Digital Image Mosaic Technology Based on Improved Genetic Algorithm

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***Abstract*—Image mosaic technology is an important technology in the field of image processing. Based on the general adaptability and clustering of genetic algorithm, we improve it, and apply it to the mosaic algorithm in image processing. In this paper, we test the validity and reliability of the designed algorithm in the process of image mosaic algorithm. Based on the image illumination mosaic and painting texture mosaic image we achieve certain artistic effect. From the convergence results of general algorithm, the results of numerical show substantially concussion, oscillation amplitude reaches a maximum of 10^{-5} . The calculation results of the genetic algorithm still have certain degree of concussion, oscillation amplitude reaches a maximum of 10^{-6} , convergence results are slightly better than the general algorithm. The improved genetic algorithm results have no concussion, the stability is very good, and the results have better astringency.**

***Index Terms*—Image Mosaic; Improved Genetic Algorithm; Digital Image; Stability; Convergence; Image Texture**

I. INTRODUCTION

The amount of information is very big in the process of image processing. Usually in order to save storage costs we optimize the data through a certain algorithm, improving the speed of extraction information. In recent years, genetic algorithm has attracted wide attention in the field of image processing [1,2]. Due to the development of electronic technology, the speed of computer hardware equipment upgrades and image process becomes more and more quickly which make the rapidly development of computer information technology. Image Mosaic technology has been applied to various fields including image measurement technology, image remote sensing technology and image processing [3]. The development of image Mosaic technology not only need hardware technology support but also need mathematics and information theory support which include the structure of algorithm in calculation process. This paper discussed image Mosaic technology based on the genetic algorithm. In this paper, it amplifies and synthesizes the image using the image Mosaic model and proves the accuracy and feasibility of the algorithm. It provides the theoretical guidance for image Mosaic technology development.

At present, the image Mosaic technology mainly includes image compression amplification technology, image Mosaic synthesis technology, the construction of the virtual scene which specific technical content is as follows [4, 5]:

(1) Image compression amplification technology

Image is easy to appear distortion in compression and amplification process, especially in the process of image magnification. If the resolution is not high, it will affect the clarity of the image. Image also can appear distortion in the process of image compression, such as the length and does not conform to the shape of the original image which need the image Mosaic technology to deal with image. It optimizes image through the vector algorithm, improves the image resolution using geometry theory and completes the high quality compression and amplification of image. But the current image Mosaic processing technology can not guarantee the quality of the image, and the processing speed is slow. So the high efficiency and high quality image Mosaic technology is the premise of the image processing.

(2) Image Mosaic synthesis technology

Image synthesis technology is the main part of image Mosaic technology. In order to reflect the beauty or artistry of the image, we often need to integrate several images together. But the current image Mosaic technology for image synthesis technology is still not perfect. There is more distortion situation after synthesized and the harmony of image is not high.

(3) Construction of the virtual scene

Virtual scene usually get different scene which need all sorts of image Mosaic. This requires higher Mosaic technology, or structure of the virtual scene is not reasonable. There is no perfect image Mosaic technology can construct high quality virtual scene. The layout of the virtual scene and the operation of the virtual animation design need image Mosaic technology. The Mosaic technology of animation is difficult to achieve, the demand on algorithm and hardware is higher. The quality of current situation Mosaic technology is not so high to realize the Mosaic technology.

So far in the field of computer image Mosaic algorithm, domestic and foreign experts put forward many methods, but each algorithm has its own characteristics, so the application field is limited. Such as R. Szeliski and J. Coughlan use the mathematical model of 2D parametric projective transformation in the process of image registration, obtain certain optimized effect in the image

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mosaic process [6]. However the image processing speed is slower. S.Mann and Picard use the bilinear model in the process of image processing, and use approximate projection transforming model, realizing not abstract feature points of image mosaic [7]. Speed of image mosaic has been significantly improved, but the processing speed is still not very fast.

