Automatic Registration Method for Leather Section Image using SIFT and Wavelet Transform

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Abstract: Image registration is one of the hot topics of image processing, which has been widely concerned by researchers. However, most existing image registration methods are inefficient and inaccuracy. Thus, this paper proposes an efficient method that uses multi-resolution wavelet transform to process the original images. This method utilizes decomposition and reconstruction of two-layered wavelet to eliminate the error matching points effectively. Experimental results show that this method has a better robustness, which can not only get more key points but also improve the correct matching rate greatly.

1 INTRODUCTION

Leather is regarded as high-grade consumer goods, because of its excellent material and attractive appearance, but its three-dimensional structure of the fiber, has not been fully discovered. As Nature starting to crack the mystery of toughness of spider silk from spider silk structure in literature (Glareh Askarieh, My Hedhammar and Kerstin Nordling, 2010), it provides guiding significance for the manufacture of man-made fibers manufacture.

With the development of image processing technology, much attention has been paid to high resolution, large image processing technology. However, due to the order of magnitude of a piece of leather fiber is very small, So it need to enlarge the larger multiples. If you want to get a complete high-definition images, image stitching (Koiolovoci, Vagvolgyib, 2000) in which the technology is particularly important where the image registration is the key part of it. Image registration is found the relative position of point to point and mapping relation between different images of the same scene shot, or establish connection to some feature points. The process usually includes: feature detection, feature matching, transformation model parameter estimation, image resampling and transformation. In recent years, more widely used based on feature points matching (Thornburg Jonathan, Rodes Charles and Lamvik Michael, 2006) are SIFT feature matching algorithm is put forward by Lowe DG in 2004 (HeMY, DaiYC and ZhangJ, 2008) and SURF feature matching (Bay H, Tuytelaars T and VanGool L, 2006) by Bay. SIFT algorithm under the condition of the scale and rotation changes better than the SURF (Huang L, Chen C, Shen H, 2015), in the field of image registration and stitching been more widely used (Jiachang Gong, Jichang Guo, 2016 and Chen Y, Shang L, 2016).

2 IMAGE ACQUISITION

2.1 Leather interface of image retrieval

The texture of leather fibre is very soft. They usually occurred deformation easily when we cut the leather into slices according to the spacing of a few microns. And it also will cause some changes in different degrees with the position and shape for every fibre in the image.

But the leather is porous material, epoxy resin is infiltrated into leather fiber. The resin will be infiltration of leather fiber as soon as the leather touched the resin which is low viscosity and strong permeability. The leather fibre is fixed with the resin fixative. Then we can get leather - resin composite material with a certainty hardness. And the material can also be mosaic, grinding, polishing and soon technology.

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2.2 Maintaining the Integrity of the Specifications

After we get the picture of metallographic sample preparation, we can confirm the interlamllar spacing of sequence diagram by measuring the thickness of the substrate. The leather sample would be put into the temperature of 40℃ for one week. After that, polish the metallographic sample preparation which is cylindrical to be smooth. Choose four points which is near the leather sample, then use micron micrometer to measure the thickness of the four points and record the dates. We can get the leather cross section images which are the first of the sample sequence images via the microscope observation.

Cut out the leather sample piece to meet the requirements of the thickness which complete the operation of take a photo, then take it for polishing, respectively measuring the thickness of the cylindrical sample piece of four points use micron micrometer, and obtain the second image on microscope, repeat the steps to get images in turn, so that we can get sequence images. Through calculation the 4 points thickness before and after in twice, take the average as the distance between two image, so we can obtain the layer spacing of sequence image.

3 SIFT ALGORITHM

3.1 SIFT algorithm description

SIFT algorithm is an operator which is based on scale space, image scaling, rotation invariance, or even affine transformation, the noise also maintained a certain degree of stability of local image features described. It can detect all of SIFT key points and 128-dimensional feature vectors from each section of the leather image. By the determination of the position, size and orientation, it establishment a descriptor for each key point, described through a set of vectors to described. In order to achieve image registration. It can be divided intoeveral steps:

1) Construction scale space, detect extreme points, to obtain scale invariance.

