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Investigation on Art Image Recognition with the Combined Methods

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Abstract

Chinese ancient art is extremely developed, and includes many kinds with different development levels, varieties. Due to the long time passed since the make time, many art products become blurred. Then, how to repair and processing them is a very important work. With the development of computer technology, the researchers conducted in-depth investigation on image recognition technology, and a lot of technologies have been developed, which can be used in the image processing. In this paper, a new combined recognition method for artistic image has been developed. Template matching method is used to match and correct the art image. This method can process the fuzzy art image into clear images. According to the practical verification, the validity of the method has been proven.

Keywords: *art image, recognition, combination, template matching, gray matching*

1. Introduction

Image processing is much applied in the various conditions, including pipeline detection [1-4], target tracking [5-6], automatic image capturing [7], digital image processing [8-9] and medical imaging [10-11]. In the processing of image, processing system must be capable of detection and correction of massive image data in real time, and human-computer interaction through the monitor. These processing functions affect the reduction characteristics of the art images in a great extent.

Low level image processing includes image sampling, filtering, rotating and other related image pixel and neighborhood operations [12-14]. These operations are generally very simple, but need to handle the huge amount of data. Therefore, the requirements of the processor has powerful processing ability. Typical image processing algorithms often need hundreds of thousands of calculation in each pixel of the image. In order to achieve such huge computing power, researchers proposed the parallel processing.

In the advanced image processing, a most powerful tool is image template operations [15-20], especially the variable template pipes or sequence [21-22]. Variable template pipeline can express many image operations properly, such as adaptive filtering and image transformation. Although many scholars studied on the problem of effective image and template implementation in recent years, few people mention that how to execute the effective implementation of universal variable template. Therefore, how to effectively calculate universal variable template or variable template pipeline is inconclusive.

Chinese ancient art is extremely developed, and includes many kinds with different development level, varieties, which often have special characteristics. But because of the long time passed since the make time, many art products, including stone carving, painting, sculpture, suffer corrosion by natural conditions and become blurred. Then, how to repair and processing them is a very important work. The results can be used for the era reduction of the art and provide extremely important materials for archaeology.

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With the development of computer technology [23-24], the researchers conducted in-depth investigation on image recognition technology, and a lot of technologies have been developed. At the same time, most of the arts appeared in bulk form, although the same prototype, but with different effects of natural conditions in the longer period of time, which leads to the different aspect in modern times. In order to process these images more conveniently, all the arts can be handled into the art images. These images can be processed and matched in computer art, and finally to the art reduction.

The main work of this paper is using the template matching method to match and correct the art image, which will help to the reduction of the artistic image. The aim of the method is to process the fuzzy art image into clear images. The main work of this paper is to establish a comprehensive image processing method, which can help the processing and analysis of the art image. The remainder of the paper is shown as the following: the principal of the template matching is introduced in Section 2; the new combined method is described in Section 3; the verification is shown in Section 4; and the Conclusion is shown in Section 5.

2. The Principal of the Template Matching

In the process of recognition of things with machine, it is often need to align the two or more images obtained with different sensors or with the same sensor at different time and different imaging conditions, or find the correspond patterns in another image according to the known model. This is called matching. Discussion of image matching here is the method investigation of the existence of an image in a known picture.

Suppose that a template $T(m,n)$ translates in a search graph $S(M,N)$, the piece of the search graph covered by the template is called the sub graph S^{ij}. It is obvious that the range of (i,j) is: $1 < i < M - m + 1$, $1 < j < N - n + 1$.

The match degree $D(i,j)$ can be expressed by the similarity of $T(m,n)$ and S^{ij}:

$$\begin{aligned} D(i,j) &= \sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n) - T(m,n)\right]^2 \\ &= \sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n)\right]^2 - 2\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n)\right]\times T(m,n) + \sum_{m=1}^{M}\sum_{n=1}^{N}\left[T(m,n)\right]^2 \end{aligned} \tag{1}$$

In the equation, $\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n)\right]^2$ means the energy of the sub graph covered by the template, and it changes slowly with the variation of the position of (i,j); $\sum_{m=1}^{M}\sum_{n=1}^{N}\left[T(m,n)\right]^2$ is the energy of the template, which is a constant; $\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n)\right]\times T(m,n)$ is the correlation between the sub graph and the template, and it also changes with the variation of the position of (i,j). When the sub graph matches the template, the value of $\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n)\right]\times T(m,n)$ gets the maximum.