II. SYSTEM MODEL

The application field of image mosaic technology is very wide. Image Mosaic algorithm is the foundation to realize image Mosaic technology [8]. It is not easy to get algorithm of high efficiency and stability. This paper develops image Mosaic algorithm of mathematical model based on the vector field algorithm, establishes image artwork vector matrix, coordinate transformation matrix and coordinate matrix after image Mosaic. It finally gets the amplification results after general amplification and vector field calculation through the image simulation using MATLAB simulation module. It finds the validity and feasibility of the image Mosaic algorithm through the analysis of the results [9]. Finally the article puts forward the steps of wizard vector field algorithm which provides a theoretical reference for the development of image Mosaic technology.

To sum up, the key point of image mosaic processing is to improve the calculation speed, the stability and convergence. Based on the genetic algorithm we improve the image mosaic algorithm. The main process is shown in Figure 1.

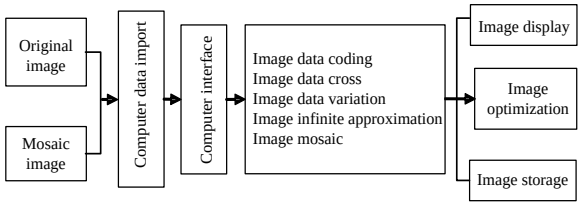

Figure 1. The flow chart of improved algorithm

Figure 1 shows the schematic diagram of the improved genetic algorithm process. From it we get the main process of the algorithm presented in this paper is based on the clustering algorithm, combining with the adaptive genetic algorithm, and binary coding on the cluster center, then processing crossover and mutation data. Finally we get the results.

Assuming the image pixel function before and after image mosaic hypothesis is $X(a,b)$ and $Y(a,b)$, we use genetic algorithm to do binary code on image function, so we can obtain in formula (1).

$$A = X + \sum_{i=1}^{m} a_i 2^{i-1} \frac{X-Y}{2^m - 1} \tag{1}$$

The process of image mosaic is process of infinite approximation for the image function $X(a,b)$ and $Y(a,b)$. Assuming $C(a,b)$ exists that if function $X(a,b)$ and $Y(a,b)$ are infinite approximations, we can get inlaid function image. The expression can be written in formula (2).

$$C(a,b) = \int\int (X-Y) da db \tag{2}$$

Suppose that the sample data of $X(a,b)$ and $Y(a,b)$ can be defined as x_k and y_l; the distance formula can be written as (3).

$$d(x_k, y_l) = \sqrt{\sum_{z=1}^{c} (x_{kz} - y_{lz})}, k, l = 1,2,...n \tag{3}$$

Gathering center at the original image samples can be expressed in formula (4).

$$M_k = \sum_{l=1}^{n} \frac{d(b_k, b_l)}{\sum_{k=1}^{n} d(b_l, b_e)}, k = 1,2,...n \tag{4}$$

Based on the genetic algorithm we first get a binary coding of clustering center.

$$\{x_{t-1}, y_{t-1}^1, y_{t-1}^2, \cdots, y_{t-1}^n\}, x_{t-1} \in R \tag{5}$$

Adaptive selection operation is such as the formula (6).

$$x_c = \sum_{m=1}^{c} eval(\psi_m)(c = 1,2,\cdots,z) \tag{6}$$

In which, ψ_m is the adaptive function; z is number of copy chromosome.

Do cross operation on the image data sequence $\{x_e^1, x_e^2, \cdots, x_e^n\}$ and $\{y_f^1, y_f^2, \cdots, y_f^n\}$.

$$\begin{aligned} \hat{x}_e^j &= u x_e^j + (1-u) x_e^j \\ \hat{y}_f^j &= (1-u) y_f^j + u y_f^j, \ j = 1,2,...,n \end{aligned} \tag{7}$$

where u is the random number, and $x \in [0,1]$. Then do mutation operation on image function, the formula is shown in formula (8).

$$\{\hat{x}_e^1, \hat{x}_e^2, \cdots, \hat{x}_e^n\} = \{x_e^1, x_e^2, \cdots, x_e^n\} + V \bullet s \tag{8}$$

In which V is a big positive; s indicates a random direction, and space is n dimension.

