Features Extraction Based On Fuzzy Clustering and Segmentation onto the Motion Region for Medium Field Surveillance Application

Mohamad Nansah Maliki[1] *Syed Abdul Rahman Abu Bakar Al-Attas*[2]

Computer Vision, Video and Image Processing (CVVIP) Research Group,
Dept. of Microelectronic and Computer Engineering (MiCE),
Faculty of Electrical Engineering,
Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
E-mail: [1]*mnansyah@hotmail.com* , [2]*syed@suria.fke.utm.my*

Abstract

Fuzzy-based clustering algorithm is becoming popular in image processing, especially in image segmentation. Based on the degree of the membership function, each pixel can be grouped into "natural group" of pixels according to the spatial coordinate using their values. In this work we present features extraction based on fuzzy clustering and segmentation onto the motion region for medium field surveillance application. Instead of using blob analysis, we believe that fuzzy based clustering algorithm, can also be used to generate different clusters. Incorporating the motion-based segmentation the complexity of the fuzzy clustering will also be reduced because only the motion region will be processed to the clustering algorithm.

1. Introduction

Fuzzy clustering organizes the original image into several "natural groups" of pixels in a given observation using fuzzy subset assumptions on clusters. From the fuzzy clustering one will obtain the degree of membership of certain pixels to a cluster, and the periphery of the cluster will become uncertain [1, 2]. Fuzzy C-Mean (FCM) clustering algorithm has a wide application especially in control engineering. Due to its ability to represent linguistic variables, fuzzy logic is a powerful tool in handling some form of uncertainty and imprecision. Here we consider the pixel value and its spatial location as the data to be analyzed. Each pixel needs to be clustered based-on its pixel value and spatial location, y-plane and x-plane to form a membership function value i.e. U_{ik}.

The aim of the paper is to simplify the data stream containing n objects into K mutually disjoint clusters. The state of the clustering is expressed by $n \times K$ matrix of U_{ik}. The criteria for this U_{ik} are shown in equations (1), (2) and (3) respectively. Each cluster is represented by its center prototype cluster V_k. These prototype clusters will keep on changing until they converge to a stable value.

$$\sum_{k=1}^{K} U_{ik} = 1; i = 1,...,n. \tag{1}$$

$$\sum_{i=1}^{n} U_{ik} > 1; k = 1,...K. \tag{2}$$

$$U_{ik} \in [0.1], i = 1,...,n; k = 1,...,K; \tag{3}$$

The criterion used to cluster each data stream is based-on the membership function U_{ik} that minimizes the total mean square error as shown in equation (4). Equations (5) and (6) show the criterion of U_{ik} and criterion of V_k (center of prototype cluster) respectively.

$$J(U_{ik}, V_k) = \sum_{i=1}^{n} \sum_{k=1}^{K} (U_{ik})^m \| x_i - V_k \|^2 \tag{4}$$

$$U_{ik} = \frac{1}{\sum_{j=1}^{K} \{d(x_i, V_k) / d(x_i, V_j)\}^{\frac{2}{m-1}}} \tag{5}$$

$$V_k = \frac{\sum_{i=1}^{n} (U_{ik})^m x_i}{\sum_{i=1}^{n} (U_{ik})^m} \tag{6}$$

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where;

$i = 1,...,n; k = 1,...,K$.

m is the degree of fuzziness,

d is the distance between two points,

and x_i is the input data.

In general, the object seen by the camera with respect to the field of view can be classified into three types; near field, medium field and far field [16]. The medium field is used predominantly in surveillance applications. In this field, most applications used blob analysis for segmentation [16]. In this paper we will show how fuzzy clustering algorithm can be used to extract information such as the center of the clusters and their respective location.

This paper is organized as follows; Section 2 describes the detection of moving object. Section 3 describes the clustering segmentation scheme and how features are extracted based on the fuzzy membership function. The link between section 2 and section 3 are related in reducing the processing time when both techniques are combined together. Section 4 provides the initial experimental result and finally section 5 gives the conclusion of the work presented.