When processing the item of $\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n)\right]\times T(m,n)$ with normalization method, the correlation of the template match can be described as the following:

$$R(i,j) = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m,n) - T(m,n)\right]}{\sqrt{\sum\sum\left[S^{ij}(m,n)\right]^2} \bullet \sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}\left[T(m,n)\right]^2}} \quad (2)$$

When the sub graph is the same with the template, the correlation coefficient $R(i,j)$ will be 1. When the search in S is completed, the correspond sub graph $S_{im,jm}$ of maximum of $R_{\max}(i_m, j_m)$ will be the match target.

This is the normalized correlation matching algorithm. For further reduction of the matching time and improve the matching efficiency, the hierarchical control strategy can be designed for the matching process. The strategy can be divided into two levels: coarse matching and fine matching. This kind of strategy can guarantee the demand of matching accuracy and matching probability.

The flow chart of the template matching can be shown as the following:

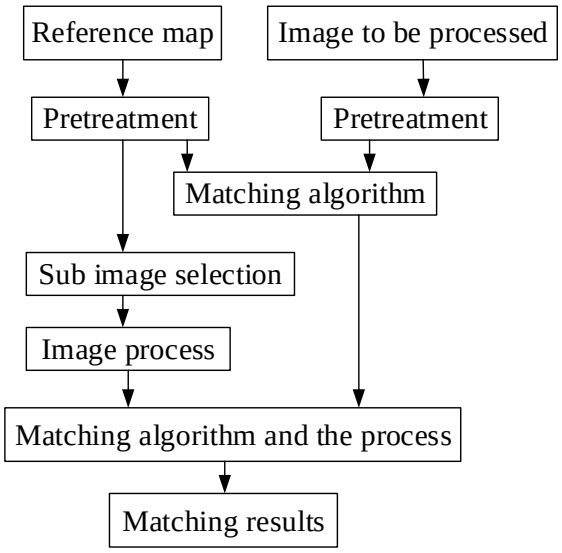

Figure 1. Flow Chart of the Template Matching

The first step of this matching and control strategy is the coarse matching. It determines the approximate location of the candidate matching point, and then fine matching will be proposed to determine the best matching point with high precise location or position. The fine matching is based on the results of the coarse matching. Therefore, the searching field will be greatly reduced. This will help to improve the efficiency:

(1) In the coarse matching stage, in order to guarantee the validity of the fine matching, it must ensure that the preselected points retained after coarse selection include the matching points.

(2) In the actual application, some optimal matching points in the coarse matching stage can be chosen to match in the fine stage.

(3) The preprocessing of the image refers to the grays data compression in image matching. In stage of coarse matching, discontinuous value of pixels can be used in the searching. However, in the fine matching stage, the pixel value and the search range should be large-scale extended.

2.2. Gray Matching

Distance of vectors y and $X_{u,v}$ in the image can be described as the difference between the two vectors:

$$\varepsilon = X_{u,v} - y \tag{3}$$

With different kinds of norms, there are some kinds of measurement algorithm for the distance.

(1) The absolute difference

$$D(u, v) = \left\|\varepsilon\right\|_1 = \left\|X_{u,v} - y\right\|_1 \text{ or } D(u, v) = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}\left|X_{i+u,j+v} - y_{ij}\right| \tag{4}$$

(2) Mean absolute difference

$$D(u, v) = \frac{1}{n \times n}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}\left|X_{i+u,j+v} - y_{ij}\right| \tag{5}$$

(3) Square difference

$$D(u, v) = \left\|\varepsilon\right\|_2^2 = \left\|X_{u,v} - y\right\|_2^2 \text{ or } D(u, v) = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(X_{i+u,j+v} - y_{ij})^2 \tag{6}$$

(4) Mean square difference

$$D(u, v) = \frac{1}{n \times n}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(X_{i+u,j+v} - y_{ij})^2 \tag{7}$$

In the above equations, $D(u, v)$ is the value of test position (u, v); $X_{i+u,j+v}$ is the gray value of the element (i, j) in the test position (u, v), that is the gray value of element $(u + i, v + j)$ in the template; y_{ij} is the gray value of element (i, j) in the image to be processed. It can be easily found that $D(u, v)$ has the minimum value at the condition of $D(u, v) \geq 0$. Under the ideal condition, the minimum value will be zero, and the matching work can be realized according to this property.

The correlation can be described as the following:

(1) Product correlation

$$R(u, v) = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1} X_{i+u,j+v} y_{ij} \tag{8}$$

(2) Normalized product correlation

$$R(u, v) = \frac{X_{u,v} \cdot y}{\left\|X_{u,v}\right\|_2 \left\|y\right\|_2} \tag{9}$$

It also can be expressed as the other form:

$$R(u, v) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{i+u,j+v} y_{i,j}}{\left(\sum_{i=1}^{n}\sum_{j=1}^{n} X^2_{i+u,j+v}\right)^{1/2}\left(\sum_{i=1}^{n}\sum_{j=1}^{n} y^2_{i,j}\right)^{1/2}} \tag{10}$$

$R(u, v)$ is the normalized correlation coefficient. When $\theta \neq 0^{\circ}$ $R(u, v)$ is less than 1, and when $\theta = 0^{\circ}$, $R(u, v)$ will be 1, then, the vectors of the two images can be seen the same.