III. PROPOSED MOSAIC ALGORITHM

Genetic algorithm is one of the most popular computer algorithms. This paper improves the genetic algorithm based on the adaptability of genetic algorithm [10, 11]. And we apply it to the mosaic algorithm of the image processing using cluster integrating mathematical mode. The main process is shown in Figure 2.

Image mosaic technology is achieved mainly through the vector transformation of the image coordinates. So the vector coordinate transformation is the main research object of image Mosaic algorithm [12]. Image Mosaic algorithm guide vector field can be divided into three coordinate systems, one is the original vector coordinate system, and the other is the vector algorithm coordinate system and the Mosaic image vector algorithm coordinate system. Original vector coordinate system transforms the coordinates through the vector wizard coordinate system

and finally obtains the image Mosaic vector coordinate system and realizes image Mosaic process. The specific process is shown in Figure 3.

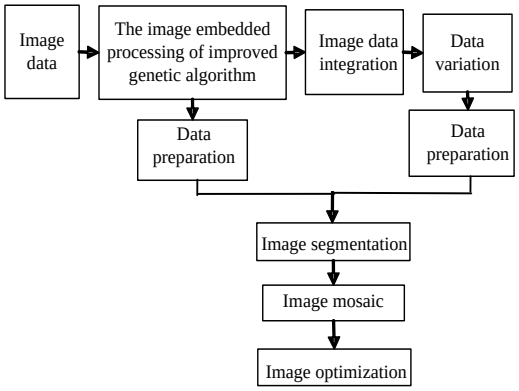

Figure 2. The mosaic process of map improved image genetic algorithm

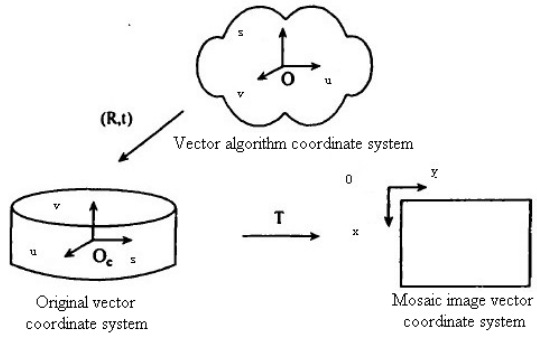

Figure 3. The process of image coordinates vector transformation

The image synthesis directional control can be realized through the image coordinate resolution model operation. The basic equation of operation is as follows:

$$\begin{pmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{pmatrix} = \begin{bmatrix} K_1 & 0 & K_2 & 0 \\ 0 & K_1 & 0 & K_2 \\ K_2 S & Z_1 K_2 & S & Z_1 K_3 \\ 0 & K_2 & 0 & K_3 \end{bmatrix} \begin{pmatrix} iV_1 \\ iV_2 \\ iV_3 \\ iV_4 \end{pmatrix} \quad (9)$$

In formula (9), V_1, V_2, V_3 and V_4 resolution mode positions and time coordinates; K_1 is coordinate after lengthen; K_2 is coordinate after widen; K_3 is coordinate after heighten; Z_1 is resolution base resolution; Z_2 is resolution Angle resolution; S is differential operator; U_1 and U_2 are resolution profile control.