The problem of SIFT algorithm can be classified as find the key point in different scale space (Tony Lindeberg, 1994), and the Gauss kernel function is the only one that can generate the multi-scale space. Convolution of Two-dimensional gaussian function $G(x, y, \sigma)$, can achieve the purpose of blurred image Template Rogos dimensions m*n (generally speaking, the size is $(6\sigma+1)*(6\sigma-1)$, then the image position (x, y) on the template of the corresponding gauss formula is：

$$\mathrm{G}(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x-m/2)^2-(y-n/2)^2}{2\sigma^2}} \quad (1)$$

The scale space of two-dimensional image $L(x, y, \sigma)$ can be defined as the convolution operation of a change in scale two-dimensional Gauss's function $G(x, y, \sigma)$ with the original image $I(x, y)$:

$$L(x,y,\sigma)=G(x,y,\sigma)*I(x,y) \quad (2)$$

Where * denotes the convolution operation, σ is the scale space factor, the smaller value the less smoothed, the corresponding scale smaller.

Scale space is realized by Gauss Pyramid, each pixel in the dog scale space need to compare with the pixel point of neighboring points around the 8 adjacent points and the upper and lower scales corresponding to the location of the surrounding neighborhood 9*2 points a total of 26 pixels, so that can detect the local minima both in the scale space and two-dimensional image space.

2) Filter and precise positioning feature points.

DoG operator can generate strong edge response, and it is needed to eliminate the unstable edge response points. A poor DoG function at the point of the peak points have larger principal curvature in the direction of across the edge, but in the direction of the vertical edge of is smaller. The relationship of main curvature and characteristic value is proportional, so it can be used to determine a threshold value to eliminate the edge response points, which can enhance the stability of the matching and improve the ability of anti-noise.

3) Distribution direction value for the feature points.

We can use the distribution features of the gradient direction. We need to specify the direction of parameter for every key point, then descriptor will have rotation invariance. For the key points detected in the DoG pyramid, gather the gradient and directional distribution feature for pixels which are in the Gaussian pyramid image neighboring window.

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Below is the module value of gradient and directional for the pixels

$$m(x,y)=\sqrt{(L(x+1,y)-L(x-1,y))^2+(L(x,y+1)-L(x,y-1))^2} \quad (3)$$

$$\theta(x,y)=\tan^{-1}((L(x,y+1)-L(x,y-1))/L(x+1,y)-L(x-1,y))) \quad (4)$$

where L represents value of a key point in spatial scale.

Direction of sampling points is carried out by the adjacent area window with the key points as the center. It shown through 36 columns (Divides the 0-360 to 10 degrees for a column).The direction of the key points is the peak of the histogram.

4) Generate feature descriptor

After the calculated of characteristics of the key points through the above steps, The value of the key points feature can be determined, we can describe the key points through a set of vectors, so that it is not affected by changes in perspective, the impact of changes in perspective.

First, determine the calculation the image area of descriptor. SIFT descriptor is a representation of statistics results about the key point adjacent area of Gaussian image gradient, In (David G.Lowe, 2004) Lowe papers suggest that descriptor use eight directions information calculated by 4*4 window in the key points scale space, in total4*4*8=128 dimensional vector. Descriptor gradient direction histogram are computed by the blurred image of the scale where the key point exist, the radius of image region is expressed as:

$$radius=\frac{3\sigma_{oct}*\sqrt{2}*(d+1)+1}{2} \quad (5)$$

where σ_{oct} indicates the scale of group containing key point.

Then rotate the coordinate axis as the key point of the main direction, so the new coordinates after the rotation is:

$$\begin{pmatrix}x'\\y'\end{pmatrix}=\begin{pmatrix}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{pmatrix}\begin{pmatrix}x\\y\end{pmatrix}\ (x,y\in[-radius,radius]) \quad (6)$$

The last, Calculate gradient value of each pixel which in the area of image radius and distribute it to eight directions, calculate the weights. Setting threshold so that we can truncation larger gradient value, then normalized processing again, remove some direction of gradient value which is the value of gradient too large cause by the illumination change to improve the identification of features. If ratio of the nearest two key point distance to the nearer two key point distance is less than the proportion of threshold then accept the matching points.

3.2 Principle of Wavelet Transform

Wavelet transform is a major breakthrough of Fourier transform and short time Fourier transform, and it is successfully applied to image denoising, edge detection and so on. Compared with the Fourier transform, The signal can be local subdivided by wavelet transform in the two dimensions of time and frequency.