The normallized form can be simplified as follows:

$$R(u, v) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{i+u, j+v} y_{i,j}}{\left(\sum_{i=1}^{n}\sum_{j=1}^{n} X^{2}_{i+u, j+v}\right)^{1/2}} \tag{11}$$

3. Combined Methods

3.1. The Steps of the Method

This paper proposes a hybrid approach. It synthetically combines template matching with gray matching to process fuzzy art image. Here, the template can not only be the clear picture, but also be fuzzy pictures. The method can be divided into several steps:

Firstly, clarity grades of the processed image should be divided. The image will firstly divide into different sub images, and then, clarity of different sub image will be judged and handled. All the information of the sub image will be stored.

Secondly, blurred image processed will be matched with the existing templates in the database. The matching process can be divided into two steps: coarse matching and fine matching. In the process of coarse matching, sub images, which are meet the demands of the clarity, will be selected to match the images in the database. When the coarse match is finished and if the matching results are good enough, the fine matching will be taken into consideration. Fine matching process requires large-scale matching work with sub image module to ensure the match accuracy of the processed and template image.

Thirdly, when the careful fine matching is completed, if the two images have highly similarity, the processed image will be modified. Extremely blurred or erased image will be taken place with that in template image, or the image with no identification will be repaired. Finally, denoising for the restored image should be processed to obtain the final image.

The whole process can be detailed shown as Figure 2.

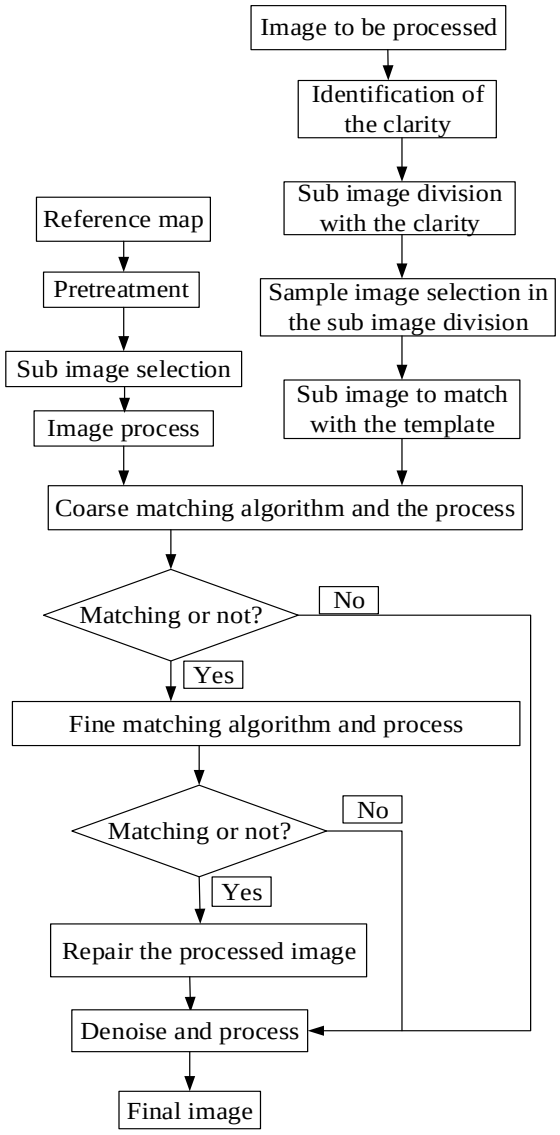

Figure 2. The Flow Chart of the Combined Method

In the combined method, the match method between the template and the blurred image adopts the gray matching algorithm.

3.2. The Algorithm Design

(1)Corase matching stage

Calculate the total search times, and match them cyclically and recursively. If take the correlation between the gray data into consideration, the sub image selected in the template can be matched according to a separated method. The matching criteria are as follows:

1) Obtain each benchmark sub image scanning from the upper left corner of a template image with every N1 pixels. Then, get extinction value with every N2 pixels in the being processed image and the template image. These values will be used to form the gray vector with smaller dimension for the correlation matching.

2)Calculate the similarity of the processed image and the template image with the use of simplified normalized product correlation similarity measure method.

3)With the recursive method of comparison, several optimal matching points will be obtained, and the corresponding reference sub graph will be selected as the candidate subgraphs.