Image synthesis equation is:

$$\begin{pmatrix} H_1 \\ H_2 \\ H_3 \\ H_4 \end{pmatrix} = \begin{bmatrix} U_1 + K_1 S & 0 & K_2 S & 0 \\ 0 & U_1 + K_1 S & 0 & K_2 S \\ K_2 S & Z_1 K_2 & R_f + K_3 S & Z_1 K_3 \\ -Z_1 K_2 & -K_2 & 0 & U_2 + K_3 S \end{bmatrix} \begin{pmatrix} iV_1 \\ iV_2 \\ iV_3 \\ iV_4 \end{pmatrix} \quad (10)$$

In formula (10), H_1, H_2, H_3 and H_4 are Image synthesis vectors. Firstly, we can transfer them to the K-S coordinate of stillness through the 3/2 transformation then get resolution and Mosaic image component through the rotating space vector coordinates. This will realize decoupling control of image and speed up the image Mosaic. Image perspective projection equation can be shown as follows [13]:

$$\frac{A'}{A} = \frac{B'}{B} = \frac{S}{C} \quad (11)$$

In 3D field, the plane coordinates of spot can be shown as:

$$A' = \frac{S}{C} A \;\; B' = \frac{S}{C} B \quad (12)$$

The transformation relationship of image Mosaic wizard vector field coordinate is [14]:

$$C \begin{bmatrix} A' \\ B' \\ 1 \end{bmatrix} = \begin{bmatrix} S & 0 & 00 \\ 0 & S & 00 \\ 0 & 0 & 10 \end{bmatrix} \begin{bmatrix} A \\ B \\ C \\ 1 \end{bmatrix} \quad (13)$$

Image magnification needs to image smooth processing. The traditional smooth processing mode is weighted coefficient method which merged image M and N into image L. Setting $X(a,b)$ as weighting coefficient. So, the following formula is established [15].

$$L(a,b) = X(a,b)M(a,b) + (1 - X(a,b))N(a,b) \quad (14)$$

The flow diagram of image mosaic technology is shown in Figure 4. Using the mat lab software can realized the algorithm of image mosaic.

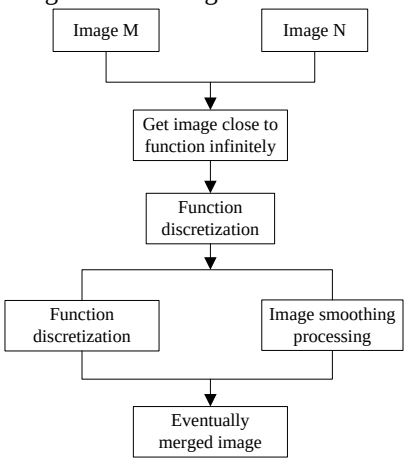

Figure 4. The flow diagram of mosaic technology processing

The algorithm has good adaptability, it can effectively improve the speed of information processing, and has good stability and convergence. Based on the theory of clustering algorithm, the genetic algorithm is improved. We apply it in the process of image processing. We test the validity and reliability of the designed algorithm in the process of image mosaic algorithm. Finally we obtain the iterative convergence curve and comparative data of calculation efficiency and accuracy. It provides the theory reference for the study of computer image processing algorithm.

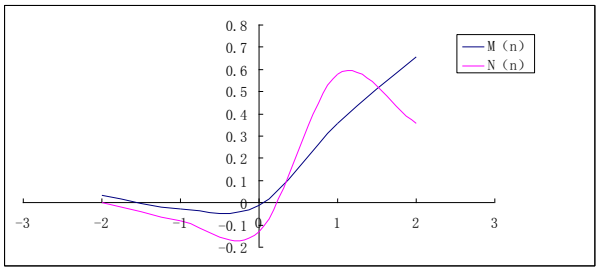

Figure 5. The trend chart of filter function coefficient

(a) Original drawing

(b) Large Picture after amplification

Figure 6. Panda pictures based on mosaic image

We can also see the effectiveness of vector field image Mosaic algorithm through the establishment of image Mosaic vector field mathematical model and MATLAB simulation. But there are also a lot of insufficient places such as color image processing in image magnification process; hue saturation processing in image synthesis process; the speed of the computer algorithm vector field.

