A New Method of Color Pattern Recognition Based on Fuzzy Clustering

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***Abstract*—The rapid development of online image monitoring has put forward more and more urgent needs for the application of computer image recognition technology. According to the design of Decision Support System (DSS) and the characteristics of online image monitoring, this paper analyzes the advantages of applying fuzzy pattern recognition technique to online monitoring image color identification and classification, and proposes a new method. Firstly, the algorithm acquires all kinds of identification color center based on sample learning sets given by experts and introduces fuzzy c-means clustering method and connected graph traversal technique. On the basis of identification color membership of pixel's corresponding color pattern and color's no-mutation rules, this paper comprehensively analyzes the whole image to form each color pattern and obtain the color identification results of each area. This method is prevalently instructional to similar color automatic identification.**

Keywords—Online Monitoring; Color; Fuzzy Pattern Recognition; Connected Graph Traversal

I. INTRODUCTION

In recent years, medical image diagnosis, character recognition, license plate recognition, satellite photography and other fields need the development based on image processing real-time online monitoring technology. The successful application of online image monitoring technology reflects the advantages of convenience, security. One of the basic realizations of computer image processing technology is that the computer is able to automatically identify the same color according to the color image, and then compose one kind of color to form a color classification base of image processing. In the past, many online monitoring systems depends more on operators' observation and analysis of image acquisition, which lacks of automatic recognition and analysis function [1]. The reason is the research on the image analysis method of complex background is not systematic and mature. Based on image recognition and analysis on the system innovation, this paper presents a realization of color recognition and classification method of monitoring image clustering method based on graph traversal, considering the industrial environment the image as the image blur and noise caused by the distortion of the disposal in line with the fuzzy theory and spirit. Therefore, the application of fuzzy C mean clustering algorithm is introduced to improve the applicability and robustness of the algorithm [2-4]. Example analysis shows that the method has better recognition accuracy and flexibility.

II. SYSTEM INTRODUCTION

The image information acquired by the image acquisition hardware systems of which can be collected through various means of communication into the supporting software system for the disposal[5] [6]. An image can be decomposed into several indicators, and one of the most important information is the color and color shape. From the point of science, these color images have a color center, and form a color block in the center of the color. To achieve the various color block color analysis, the algorithm using statistical tools for the weighted average of the typical sample to obtain each sample of color center. After the determination of the color center of sample set, with these color centers as constraints, the whole image of each pixel as a computing unit, through fuzzy mathematics and graph traversal algorithm, obtains the membership of each pixel corresponding to typical samples of various kinds of color center, and classifies it according to the optimal membership.

According to the traditional classification methods, the principle of maximum degree of membership is usually used. There will be a single pixel according to the maximum degree of membership for a one-time ownership color class, without considering the pixels belonging to other color classes. In this case, fuzzy clustering algorithm, the results obtained cannot be fully utilized. Thus, this paper proposed a new method to improve the image color characteristics, based on the fact that mutation does not occur with adjacent coupling by introducing the fuzzy c-means clustering method and graph traversal algorithm using computer technology to realize multilayer fuzzy processing. The advantage of this method is that the same process of on-line monitoring of images of various colors of clustering classification also obtains whole color block distribution of the whole image. It can be more efficient use of the algorithm to obtain the fuzzy membership degree of all kinds of rich information, while the introduction of fuzzy algorithm also improves the robustness and anti-noise of the whole algorithm.

III. LEARNING OF TYPICAL COLOR BLOCK CLASS CENTER

In the online monitoring image acquired by the hardware acquisition device and in the selection of senior equipment experts, a number of examples are selected. On the basis of the formation of the typical color blocks of the color class center, the various typical color block type center of the learning set is built. The specific method is to use the statistical method to calculate the RGB value of the center of the color class (taking the RGB color system as an example), The RGB component value of the typical color block color class center respectively corresponds to the average value of the whole sample of the typical learning set corresponding to the RGB component, and the specific calculation method is as shown in the formula 1.

$$mean(R) = \frac{\sum_{i=1}^{N} R_i}{N} \quad mean(G) = \frac{\sum_{i=1}^{N} G_i}{N} \quad mean(B) = \frac{\sum_{i=1}^{N} B_i}{N} \qquad (1)$$

Std(R,G,B) is:

$$std(R) = \sum_{i=1}^{N}[R_i - mean(R)]^2 \quad std(G) = \sum_{i=1}^{N}[G_i - mean(G)]^2 \quad std(B) = \sum_{i=1}^{N}[B_i - mean(B)]^2 \qquad (2)$$

In formula (1) (2), N is the number of samples, mean (R, G, B) is the center of the RGB component value of each color class center respectively, STD (R, G, B) is the standard deviation of each component of RGB.

