Research Paper

MULTILEVEL THRESHOLDING FOR VIDEO SEGMENTATION USING IMPROVED FUZZY C-MEANS CLUSTERING ALGORITHM

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ABSTRACT:
Video segmentation has been a significant and challenging problem for many video applications. The major issue involved in retrieving and storing the video data is video segmentation. Video segmentation is a clustering process that classifies one video succession into several objects. Spatial information enhances the quality of clustering process which is not utilized in the conventional FCM. Generally the fuzzy c-mean (FCM) algorithm is not robust against noise. Therefore, it is not used in video segmentation. An improved fuzzy c-means (IFCM) algorithm incorporates spatial information into the membership function for clustering of color videos. In this paper, HSV and IFCM models are used. Hue, Saturation Value (HSV) model is used for decomposition of color video and then IFCM is applied separately on each component of HSV model. For optimal clustering, gray scale image is used. Additionally, spatial information is incorporated in each frame separately and multilevel thresholding is applied to get better frame. In this paper, a powerful method is used for noisy color video segmentation and it works for both single and multi-feature data with spatial information. The result shows that the proposed method reduces noisy content in an image and enhances the image accuracy.

KEYWORDS: Fuzzy C-Means, HSV, Improved Fuzzy C-Means, multilevel thresholding, spatial information, video segmentation.

I. INTRODUCTION

The process of analyzing and manipulating images using a computer vision is image processing. This operation is performed in order to get an enhanced image. The advantages of Digital Image Processing are that, 1) it allows many algorithms to be applied to the input data and 2) It avoids noise and signal distortion problems. An image (digital image) is created by a finite number of pixels, each of which has a particular location and values. These elements are called image elements, and pixels. Image segmentation plays a vital role in image processing domain. The role of segmentation is crucial in most tasks requiring image analysis. However, a accurate segmentation of an image is very difficult to achieve by purely automatic means.

A) Application of Segmentation

1) Industrial inspection
2) Optical character recognition (OCR)
3) Tracking of objects in a sequence of images
4) Classification of terrains visible in satellite images.
5) Detection and measurement of bone, tissue, etc., in medical images.

It is the method by which an image is subdivided into homogeneous regions that have same intensity, colors, and contours (i.e) partitioning of image into various non-overlapping regions or partitioning a digital image into multiple segments (set of pixels). The Figure 1 shows the basic block diagram of video segmentation.

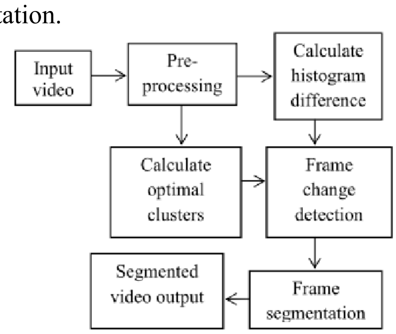

Figure 1: Basic Block Diagram of Video Segmentation

There are different techniques for segmentation scheme e.g. thresholding, clustering, artificial neural networks (ANNs), region growing, edge detection etc. Thresholding plays a very effective role in the field of segmentation. Depending on the threshold value selected from histogram of the image, there are two thresholding techniques they are: (a) bi-level thresholding (b) multilevel thresholding. If the object in an image is extracted from the background by computing a single threshold value, it is termed as bi-level thresholding. Classifying an image into several different regions according to color, and then by setting multiple threshold values in an image is known as multilevel colored image thresholding. In this paper, a multilevel thresholding is used and it is applied in each frame of video by the IFCM clustering algorithm. Thresholding techniques are very popular for segmenting the gray-scale images because of their simplicity. However, color image segmentation is still a challenging field in image processing. In case of color image multilevel thresholding, there are 3 color bands such as red, green, and blue frames has been considered to obtain the segmented color image.

The rest of this paper is organized as follows. Section II gives a brief overview of the related work. Sections III present our new salient object clustering and IFCM algorithm for video segmentation. The experimental results and discussion are given in Sections IV. Finally conclusion is presented in section V.

II. RELATED WORK

The SLIC and FCM algorithms are used for video segmentation in order to track and segments an object from the video was done by Priyanka Dhiman and Mamta Dhanda [1].