(1) Color and saturation

In the image magnification and synthetic process, resolution and color contact ratio have been transformed which can ensure there has no distortion situation. But there has the shortage of place of color and tonal processing. Color motif and color saturation not have been transformed which will caused the lost and tonal unsaturated of color.

(2) The speed of the algorithm

With the computer's hardware condition, in order to guarantee algorithm can realized in general computer we must reduce the complexity of the program. So we need to design and optimize algorithm to ensure the stability and rapidity of vector field image Mosaic algorithm.

Table I shows the coefficient of filter function. We select a few pictures to simulate image Mosaic. One group is image magnification Mosaic and another group is image synthesis Mosaic.

TABLE I. THE COEFFICIENT OF FILTER FUNCTION

N	M(n)	N(n)
-2	0.0356	0
-1	-0.0287	-0.0798
0	-0.0122	-0.1298
1	0.3578	0.5782
2	0.6579	0.3565

Figure 5 is the trend of filter function coefficient. The $M(n)$ image coefficient changes increase gradually; $N(n)$ image coefficient changes into sinusoidal function profile.

In Figure 6, the panda pictures are amplified from small size to big size. Mosaic image is still clear through the resolution.

Figure 7 shows that it was merged into two images, and we can also determine the repeat part. Image Mosaic algorithm made the Figure more harmonious, the color more coordinating and image more flat.

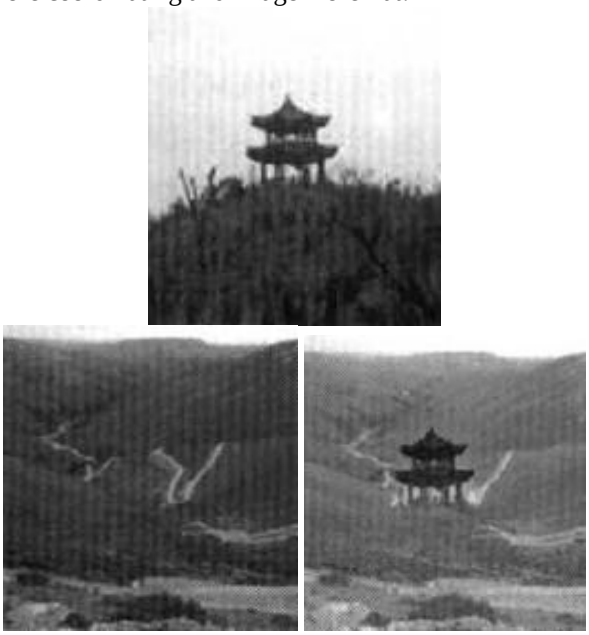

Figure 7. Mosaic synthetic map

IV. EXPERIMENTAL RESULTS

In order to verify the effectiveness and reliability of algorithm proposed in section second, we combine with the actual image processing process, and do image mosaic [17, 18]. The calculation results are used to validate the algorithm. The pretreatment of image is shown in Figure 8, and it is an ordinary image lack of illumination. Through the image illumination mosaic and painting texture mosaic image we can achieve certain artistic effect.

In this paper, we use the improved genetic algorithm to do iterative calculation on the image, and the results are analyzed by image processing software. We obtain the

convergence curves of the iterative process, and it is shown in Figure 9.

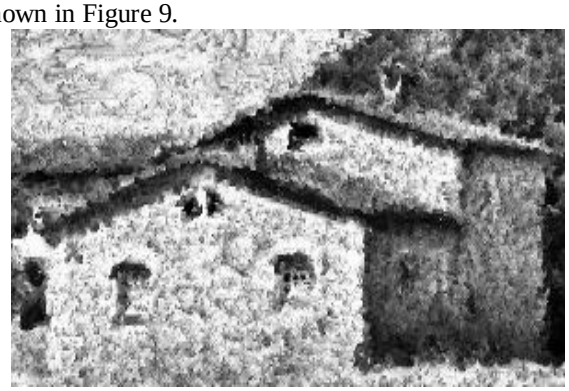

Figure 8. The image to be processed

Figure 9 shows the convergence of the iterative curve algorithm. In 300 steps of iterative calculation, the stability of calculation result is not good, and the number appears substantially concussion. Oscillation amplitude reaches a maximum of 10^{-5}, convergence results are not good.