It can be obtained some typical equipment color center, such as the red Mutual inductor and grey transformer in power system, yellow (A), green (B), red (C), white helmets (leaders), blue helmets (managers), yellow safety helmet (construction personnel), red hat (outside workers). These entire color centers for the next step will be used to guide the monitoring and the color of the image recognition. From images, the three primary colors RGB color and the commonly used color stimulus color is XYZ, PAL brightness color YUV, Other color I1I2I3 can transform to each other. Therefore, online detection image in each color under the typical color block class center can be calculated separately.

IV. Single Pixel Fuzzy Membership Degree

In order to calculate the membership degree of any single pixel in the image to the center of the color of the typical color block, and lays the foundation of the color classification and the shape of the entire image analysis. After comprehensive comparison, the fuzzy C means clustering method is more appropriate[7] [8].

Traditional fuzzy C means method represents the sample set with, the goal is to make the clustering criterion function (3) for the minimum.

$$J_m = \sum_{i=1}^{C}\sum_{j=1}^{N}(u_{ji})^m \left\| x_j - w_i \right\|^2 \qquad (3)$$

The membership degree matrix $U = \{u_{ji}\}$ is a function of membership function. uji represents the degree of membership of xj belonging to Ci class which is required to satisfy the following conditions:

(1) $u_{ji} \in [0,1], i = 1, 2, \cdots C; j = 1, 2, \cdots N$;

(2) $\sum_{i=1}^{C} u_{ji} = 1, j = 1, 2, \cdots N$

(3) $\sum_{j=1}^{N} u_{ji} > 0, i = 1, 2, \cdots C$.

Traditional fuzzy C means method is based on the objective criterion function J_m iterative optimization to complete the algorithm:

$$u_{ji} = \frac{\left(\frac{1}{\left\| x_j - w_i \right\|^2}\right)^{\frac{1}{m-1}}}{\sum_{i=1}^{C}\left(\frac{1}{\left\| x_j - w_i \right\|^2}\right)^{\frac{1}{m-1}}} \qquad (4)$$

$$w_i = \frac{\sum_{j=1}^{N}(u_{ji})^m x_j}{\sum_{j=1}^{N}(u_{ji})^m} \qquad (5)$$

The specific steps of the algorithm are:

First, set the number of categories for the sample *C*, and set the allowable error E_{max}, set *t*=1;

Second, calculate the class center $W(t) = \{w_1, \ w_2, \ \cdots \ w_i, \ \cdots \ w_c\}$ according to the formula (5);

Third, calculate new membership matrix $U(t+1) = \{u_{ji}\}$ according to formula (4);

Forth, calculate error $\Delta = \max \left\| U(t+1) - U(t) \right\|$.

If the error Δ> allowable error E_{max}, then return to the second step, or to the end of the computation.

From the above logic implementation, traditional fuzzy C means clustering center is only used to calculate the optimal solution (the solution obtained for several iterations), also need to interpreting the definition of these centers for classification is also needed in classification. From the implementation process of online monitoring of image color recognition, image color experts classify the blocks based on a subjective impression of a typical color class (the impression complies the acknowledged classification). In the identification of the interpretation, experts compare the object with each typical color class and divide them into the most appropriate category. This means, in the objective function calculation of fuzzy C means clustering algorithm; the class center is fixed in advance. Thus, this kind of center of fuzzy C means clustering algorithm is fixed without iteration, the optimal solution under the constraints in one calculation. The improved fuzzy C means clustering algorithm is simplified as:

First, calculate the typical samples of each color block class center by formula (1);

Second, calculate the object corresponding to the color of each color category of the matrix by formula (4);

Third, the membership degree matrix is de-fuzzied by fuzzy mathematics tools;

Fourth, obtain the final classification results.

From the above logic implementation, the process of the fuzzy C means algorithm of the fixed class center and experts interpretation are the same, and it does not need iteration. Besides, the optimal solution can be quickly obtained. Therefore, using the class center fixed FCM algorithm for online monitoring image automatic classification has obvious advantages compared with the traditional FCM algorithm.

V. Analysis of Image Color Blocks on Line Monitoring

The improved fuzzy C means clustering method proposed in this paper can get the membership matrix of each pixel in the whole image U={uji}. According to the fuzzy processing of the membership matrix, the category of each unit can be obtained. The classical method of defuzzification "maximum membership principle" is simple and convenient, but it only pays attention to the maximum membership component without making full use of the fuzzy C means method to obtain the membership matrix contains the rich information which makes it difficult to further optimize the classification results.