2. Detection of Moving Object

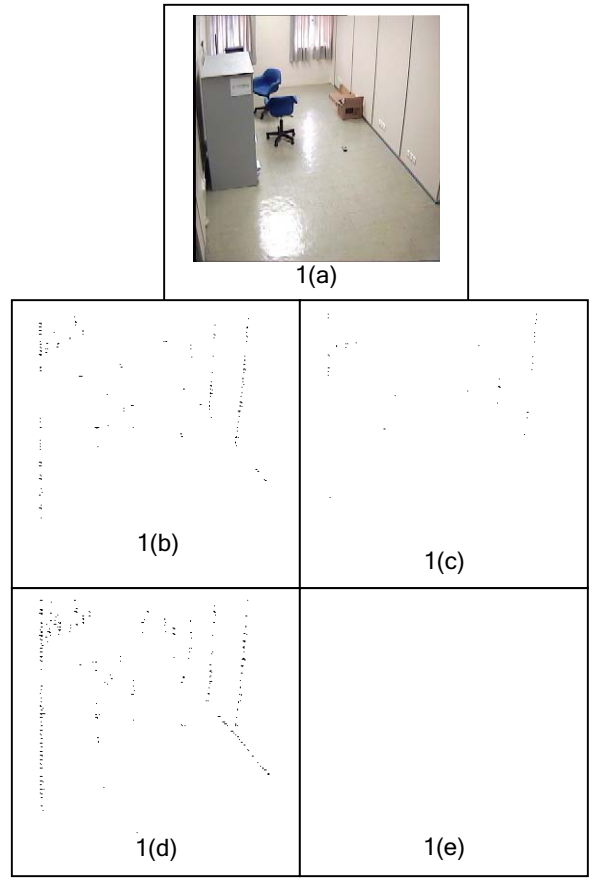
Since we are interested in the moving object region only, we concentrate our algorithm technique in this region. In addition, this will also overcome the computation complexity of the FCM algorithm. To do this, motion object detector has been applied. The detector consists of color separation, frame differencing and projection histogram.

2.1. Color Separation

Video sequence captured from RGB format suffers from blinking artifact. From the RGB format we separate the color information into the YUV format because the sensitivity of the luminance component is more stable compared to the color component. The transformation from RGB to YUV format is done through equations (7) where the details can be found in [3].

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.589 & 0.436 \\ 0.615 & -0.515 & -0.1 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{7}$$

Within the YUV format, the Y-luminance data has been selected for motion detection module, while both chrominance values U and V are kept to reconstruct color video for displaying purpose. Figure 1 shows the result of frame differences between two consecutive frame without any moving object.



Figures 1. 1(a) Original live color captured at time t, 1(b), 1(c) and 1(d) show the results of differencing consecutive frames using the R, G, and B component respectively. Figure 1(e) Result of frame differencing based on luminance- note the absent of blinking artifacts.

2.2. Motion Detection

There are many existing motion detection algorithms that are already established and some of them can be found in [4, 5, 6, 7, 8, 9, 10, 11, 12, and 13]. Generally all of these techniques can be divided into four categories, i.e. pixel-based, features-based, optical flow [14] and frequency domain approach as mentioned in [4].

In this research work, the motion detection technique employed is based on differencing between edges taken from two consecutive frames. Features are taken from the edges of the image. We employed the Hexagonal-Based Edge Detector (HED) as was done in [15]. One superior advantage of using HED is its speed performance which makes it suitable for real-time application [15].

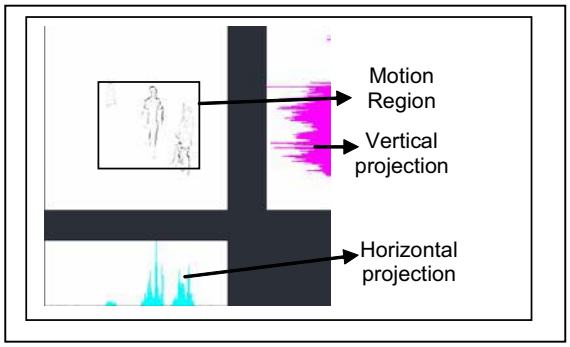


Figure 2. Motion region detection based on projection histogram

2.3. Projection histogram

Projection histogram technique is applied to the output edge map from the motion detection module. We make use of the histogram projection technique to encompass the moving object within a box. Figure 2 shows the result of motion region detector based on the projection histogram. Based on the motion detection algorithm one can segment the monitored area into motion region and static region as was done in [15], using projection histograms. Unfortunately this method fails when multiple moving objects in the monitoring area are too closed to one another. Moreover the technique works for stationary or mounted camera only. For the pant and tilt camera, motion detection and segmentation using image mosaic has been reported in [9] and noise reduction using time-varying noise level technique has been proposed in [8].