(2) Fine matching stage

1) Appropriate expansion search matching near the matching points obtained in the rough stage will be completed firstly. Here, we give a rule for the expansion search. If the search goes on with each N1 pixels in the rough matching, the search will go on with the number of pixels ranged from 0.75N1 to N1.

2) Select the candidate subgraphs with the simplified normalized product correlation similarity method, and gray information will be matched in its extended range.

3) In all the measured values, the position with the biggest $R(u, v)$.

3.3. Decision of the Template Information

In the combined method, the template information include the following items:

(1) Selection of the template: higher performance of classification; obvious difference between selected templates; easy to recognize and calculate; cover the main pixel information.

(2) The size of the template: adaptive size for the templates.

(3) Number of the templates: less numerous, and sometimes, multiple image feature template can be used.

(4) Template type: rigid or flexible. Rigid template is prior.

4. Verification

In order to verify the validity of the combined method, some examples are used to do the experiment. Here, we choose some groups of art images to verify the method. All the original source of the images is comes from the reference [25], and the images are preprocessed to the gray type. For the first group, we give an example with no template to process the image. For the second group we give an example with template. In the second group, the art image is both processed with the template and without the template, which can be used to prove the effect of the template on the image processing.

(1) The first group

For the first group, we give the art image of curve, and there is a person in the picture. This kind of art image is quite few, so it is quite hard to find a template in the actual condition. At the beginning, the picture is quite blurred. It should be processed to make the image clear. Only the clear image can be used in the research of the image characteristic.

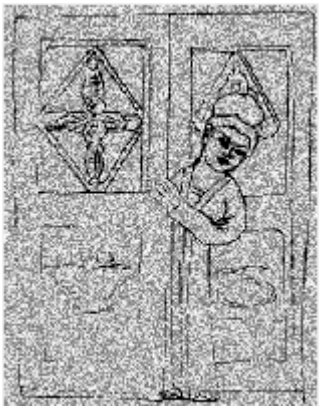

Figure 3. The Original Image

Figure 4. The Processed Image Just with Denoising Method

In Figure 3, the image is filled with noise points, which may include the existed noise, and fuzzy caused by the corrision. To this kind of problem, the combined method is mainly based on the denoising method. From the Figure 3 and Figure 4, it can be seen that the Figure becomes a little clear, but it may still locate at the low clarity level. Just with the denoising method, the image will be virtual, and it has a bad reduction performance. Therefore, it can not get enough characteristics as much as possible.

(2) The second group

For the second group, we give an ancient image of carving. This image has a special template. The template is also not clear. In the combined method, the template need not quite clear. Figure 5 shows the original image which is to be processed. The Figure 6 gives the template. Figure 7 gives the image after the matching with the template. And the Figure 8 gives the finally processed picture.

Figure 5. The Original Image

Figure 6. The Template

Figure 7. Image after the Match Process

Figure 8. The Final Processed Image

From the Figure 5 to Figure 8, it can be seen that the picture become much clear. Compared with the first group, the process effect is much better. When the template is blurred, it just can give the help in the seriously damaged part of the image; when the template is clear enough, the image to be processed will be greatly improved. In this example, we give the template, which is a little more clear. When matching the image, the image to be processed has a great similarity with the template. The processed image is repaired with the template. After the repair work, it is a little virtual, but it is clear, therefore, the further step to process the image will be easy. After the finally process work, it is quite clear. It can also be shown that processing the blurred image with template can improve the process effect. However, it should be noted that the final processed image has a big difference with the original image, and the background disappeared. This may be that the numbers of the sub images selected for the match work of the template and the processed image may be not big enough. In the future investigation, how to properly choose the number of the sub images to keep the process efficiency should be paid more attention.

5. Conclusion

Image processing is much widely applied in the various conditions. Low level image processing includes image sampling, filtering, rotating and other related image pixel and neighborhood operations. And with advanced image processing, a most powerful tool is image template operations. Therefore, the template method becomes very important. At the same time Chinese ancient art has a quite brilliant history, but many arts suffer natural corrosion and become blurred. And then, the how to repair and processing them becomes a very important work. Computer technology is an effective way to process it.

In this paper, we proposed a combined method based on the template matching. The aim of the method is to process the fuzzy art image into clear images. The method can be divided into several steps: firstly, clarity grades of the processed image should be divided; secondly, blurred image processed will be matched with the existing templates in database; thirdly, extremely blurred or erased image will be taken place with that in template image, or the image with no identification will be repaired. Finally, restored image should be processed to obtain the final image.

According to the verification, it can be seen that the template matching is extremely important in the processing of the blurred image. If the template is quite clear, the image will be clear. Otherwise, the picture will not get better effect. Therefore, if want clear process results, a good template is needed and a good template can be improved with the development.

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