Jiamin Ning et al.[2] shows a method of modern intelligent video surveillance, an optimizing motion detection algorithm aim at overcoming the flaw of conventional background subtraction algorithm. Sudhanshu Sinha, and Manohar Mareboyana [3] describes the video segmentation scheme with simplified mean shift filter and K-Means clustering are used in modelling the background.Kalpana Shrivastava et al.[4] described that the modified k-means clustering used in the medical image reduced the noise present in the image by calculating it. Joshi et al.[5] presented a fuzzy clustering method to short video sequences with gradual shot changes. Its centroid frames are selected as key frames, for each shot. Their approach has two major problems. First, the number of clusters has to be pre-assigned. In real situation, the actual number of clusters may not be known in before the time. Second, the more abrupt shot changes in a long video sequence and produce more inaccurate clusters. Therefore, this method is not suited for long video sequences with abrupt shot changes.

Rajasekhar Nalabolu et al. [6], proposed a motion detection method based on background subtraction which using morphological processing and fuzzy color histogram. The morphological process and filtering are used to remove unwanted pixel from the background, which is used in dynamic texture scenes. The background subtraction algorithm uses fuzzy color histogram (FCH), which having an ability to reduce color variations generated by background motion. The drawback of histogram based methods is, it would not able to consider spatial contextual information of the image and it is computationally complex.

III. METHODOLOGY

3.1 Video Segmentation

The video segmentation refers to decomposing a video data into meaningful elementary parts. The result of video segmentation is a set of segments that collectively cover the real entire video data. A video signal keeping of temporal information, which introduces the object motion and camera motion concept, is one of the major differences between image signal and video signal. Therefore Video has both temporal nature and spatial (static) nature.

3.2 Traditional Fuzzy C-Means Clustering

Fuzzy c-means (FCM) is a method of clustering which divides one piece of data to be in the right position to two or more clusters. This method (developed by Dunn in 1973 and improved by Bezdek in 1981) is continuously used in pattern recognition. It is a powerful unsupervised method used for the analysis of data and for constructing a model. In many situations, fuzzy clustering is more natural than hard clustering. Fuzzy c-means algorithm is most widely used. This algorithm works by assigning membership to each data point corresponding to each cluster center on the basis of distance between the cluster center and the data point. If cluster center have more number of data near to it, this data is its membership towards the particular cluster center. Clearly, summation of membership of each data point should be equal to one. After each iteration of FCM, membership and cluster centers are updated (according to the formula).

Algorithm

1. Initialize $U=[u_{ij}]$ matrix, $U^{(0)}$
2. At k-step: calculate the centers vectors $C^{(k)}=[c_j]$ with $U^{(k)}$.

$$C = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_i}{\sum_{j=1}^{n} u_{ij}^{m}}$$

3. Update U(k) ,U(k+1)

$$u_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{2/(m-1)}}$$

4. If $\|U(k+1)-U(k)\| < \varepsilon$ STOP; otherwise return to step 2.

where m is any real number greater than 1,
u_{ij} is the degree of membership of xi in the cluster j,
x_i is the i^{th} of d-dimensional measured data,
c_j is the d-dimension center of the cluster,
The advantage of FCM is Unsupervised, and limitation of FCM is complex computational time, Sensitivity to the local minima, Sensitivity to noise.

3.3 Improved Fuzzy C-Means Clustering

In this paper, the improved version of Fuzzy C-Means algorithm is used. Clustering is the process of organizing objects into groups whose members are similar in color, contour etc. An unsupervised learning task is clustering, where the pixels are classified in to a finite set of categories known as clusters or groups. It is an unsupervised classification because there is no available data to train the pixels [1]. The main drawback of the standard FCM for image segmentation is that the objective function does not consider the spatial information and it is an iterative clustering method. Therefore, this algorithm is wrongly classified because of its abnormal features.

An improved FCM algorithm is introduced to segment the video which is affected by outlier, noise etc. The improved FCM algorithm is generally based on the concept of data compression and the input data's dimensionality. Improved Fuzzy C-Means algorithm offers an overcoming of one limitation of traditional Fuzzy C-Means which is time consuming. The improved FCM algorithm utilizes less number of dataset, and its convergence rate is highly enhanced when compared with the conventional FCM. The improved FCM algorithm is nearly similar to conventional FCM except the process of change in the cluster updation and membership value updation criterions. The IFCM algorithm steps are given below,

Step 1: Define number of clusters
Step 2: Randomly initialize the membership matrix.
Step 3: Calculate each cluster's centers.
Step 4: Update the membership matrix.
Step 5: Check whether the threshold value is satisfied or not. If yes, stop the process. If not then go to step 3.

