957	51500	52534

VI. CONCLUSION

In this paper, we have proposed a hybrid video segmentation technique to segment both the static and dynamic objects. The segmentation process using the frame difference algorithm basically segments the objects by considering the key frame as background which only produced the motion difference from key frame with remaining frames. The proposed technique also utilizes consecutive frame intersection method which considers consecutive frame differences and hence provided better result. The addition of anisotropic diffusion method for extraction of objects in the video shots also proves to be effective in segmentation. The accuracy of the method is analyzed for different video sequence and the results shows that the proposed method is effective for segmentation.

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