To make full use of the result of the algorithm and realize the optimal classification, this paper puts forward the concept of fuzzy point based on the fuzzy mathematics theory. Engineering practice shows that the image acquisition, transmission, processing and other processes may all introduce fuzzy points. The fuzzy point is defined as calculated as the computing unit (pixel) if its maximum membership value is not greater than the degree of membership value of more than 20% points. For the fuzzy point, if only based on the point operation and in accordance with the "maximum membership principle" of its classification, the results are often wrong. To avoid the occurrence of this kind of situation and restrain the effect of eliminating noise, this paper proposes a new way of thinking which is based on the principle of the color block does not mutate. The attribution of a point color depends on its own color attributes and adjacent points of color attribute, which is the adjacent field operations will be considered in the algorithm.

Engineering practice shows that the image color is often a block distribution. The pixels of the same color blocks can be connected to each other to form a co-color region, where the pixel color often has the characteristic of no mutation. Therefore, we can use the computer connected graph traversal algorithm, in the computing unit (pixel point) in the process of obtaining with full consideration of the properties of the neighborhood. This information can be determined in all areas of the whole monitoring results of image color distribution (color and shape), so as to decompose the image to form color block with similar color which realizes the implementation of classification and meanwhile lays the foundation of next step.

In the algorithm, there are three kinds of states that can be defined in pixels.

To be processed: the unit has not yet been traversed; its color classification results are unknown;

Processing: the unit has been traversed; its color classification results are unclear;

Processed: the unit has clear color classification results.

In order to achieve the region partition of the same color block, the algorithm defines a present color class processing stack that the first object of the present color class is a non fuzzy point identified by a color class. By introducing the connected graph traversal method, the algorithm utilizes the stack in the process of traversing and the design of the de-fuzzy processing method (based on adjacent regions) is:

Step 1: Each computing unit (pixels) has not been processed. Take the first computing unit (pixel) as the initial processing object, and determine whether the current computing unit is a non fuzzy point that has not yet been processed. If not, scan the units with the order from top to bottom, from left to right to continue to search the non fuzzy point that has not been processed. If yes, Set the status of the point state as processed (color category belongs to the biggest category), set the current processing category as the category, and the press it into the stack and jump to Step 2 for processing. If no suitable non fuzzy point is found, then scan again from the beginning. Classify the unclassified fuzzy points according to step 3, until the entire image pixels are processed to complete the classification.

Step 2: Determine whether the color class processing stack is empty. If not, execute the pop stack processing. If the point is fuzzy, then jump to Step 3 for processing; otherwise determine whether the color category of the non fuzzy point is the current category. If yes, set the state of the calculation unit for the state of processing, the point of its membership is the largest color category. Set this point as a benchmark, press the to-be-processed points in 3 x 3 computing unit of the adjacent regions to stack, with the scan sequence from top to bottom, from left to right and continue to perform Step 2. If not, it means the color blocks of present color classification have been traversed, then return to step 1 to search for no fuzzy points in last scan position.

Step 3: When the current computing unit is a fuzzy point, determine if there are to-be-processed points in the adjacent area of the 3 x 3 computing unit. If not, determine the color category combined with its adjacent area color category computing unit information. The specific criterion is to take the color category information of all the pixels in the 3 x 3 neighborhood around the point, and take the most color category to be the one that this fuzzy point belongs. Set the status of the point state processed, and turn to step 2. If yes, set the status of current point as processing, and press it back to the stack. Then press non-processed point into the stack and turn to step 2 for processing.

Step 4: Count each color region and set the color of pixel points with greatest numbers as the belonging color category in this area. The completion of classification also lays the foundation for the future analysis and determination.

From the logic realization, this algorithm obtains a complete monitoring of the image color block distribution and shape information meanwhile achieves a more accurate classification of the pixel color in the process by introducing computer connected graph traversal and fuzzy points in the adjacent area determination. To verify the validity of the algorithm, this paper compiles processing programs based on VC design and selects 300 random online monitoring images. The result of the conformance rate is above 90%. From this, we can see that this method has better recognition performance for the automatic classification of color blocks.

VI. CONCLUSION

Online monitoring and recognition technology is becoming more important. The computer intelligent recognition and image processing analysis is an important foundation of this technology. Based on studying the characteristics of the on-line monitoring image color recognition, this paper proposes a new method of automatic recognition and classification for color recognition, which is suitable for on-line monitoring. Moreover, this method has guided significance for automatic classification of similar colors. Based on the improved fuzzy C means clustering method on the fixed class center, this method can quickly calculate the membership matrix of each pixel in the image. On the foundation of the matrix, through the introduction of the adjacent region fuzzy point identification method, the color and shape information of the whole image can be obtained quickly. Next, the research will focus on low image quality; inaccuracy of camera focuses which causes negatives and false reports. With the continuous improvement of computer technology and image processing, recognition algorithm, image processing and recognition technology in the online image monitoring will be further studied and applied which has a profound impact on the future of online monitoring and control technology progress.

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