When we use wavelet analysis the image, we should choose the appropriate basic wavelet or wavelet, wavelet function is formed by a series of basic wavelet translation, flexible operation, and finally the signal will be projected onto the signal space composed of translation and stretch wavelet for analysis.

1) Wavelet definition

Set $\varphi(x)\in L^2(R)$, and meet the conditions $\hat{\varphi}(0)=0$, then we called $\varphi(x)$ as basic wavelet or wavelet, the wavelet function is obtained by scaling and translation:

$$\varphi_{a,b}(x)=\frac{1}{\sqrt{a}}\varphi(\frac{x-b}{a})\text{▯▯▯}a,b\in R,a\neq 0 \quad (7)$$

Where a is stretch factor, b is the translation factor.

The continuous wavelet transform of any function $f(x)\in L^2(R)$ is defined as:

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$$(W_\varphi f)(a,b)=<f,\varphi_{a,b}>=\frac{1}{\sqrt{a}}\int_R f(x)\overline{\varphi(\frac{x-b}{a})}dx \quad (8)$$

The local change of the continuous wavelet transform, the high frequency resolution, low resolution in low frequency, which is more conducive to the extraction of features in the image.

2) Image registration based on wavelet transform

Wavelet analysis has multi-scale characteristics, it provides a more flexible processing method for image processing. In this paper, we use the discrete

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wavelet transform, the image is decomposed into 2 layers, and the low frequency components of the 2 layer are used to match the image. Experiments show that the low frequency component contains most of the information of the image, through the removal of high frequency components of noise, improve the robustness of the matching.

DbN wavelet is the discrete orthogonal wavelet designed by Daubechies, generally referred to as dbN, where N is the order of the wavelet, the size of the N reflects the smoothness and concentration of the wavelet. Only N = 1 (Haar wavelet) has an analytic expression. Haar wavelet as the wavelet analysis of the most typical wavelet, the analytical method of the expression as follows:

$$\varphi(x)=\begin{cases}1 & 0\le x<1/2\\ -1 & 1/2\le x<1\\ 0 & other\end{cases} \qquad (9)$$

The corresponding scaling function is:

$$\varphi(x)=\begin{cases}1 & 0\le x<1\\ 0 & \text{other}\end{cases} \qquad (10)$$

DbN wavelet function and the effective support area of the scale function is 2N-1, and the vanishing moment of wavelet function is N, so its scalability is better, which can effectively solve the boundary problem.

The image processing algorithm based on wavelet design as follows:

- Firstly, use multi-scale wavelet analyze and deal with the image which have much noise, we can get low frequency images by the 1 layer wavelet decomposition;
- Using the obtained image to carry out wavelet threshold denoising operation, after that,carry out the operation of 2 layer decomposition, then we can obtain the two stage low frequency image;
- Reconstruction of two stage low frequency images and use it for registration;

4 EXPERIMENTAL RESULTS

The experiment done in matlab programming under Windows 7 in this article, the experimental data is image slices of the pigskin leather, on the condition of leather image translation, rotation, and the change of illumination to complete the operation of image registration, the result as follows.

Table 1: Comparison of image registration.

Image	key point count (1st image)	key point count (2nd image)	Matching point	Correct rate
Original image	1278	1663	5	80%
Wavelet Image	1404	1763	7	100%

Image registration is affected by illumination, position, etc. In this experiment, we use different layers of images, there are differences in the position and brightness, and the edge of the feature area is not obvious. The matching results of the original image are shown in Figure 1, Figure 2.

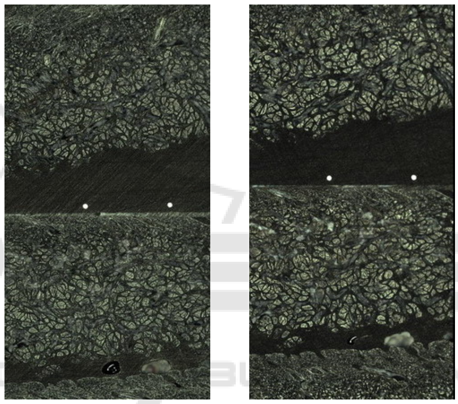

Figure 1: Original image a,b

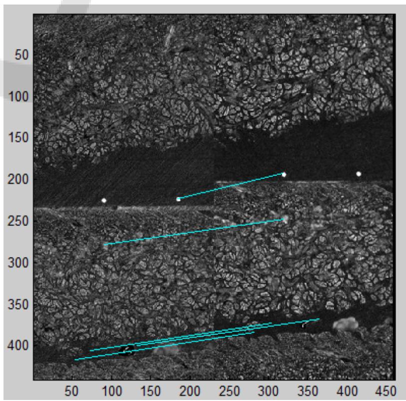

Figure 2: The results of original image registration

The image matching results of the after 2 layers of wavelet transform are shown in Figure 3, Figure 4.