The modified criterions are showed below,

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}^{m} y_i}{\sum_{j=1}^{n} u_{ij}^{m}}$$

$$u_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{d_{ij}}{d_{kj}}\right)^{2/(m-1)}}$$

Where, $d_{ij} = y_j - C_i$; y_i= Reduced Dataset

Here, IFCM is used to determine the optimal number of cluster formation from each frame. A detailed explanation of Figure 2 is given below. We took a sample video as an input video. In the next step the video is converted into number of frames. Then the mean of the each frames are calculated by inbuilt mean factor (i.e) it is 2-dimensional mean. By calculating the mean, it adjusts the each pixel value according to the mean value. In this paper, contrast limited adaptive histogram equalization (CLAHE) is used for image enhancement. Adaptive histogram equalization (AHE) is suitable for improving the local contrast of the video but it has a tendency to over-amplify noise in relatively homogeneous regions of a video's frames. To prevent this limitation, CLAHE is used.

First, calculate the image saliency by using the color and space information of both local and global in single scale. Then by applying the multi-scale fusion, it effectively inhibit outstanding but not salient region in each single scale, and different scale can also reflect salient region of the images from different aspects. Then it automatically defines the number of clusters present in a frame. Many image or video display devices allow only a limited number of colors to display the video. Usually, this set of available colors, called a color palette, that may be selected by a user. Such device restrictions make it particularly difficult to display natural color video since these video usually contain a wide range of colors, then it must be quantized by a palette with limited size. This color quantization problem is explained in following sentence: the selection of an optimal color palette and the optimal mapping of each pixel of the frame to a color from the palette.

Adaptive color quantization only allows limited number of colors to display. Then, there are only 16 possible colors to produce the each frame after applying color quantization. Adaptive median filter is used for pre-processing. The median is less sensitive than the mean to extreme values (called outliers). The gradient of the each frame is extracted by estimating the phase and magnitude of a frame. The inbuilt DTCWT is used to decompose the video frames.

The entire work is divided into two stages. Firstly, separating the colors of each enhanced frames using de-correlation stretching is processed and then the regions are grouped into a set of classes using IFCM algorithm. Using this two steps process, it is possible to reduce the computational cost avoiding feature calculation for each pixel in the frame.

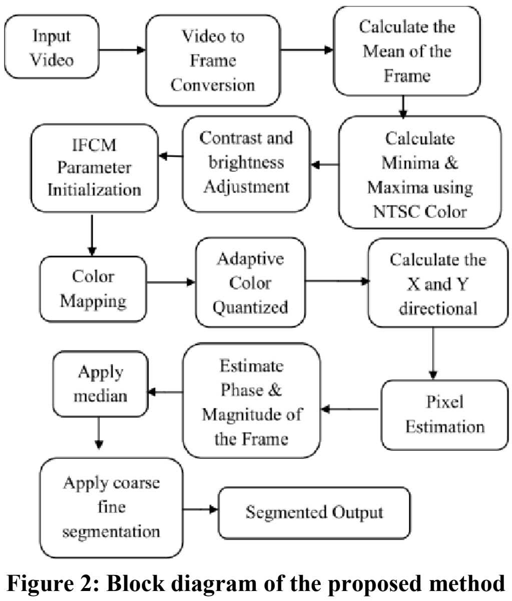

Figure 2: Block diagram of the proposed method

Then the thresholding values are automatically calculated by the IFCM. We get the accurate video sequences after segmenting the frames.

IV. SIMULATION RESULTS

We present extensive experimental results of the proposed method. Firstly, we took a video from the surveillance camera or a sample video and the length of the input video is 31secs in which there are 24 frames per second and then input video is converted into 744 frames. Here we took ten frames from 744 frames for simplicity. The multilevel adaptive color quantization process reduces the number of distinct color used in a frame. After that classifying each frames into several different regions according to color, and by setting multiple threshold values. The color frame is converted into gray level in order to simplify the process. There are 16 clusters present in the output and K - indicates the number of clusters present in the frame. We used HSV model for decomposition of color video and then IFCM is applied separately on each component of HSV model. The color frame is converted into gray level in order to simplify the improved fuzzy c-means algorithm process, k=16 which represents the number of clusters present in the frame.