3. Clustering and Segmentation

For analysis purpose, redundancies information in captured image should be eliminated as much as possible. In clustering segmentation, redundancies in captured image are manipulated so that the representation of the image is simplified. Through segmentation, each pixel will be grouped according to its homogeneity. We proposed FCM algorithm in our segmentation algorithm. FCM uses unsupervised segmentation scheme with supervised number of clusters. With this procedure pixels will be clustered into "natural group" relying on their spatial location and similarity intensity value.

In the first stage, 2D image data need to be represented by into 1D data. The way of doing this is by concatenating the image into a column vector as shown in Figure 3(a) and 3(b). Each representation of data will form the M-dimensional of FCM algorithm. Figure 3(b) shows an example of a 3-dimensional FCM and Figure 3(c) shows an example of a 5-dimensional FCM respectively. Figure 4 show the flowchart for the FCM algorithm .

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8			x_{M-1}	x_M
y_1	I_{11}	I_{12}	I_{13}	I_{14}	I_{15}	I_{16}	I_{17}	I_{18}	..	..	$I_{1,M-1}$	$I_{1,M}$
y_2	I_{21}	I_{22}	I_{23}	I_{24}	I_{25}	I_{26}	I_{27}	I_{28}	..	..	..	$I_{2,M}$
y_3	I_{31}	I_{32}	I_{33}	I_{34}	I_{35}	I_{36}	I_{37}	I_{38}	..	..	..	:
y_4	I_{41}	I_{42}	I_{43}	I_{44}	I_{45}	I_{46}	I_{47}	I_{48}	..	..	..	:
y_5	I_{51}	I_{52}	I_{53}	I_{54}	I_{55}	I_{56}	I_{57}	I_{58}	..	..	..	:
y_6	I_{61}	I_{62}	I_{63}	I_{64}	I_{65}	I_{66}	I_{67}	I_{68}	..	..	..	:
	:	:	:	:	:	:	:	:	$\ddots$	..	..	:
	:	:	:	:	:	:	:	:	:	$\ddots$	..	:
y_{N-1}	$I_{N-1,M}$	:	:	:	:	:	:	:	..	..	$\ddots$	$I_{N-1,M-1}$
y_N	$I_{N,1}$	$I_{N,2}$	$I_{N,3}$	$I_{N,4}$	$I_{N,5}$	$I_{N,6}$	$I_{N,7}$	$I_{N,8}$	..	..	I_{NM-1}	I_{NM}

3(a)

l	x	y	L
1	1	1	I_{11}
2	1	2	I_{21}
3	1	3	I_{31}
4	1	4	I_{41}
5	1	5	I_{51}
6	1	6	I_{61}
7	1	7	I_{71}
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
N*M-2	M	N-2	$I_{N-2,M}$
N*M-1	M	N-1	$I_{N-1,M}$
N*M	M	N	I_{NM}

3(b)

l	x	y	R	G	B
1	1	1	R_{11}	G_{11}	B_{11}
2	1	2	R_{21}	G_{21}	B_{21}
3	1	3	R_{31}	G_{31}	B_{31}
4	1	4	R_{41}	G_{41}	B_{41}
5	1	5	R_{51}	G_{51}	B_{51}
6	1	6	R_{61}	G_{61}	B_{61}
7	1	7	R_{71}	G_{71}	B_{71}
:	:	:	:	:	:
:	:	:	:	:	:
:	:	:	:	:	:
:	:	:	:	:	:
:	:	:	:	:	:
:	:	:	:	:	:
:	:	:	:	:	:
N*M-2	M	N-2	$R_{N-2,M}$	$G_{N-2,M}$	$B_{N-2,M}$
N*M-1	M	N-1	$R_{N-1,M}$	$G_{N-1,M}$	$B_{N-1,M}$
N*M	M	N	R_{NM}	G_{NM}	B_{NM}

3(c)

Figure 3. 3(a): 2D data for one frame. 3(b) 1D Data into 3D FCM algorithm and correlated with same corresponding level, l. 3(c) 1D Data into 5D FCM algorithm and correlated with same corresponding level, l.

