An Image Mosaic Block Detection Method Based on Fuzzy c-means Clustering

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***Abstract*—With the development of the Broadcasting and Video network, the Monitoring System on Digital Video Broadcasting is becoming more and more important. Image recognition technology is widely applied to detect the degraded video in the television observation system. Mosaic block easily occurs in the TV signals, which will degrade the video quality. The conventional mosaic detection algorithm can't distinguish Chinese character from real mosaic block. In order to solve the problem, we propose a mosaic block detection method based on fuzzy c-means clustering to detect mosaic block. The method contains three steps. First, the frame is processed by Sobel edge detection algorithm to obtain the edge image. Second, clustering features are extracted for the fuzzy c-means clustering algorithm. Third, a fuzzy c-means clustering is employed to distinguish mosaic blocks from all the normal image blocks. Experimental results show that our algorithm could differentiate Chinese character with real mosaic block.**

Keywords- mosaic block detection; image; edge detection; feature extraction; fuzzy c-means clustering

I. INTRODUCTION

In recent years, there has been an explosion in the exploitation and availability of digital visual media. Digital video broadcasting is widely applied to transmit digital TV signal. Mosaic block easily occurs in TV signals, which will degrade the video quality. It becomes important to detect degraded video with the extensive application of digital visual media. In the television observation system, the decoding digital TV signal is usually supervised artificially. The malfunction of digit TV signal refers to static frames and mosaic frames [1].

Currently, the mosaic detection technology is being studied extensively. In [1], edge detection and signal feature of YPBPR are combined to detect mosaic. The detection method could achieve 91% recall alarm rate and 5% false alarm rate. A degraded video detection approach based on support vector machine (SVM) and template matching has been proposed in [2], which could achieve 96.1% recall alarm rate and 5.6% false alarm rates. The recall alarm rate is improved by using the method. However, the algorithm couldn't distinguish Chinese character from real mosaic blocks. So far, to our best knowledge, no method has been proposed to solve the issue.

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We propose the method based on feature extraction and fuzzy c-means clustering (FCM) [3]. Firstly, the image is converted into the grayscale image. Then it is processed by edge detection algorithm and feature extraction. Finally, FCM algorithm is employed to distinguish mosaic blocks from the normal blocks. The experiment shows that our mosaic detection algorithm can distinguish Chinese character from real mosaic blocks. Consequently, the efficiency of mosaic detection in our algorithm is better than the algorithm proposed in the paper [2] on this respect.

In the following sections, we first introduce the framework of mosaic block detection. Then the edge detection and feature extraction are described in section 3. In section 4, FCM algorithm based mosaic detection is described, and the experimental results are shown in section 5 in detail. Finally we make conclusions in section 6.

II. MOSAIC DETECTION FRAMEWORK

A framework of mosaic Detection is proposed, which includes edge detection, feature extraction, and FCM clustering, as shown in Fig.1. The input video is captured by the Digital TV Receiver and decoded into video frames. Each frame is processed by edge detection algorithm, based on the result of which, the type of each block in the frame is defined. Then each type is assigned a corresponding value. The value of each type is considered as one of the clustering feature. Variance that between the gray of current block and the four blocks around is calculated. It is considered as another clustering feature. Then the FCM algorithm is employed to distinguish mosaic blocks from all frame blocks. Finally, according to the classification results, the mosaic blocks of the image are detected. When the number of mosaic blocks is higher than a threshold, the image is regard as a frame with mosaic blocks.

III. EDGE DETECTION AND FEATURE EXTRACTION

A. Edge Detection

1) Edge Detection

Image edge is a fundamental feature of image, which contains abundant internal information. The size of a block is 16×16 pixels. A mosaic block displays the square shape in the edge image. The input video is captured by the Digital TV Receiver and decoded into video frames. Each frame is converted into the grayscale image which is processed by

Sobel edge detection algorithm [4]. In the Sobel edge detection algorithm, the adaptive thresholding is used to turn grayscale image into binary image. If the gray of a pixel is bigger than the threshold value, the pixel is defined as an edge pixel and it's gray is set as 255, else the gray of is set as 0.The grayscale image and the edge image are shown in Fig.2 and Fig.3, respectively. According to the Fig.2, there are some Chinese character in the bottom of the image.