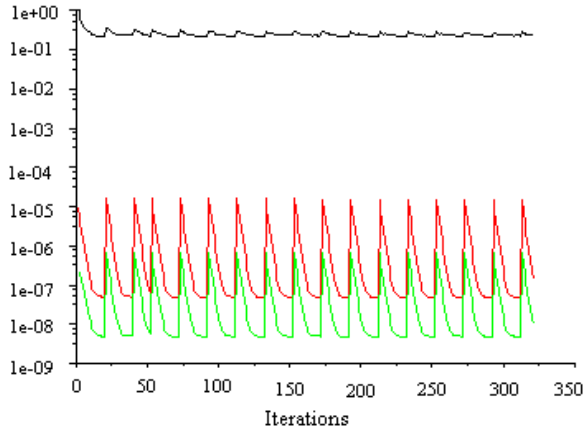

Figure 9. The general algorithm of iterative calculation

Figure 10 shows convergence curve before the improved genetic algorithm. In the 300 steps of iterative calculation, the stability of calculation result is better than the general algorithm. But it still has a certain degree of concussion. Oscillation amplitude reaches a maximum of 10^{-5}. Convergence results are slightly better than the general algorithm.

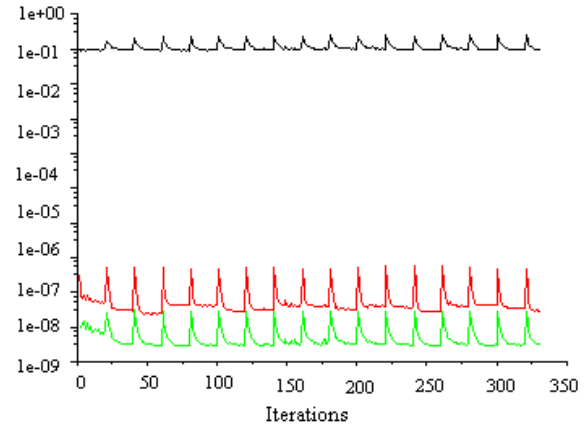

Figure 10. The calculation curves of Genetic algorithm

Figure 11 shows the iterative convergence curve of the improved genetic algorithm. In the 300 steps of iterative calculation, the stability of calculation result is better, and the results have no concussion [19]. And it achieves stable convergence in the 120 step. The accuracy of convergence is very high.

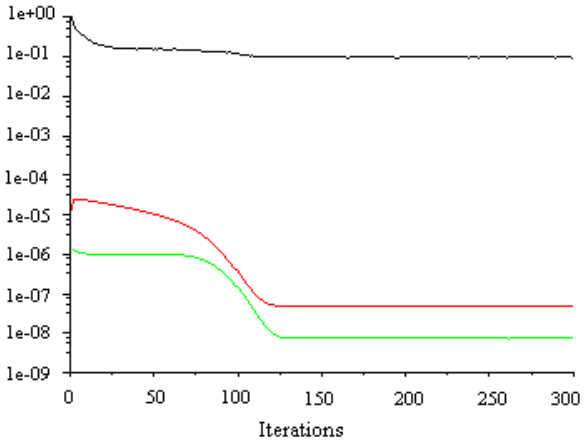

Figure 11. The calculation curves of iterative improvement genetic algorithm

Figure 12 shows the image effect after light mosaic. From the chart we can see image illumination color is better, higher light saturation. It achieves good artistic effect.

Figure 12. The effect chart after embedded light

Figure 13. The effect chart of mosaic painting

Figure 13 shows the effect graph after the painting texture mosaic. From the Figure we can see image painting texture is obvious, and have obvious difference with the ordinary digital images. It achieves good artistic effect.