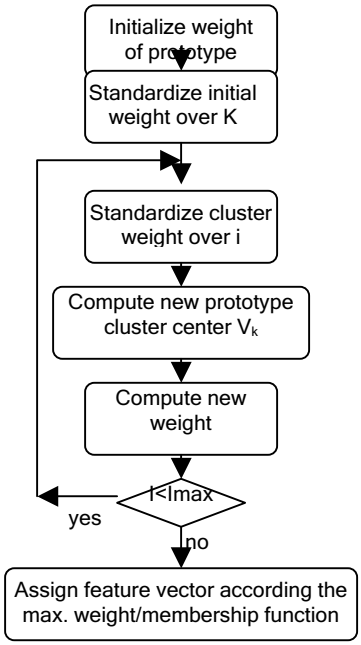
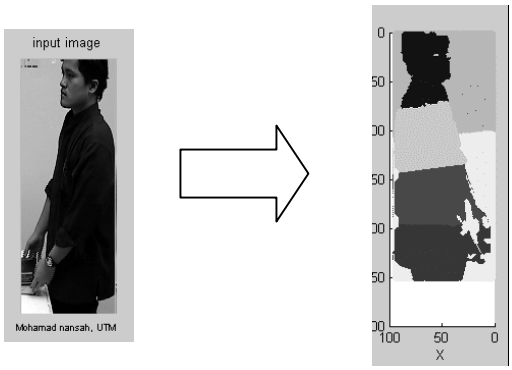


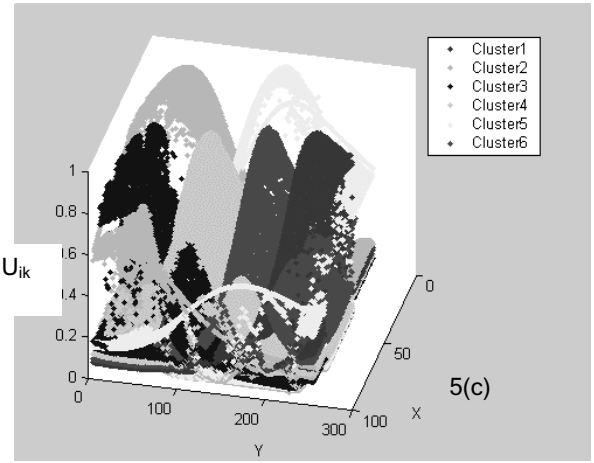
Figure 4. General flowchart for the FCM algorithm.

4. Initial experimental results and discussion

As described before, we applied fuzzy clustering onto the motion region to reduce complexity i.e. motion-based segmentation. Figure 5 below shows the fuzzy clustering algorithm onto the motion region. Figure 5(a) is the motion region and figure 5(b), 5(c) and 5(d) show the result in different view angle.



5(a) 5(b)



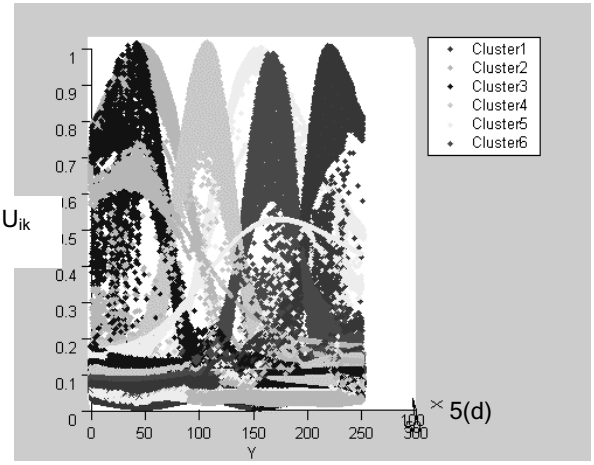


Figure 5 - 5(a): Output from motion region detector. 5(b): Output from clustering algorithm. 5(c) :Membership function U_{ik} plot with their corresponding spatial location (x,y). 5(d): Same graph as 5(c) accept their view angle.

Conclusions

The aim of this work is to extract the moving feature and enhance the feature in real-time live video frame rate. Motion region is obtained using the projection histogram applied on differenced edge-image. Once the motion region is located then clustering algorithm is applied to extract the center point of each cluster. The continuation of this research is to use this simplification into feature trajectory module. Figure 6 show the result of FCM algorithm on the motion region for frame 29 to frame 34.