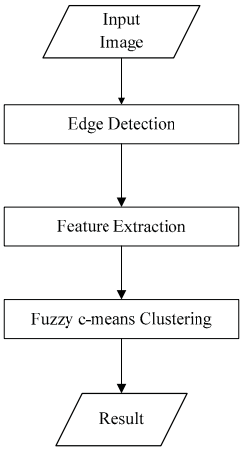

Figure 1. the Flowchart of the Proposed Mosaic Detection Framework

Figure 2. the Grayscale Image

Figure 3. the Edge Image

2) Local Edge Connection

In order to remove the isolated pixels and connect the edge, the edge image is processed by the following rule. A and B are both edge pixels. If there is a pixel between A and B in the edge direction, then the pixel is considered as an edge pixel.

B. Feature extraction

Extractive character of target is the main purpose of image feature extraction. It is one of the research aspects in target recognition to look for invariable feature of image by geometric transforms, these invariable features are an important symbol of difference classification on the target object. The edge image is obtained by edge detection algorithm. Then features for FCM algorithm are extracted by the direct selection method in [5].

1) Judge the edge existence of blocks and Define the edge types of block

A mosaic block displays the square shape in edge image. The judgment is used to estimate whether the four edges of the block exist. T_{edge} is defined as the threshold value of the edge judgment, and N_{edge} is presented the number of edge points. If $N_{edge} \geq T_{edge}$, the edge of the block is confirmed to be true. According to the edge judgment, the edge types of a block are classified into three cases. It's shown in Fig.4.

2) Extract features for FCM algorithm

In the feature extraction the value of the different types is defined as one of the clustering feature, and Variance that between the gray of current block and the four blocks around is considered as another clustering feature.

It is assumed that a block with type1 isn't a mosaic block, and the type3 is the mosaic block on the whole. However, the blocks with type2 cannot be judged, because the result of edge detection is not so accurate. In order to improve the veracity of the mosaic detection, we consider the variance as another clustering feature except the value of block type.

For every block, the input vector is described by a two dimensional vector representing the bounding box of block:

$x_i = (T_i, V_i)^T$ where T_i represents the value of the block type, and V_i represents the variance. It should be notable that before the input vectors is classified by the FCM algorithm, the variable dimension is adjusted.

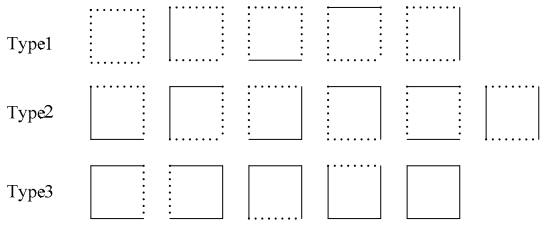

Figure 4. Three edge types of a block

IV. FCM ALGORITHM

Many fuzzy clustering methods are introduced in [6]. FCM algorithm is one of most important and popular fuzzy clustering algorithms. At present, this algorithm (developed by Dunn in 1973 and improved by Bezdek [7] in 1981) has been extensively used in feature analysis, pattern recognition, image processing, classifier design, etc. (see [8]). It is the process of grouping a data set in a way that the similarity between data within a cluster is maximized while the similarity between data of different clusters is minimized. This clustering method is essentially an iterative procedure. This iteration is based on minimizing an objective function that symbolizes the distance from any given data point to a cluster center weighted by that data point's membership rank [9]. The purpose of clustering is to distinguish mosaic blocks from all the image blocks, so we classify all of the blocks into two clusters.

Let $\mathrm{X} = (x_1, x_2, ..., x_i, ..., x_N)$ indicates the image with N blocks to be classified into c clusters, where $x_i = (T_i, V_i)^T (i \in (1, 2, ..., N))$ represents the features data of every block.

Each sample is not strictly divided into a certain category but belonging to a category in a certain membership grade. The division can be stated by the membership matrix $U = (u_{ij})_{c \times N}$, u_{ij} shows the membership grade of $i(i \in (1, 2, ..., N))$ to $j(j = 1, 2, \ldots, c)$. The requirements as follows shall be meets:

$$\begin{cases} u_{ij} \in (0,1) \\ 0 < \sum_{j=1}^{N} u_{ij} < N, \forall i \\ \sum_{i=1}^{c} u_{ij} = 1, \forall j \end{cases} \quad (1)$$

FCM divided objective function is defined as followed:

$$\mathrm{J_m(U,V)} = \sum_{j}^{N} \sum_{i}^{c} {u_{ij}}^m {d_{ij}}^2 \quad (2)$$