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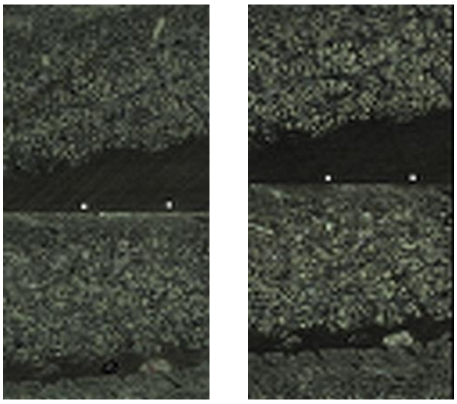

Figure 3: The image after wavelet transform a, b

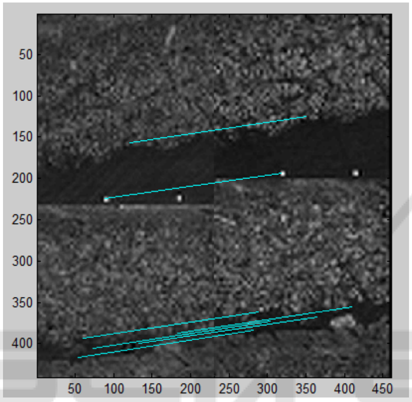

Figure 4: The results of the image after wavelet transform

Experimental results show that the original image matching have error point, but using wavelet to low-frequency image processing, it not only makes the image edge response is more sensitive, but also through the noise processing, reduce the matching error, correct matching rate increased significantly. Compared to the original image, the image after wavelet transform can get more matching point, use the method, iamge registration can not only improve efficiency, and has better robustness and higher accuracy.

5 CONCLUSION

This experiment use leather image in the article, Experiment results show that the image after wavelet image processing, the feature points matching rate of SIFT algorithm increased significantly, the correct rate is also improved, there is a better efficiency and robustness.

Recently, as the rapidly developing of image information, SIFT algorithm has made a great contribution to image automatic mosaic and image fusion, based on feature matching, we can move forward apply SIFT algorithm to practical application, as target recognition and image data, ect. Provide essential conditions for image analysis and other technology.

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REFERENCES

Bay H, Tuytelaars T, VanGool L,2006. *SURF：speeded up robust features.* Proceedings of the 9 European Conference on Computer Vision.

Chen Y, Shang L,2015. *Improved SIFT image registration algorithm on characteristic statistical distributions and consistency constraint*. Optik - International Journal for Light and Electron Optics

David G.Lowe. 2015. *Adaptive registration algorithm of color images based on SURF*. Measurement.

Glareh Askarieh,My Hedhammar,Kerstin Nordling, etc. 2010. *Self-assembly of spider silk proteins is controlled by a pH-sensitive relay*. Nature.

HeMY，DaiYC，ZhangJ. 2008. *Image registration by integrating similarity and epipolor constraints*. Proceedings of The 3rd IEEE Conference on Industrial Electronics and Applications.

Huang L, Chen C, Shen H, etal. 2015. *Adaptive registration algorithm of color images based on SURF*. Measurement.

Jiachang Gong, Jichang Guo, 2016. *Image copy-move forgery detection using SURF in opponent color space*. Transactions of Tianjin University

Koiolovoci, Vagvolgyib, 2000. *DApplication of panoramic annular lens for motion analys is tasks:Surveillance and smoke detection*. IEEE

DThornburg Jonathan, Rodes Charles, Lamvik Michael, etc, 2006. *Image analysis method (IAM) for measurement of particle size distribution and mass availability on carpet fibers*. Aerosol Science and Technology.

Tony Lindeberg, 1994. *Scale-space theory: A basic tool for analysing structures at different scales*. Journal of Applied Statistics

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