Table 2 shows the actual use of iterative step in image processing. From it we can see the average iteration step of the improved genetic algorithm is 1802, less than genetic algorithm before improvement. It verifies the effectiveness and availability of improved genetic algorithm.

TABLE II. THE IMAGE PROCESSING OF ITERATIVE STEP TABLE

Calculation results	Genetic algorithm (step)	Improved genetic algorithm (step)
Minimum value	2052	1699
Maximum value	2036	1905
Average value	2044	1802

Table 3 shows the actual use time of the image processing. From it we can see the average time with the improved genetic algorithm is 12.69s, it is obviously less than the algorithm before improved. It verifies the effectiveness and availability of improved genetic algorithm.

TABLE III. USING TABLE BY IMAGE PROCESSING

Calculation results	Genetic algorithm (s)	Improved genetic algorithm (s)
Minimum value	18.52	13.26
Maximum value	17.32	12.12
Average value	17.92	12.69

Table 4 shows the accuracy of image processing. From it we can see the average accuracy rate of improved genetic algorithm is 97.2%, better than the genetic algorithm before improved. It verifies the effectiveness and availability of improved genetic algorithm.

TABLE IV. IMAGE PROCESSING ACCURACY

Calculation results	Genetic algorithm (%)	Improved genetic algorithm (%)
Minimum value	76.4%	92.3%
Maximum value	66.1%	91.1%
Average value	68.9%	97.2%

From the examples of image processing simulation, we can see that the genetic algorithm can be widely used in image Mosaic technology very good and can got good treatment effect.

(1) Image Mosaic technology uses complicated algorithm, so the calculation process is slow. A simple and efficient algorithm for Mosaic technology is very important. Speed also influenced by the computer hardware. If the speed of hardware processing is faster and faster, the realization of mosaic technology is simpler.

(2) Design is the key of the image mosaic technology algorithm. Now there are few simple and efficient algorithms. The algorithm commonly used is achieved through the mathematical transformation, but the efficiency and quality also is not very high and image processing is easy to distortion. Using the genetic algorithm can make the data parameter optimized but the realization of the software is complex.

(3) The software of image processing is MATLAB which is commonly be used, except the software PS which interface is image processing at present. MATLAB has obviously advantages on matrix efficient treatment. But the software is bigger, and it is more troublesome when combined with computer. So a simple and efficient algorithm of image Mosaic treatment can not only realize the rapidity and efficiency of image Mosaic but also can reduce the requirements of image Mosaic technology on hardware and software.

V. CONCLUSION

This paper established the mathematical model of image Mosaic algorithm through the wizard vector field algorithm and got the 3D projection coordinate and other important data algorithm through the vector coordinate transformation. We can carry out the simulation experiment of image Mosaic algorithm by using MATLAB simulation module, to obtain the image magnification and synthesis results.

Through the simulation results we found that the common images and images after vector field algorithm Mosaic processing are quite different. Vector field algorithm can guaranteed the image Mosaic process definition have not distortion. In the image synthesis Mosaic simulation we can see that the contact ratio of image through the vector field image Mosaic algorithm is very good. Image Mosaic technology has been widely used in engineering fields. So the development of practical, fast and reliable algorithm is the focus of future researches. Combining with the adaptability of genetic algorithm, and improves it. We apply it to the mosaic algorithm in image processing and achieve better image processing results. From the mosaic effect, after light mosaic, image illumination color is better, higher light saturation, achieving good artistic effect. After the painting texture mosaic, image painting texture is obvious. And it has obvious difference with the ordinary digital images, achieving good artistic effect. From the point of calculation accuracy and the efficiency, the average iteration step of the improved genetic algorithm is 1802, the average time is 12.69s, and the average accuracy rate is 97.2%. It verifies the effectiveness and availability of improved genetic algorithm.

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