Among the function, $V = (V_1, V_2, ..., V_c)$ is the center of the clustering. $d_{ij} = \left\| x_j - V_i \right\|$ is the Euclid distance of samples and each clustering centers. The parameter m is a weighted index to control the fuzziness of the resulting partition, m will be fuzzier when it gets bigger. Another parameter ε is a value as the termination condition of the iteration. The algorithm can be formulated as the following four steps in which s denotes the iteration number.

a) Set the number of clusters c $(c = 2)$. *Initialize* $U^{(s)}$ *randomly and set* $s = 0$.

b) Calculate the cluster center $\left\{V_i^{(s)}\right\}$ *in* $U^{(s)}$ *:*

$$V_i^{(s)} = \sum_{j=1}^{N} {u_{ij}}^m x_j \Big/ \sum_{j=1}^{N} {u_{ij}}^m, \quad i \in (1, 2, ..., c) \quad (3)$$

c) Compute u_{ij} *in* $U^{(s)}$ *as*

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

$$(i = (1, 2, ..., c), j = (1, 2, ..., N)) \quad (4)$$

d) If $\left| U^{(s+1)} - U^{(s)} \right| \le \varepsilon$ *,then turn to e); otherwise , return to step b).*

e) Stop the algorithm, then output (U, V)

The cluster center of each cluster and the membership grade of every feature vector to the clusters are obtained.

If $u_{ij} > u_{wj} (w, i \in (1, 2, ..., c), i \neq w)$, then vector x_j belongs to the cluster i.

It is worth noting that in the above algorithm, the cluster center of each cluster is selected randomly. The clustering result is sensitive to the initial cluster centers. In order to reduce the sensitiveness, the selection of the initial cluster centers follows the rule proposed in [10].

V. EXPERIMENT RESULTS

We apply our algorithm over a large number of images with variance complexity. The experimental results for a

sample image are shown here. The images in our experiment are from video frames captured by Digital TV Receiver. The size of each image is 704×576 pixels. We use the following parameters to initialize the FCM algorithm. The clustering number is set as $c = 2$, $\varepsilon = 0.001$. The results of clustering process are shown in Fig.5, which indicates that the process of iteration is convergent.

The visual result of mosaic detection is given in Fig.6. The experiment shows that our mosaic detection algorithm can distinguish Chinese character from real mosaic block artifacts. Consequently, the efficiency of mosaic detection in our algorithm is better than the algorithm proposed in the paper [2] on this respect. Recall and false alarm rate are used to evaluate algorithm. Recall rate is the percentage of real frame with MB detected as mosaic block. False alarm rate is the percentage of frame without MB detected as frame with MB. The recall rate is 94.5%. The false rate is 5.3%, and it will increase in some complex background, especially when the mosaic block is mixed with background.

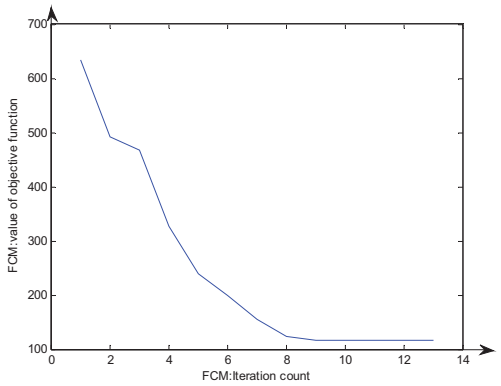

Figure 5. Clustering process of blocks

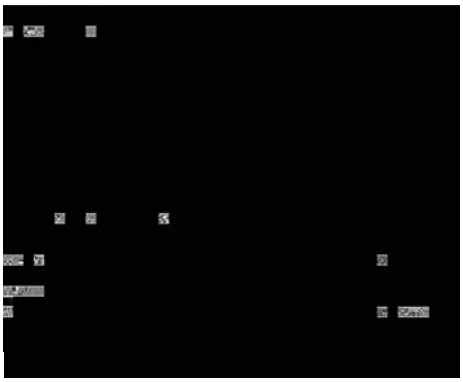

Figure 6. MS Detection

VI. CONCLUSIONS

In this paper, we propose a mosaic block detection method based on FCM algorithm to detect mosaic blocks in image. The edge detection and feature extraction prepare the feature vector for FCM algorithm. The experiment shows that our mosaic detection algorithm can distinguish Chinese character from real mosaic blocks. The recall rate is 94.5%. The false rate is 5.3%. The efficiency of mosaic detection in our algorithm is better than the algorithm proposed in the paper [2].

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