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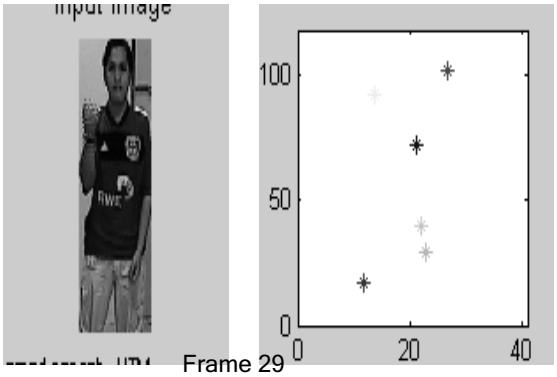
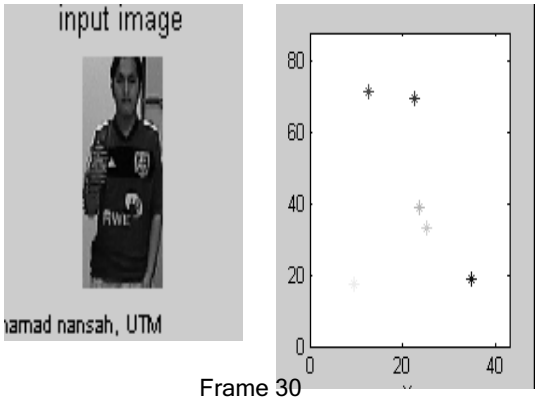
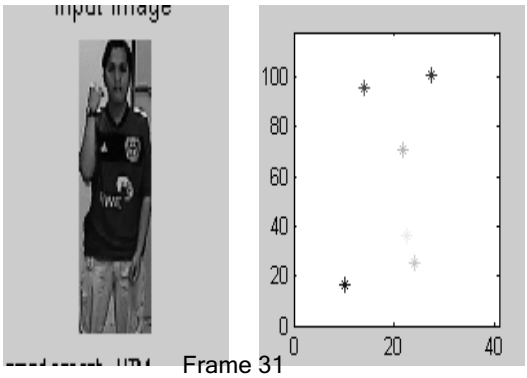


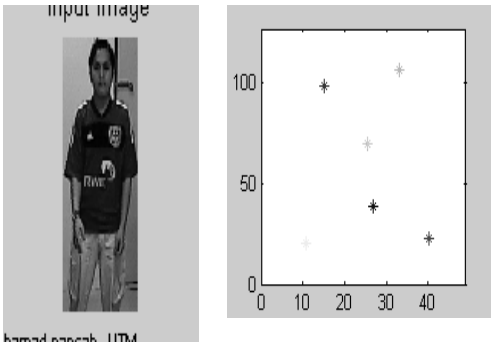
Frame 29



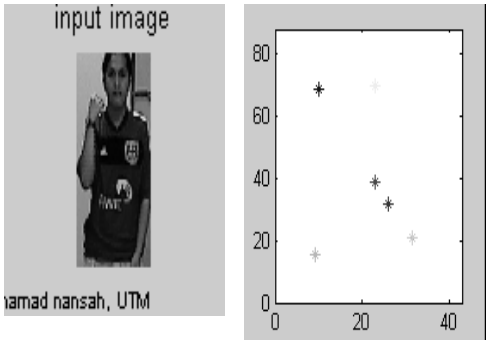
Frame 30



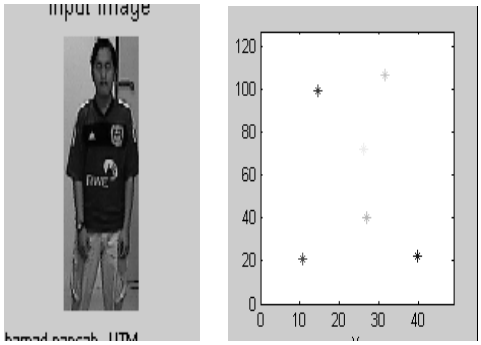
Frame 31



Frame 32



Frame 33



Frame 34

Figures 6 - Sample of activities taken from frames 29-34. Each frame is shown with its corresponding center each cluster.

Acknowledgements

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