The filtration is the process of replacing each pixel intensity value with the new value take over a neighbourhood of fixed size. The input video is shown in Figure 3.

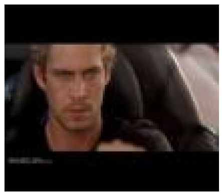

Figure 3: Input video

4.1 Contrast and Illumination

The intensity of each rows and columns pixel of the frame is increased or adjusted to certain level by the mean level enhancement. The contrast and illumination of the input frame is enhanced and is shown in Figure.4.

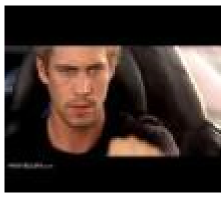

Figure 4: Contrast and Illumination Enhanced Frame

4.2 Multilevel Adaptive Color Quantization

The multilevel adaptive color quantization is process that reduces the number of distinct color used in an image as shown in Figure.5. Color quantization is a critical task for displaying frames with many colors on device. 16 colors are available there in adaptive color quantization model.

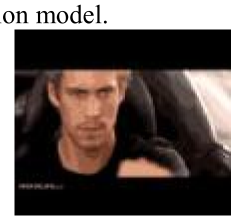

Figure 5: Multilevel Adaptive Color Quantization

4.3 Intensity and Texture Gradient

The color frame is converted into gray level in order to simplify the improved fuzzy c-means algorithm process. The intensity variation of the pixels i.e (peaks and valleys) is highlighted is shown in the Figure 6. The texture variation in the 50th frame is extracted in the Figure 7 and 8. The output multilevel thresholded frame is shown in the Figure 10. And the illustrated thresholding surround is extracted is shown in the Figure 9. The multilevel thresholded video is shown in the Figure11.

Figure 6: Intensity Gradient Based IFCM

Figure 7: Texture Gradient IFCM Clustering

Figure 8: Total Gradient IFCM Clustering

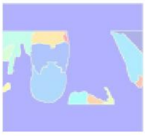

Figure 9: Illustration of Original Surround

Figure 10: Multilevel Segmented Using IFCM with Otsu Thresholding

Figure 11: Segmented Video Output

Otsu's method is the best threshold selection methods for the images (or frames from the video) with regard to similarity and shape measures. It will find the threshold values where from foreground and background pixels with better computation time. Using adaptive median filter, the unwanted noise like Gaussian noise, salt and pepper noise etc., presented in the frame has been removed.

Table 1 shows the IFCM based Otsu thresholded output. Table 2 shows the PSNR values for existing [1] and proposed method. From the table 2, the PSNR values are obtained from proposed method is higher. Figure 12 shows the graphical representation of average PSNR values.

Table 1 Output Segmented Frames

Input Video	Illustration of Original Surround	Multilevel Segmented Frame Using IFCM With Otsu Thresholding	Output Video
			

Table 2 PSNR Comparison

S.No	PSNR (dB)	
	Existing Method [1]	Proposed Method
1	42.973	43.019
2	41.447	43.075
3	41.160	42.625
4	41.374	43.105
5	41.520	42.814
6	40.985	43.175
7	40.647	42.795
8	41.691	43.260
9	41.603	43.364
10	41.025	43.210

Figure 12: Graphical Representation of average PSNR values

V. CONCLUSION

In this paper, we have presented pixel-wise saliency maps using Improved Fuzzy C Means Segmentation with thresholding technique is used which converts spatial function into membership function. From the experimental results, the noise present in the frame is 0.0092 and the accuracy of the threshold frame is also very efficient than other methods. In this paper, we have calculated the Peak signal to Noise Ratio of Existing and Proposed segmentation. Thus the Peak signal to Noise Ratio value obtained in proposed method is 43 dB and the entropy is 0.9460, which is greater than the existing methods. The frames are segmented at the speed of 127.99 secs. Graphical representation of average PSNR shows the proposed method reduces noisy content in an image and enhances the image accuracy**.** Software package used for simulation is MATLAB R2013a version.

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