IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 3, March 2016

Image Registration Algorithm Based on Image Normalization

Wu Jianzhen[1, 2], Li Hongqin [1], Luo xiao[1]

School of Electronic and Electrical Engineering, Shanghai University of Engineering Science, Shanghai[1]

School of Computer Science and Software Engineering, East China Normal University, Shanghai[2]

Abstract: Image registration is a central problem to many tasks for image processing and is widely used in many applications such as automatic navigation, medical diagnostics, computer vision and etc. An image registration scheme using image normalization is proposed in this paper. Image feature points robust to rotation, scaling, noise and JPEG compression are obtained by the affine invariant Harris feature point detector and used to make the Delaunay triangle to estimate the affine transform parameters through image normalization. Simulation results show that the proposed scheme can effectively estimate rotation, scaling and translate parameters and has high estimation accuracy under common image attacks.

Keywords: Image normalization, Harris detector, Affine transforms, Robustness.

1. INTRODUCTION

Image registration techniques is one of the rapid developed image processing technology in recent years, and it is an important part of the remote sensing image processing, automatic navigation, medical diagnostics, computer vision and etc. It plays an important role in civilian and military fields [1]. When images are taken from different perspectives, images are not aligned spatially [2]. For the given two images to be registered, the main task of image registration is to find an optical geometrical transformation such as rotating, scaling, translating between two images, so that after applying the corresponding affine parameters, the transformed image can be aligned with another image topologically and geometrically [3]. The type of geometrical transformation and corresponding geometric relationship between images largely depend on applications.

In the last several years, there is a great deal of effort spent on developing the image registration techniques. The conventional image registration algorithms can be basically classified into three categories: mutual information based methods [4], transform domain based methods [5] and feature based methods [6]. The key of mutual information based registration methods is to find the optimal parameters between images when the mutual information of two images reaches the maximum value. The main idea of transform domain based registration methods is to transform the image to be registered to the frequency domain (such as Fourier transform domain or wavelet transform domain), and achieve registration between images according to corresponding relationships of the affine transformation features. Feature-based registration methods mainly use image processing feature extraction technology to extract feature points of the registered image and the original image (such as edges, corners and etc.), using some criteria to find the corresponding feature points, and then calculate the registration parameters and finish the final image registration.

I. Ethanany [7] proposed a novel method utilizing feed forward neural network to register an attacked image through 144 DCT-base band coefficients as the feature vector, but due to the un-orthogonality of DCT base space, it needs a large number of input features to describe image global pattern, thus expose a high computational cost and is hard to implement in practice. In addition, estimation accuracy and robustness toward noise and cropping is not so desirable.

In order to improve the accuracy to cropping attack, rotation with cropping attacks will only cut some feature points in the edge, and there will many other feature points to be available .As the accuracy of affine parameters mainly depends on the selection of feature points, Reference [8] analyses three different feature point detectors: Harris, Achard - Rouquet and SUSAN detectors. In his experiment, features points were extracted by these three detectors from images before and after undergoing geometric transformation, noise, JPEG compression. The results show that Harris feature point detector is the most stable detectors under rotation, scaling and noise attacks. Therefore, we propose to use of a kind of Harris feature point detector in this paper to extract affine invariant feature points, using these feature points constituting the Delaunay (Delaunay) triangles, and then using image normalization to match triangles in the image before and after affine transformation, finally these matching triangles will be used to calculate affine transformation parameters. Below we first introduce Harris affine invariant feature point detector.

2. AFFINE INVARIANT HARRIS DETECTOR

Harris detector is proposed by C. Harris and M. Stephen [9] in 1988, it is a point feature detector for still image. The construction of the detector is based on a corner detection function proposed by Moravec[10]. According to the auto-correlation function of signal processing, array M corresponding to auto-correlation function is given. The eigen value of M is the one order curvature. As to any point in the image, if the horizontal & vertical curvatures are

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 3, March 2016

greater than that of other points in the local neighborhood, the point is regarded as a feature point. The equation for Harris detector is only related to the 1st derivative of the image.

$$M = G(s) \otimes \begin{bmatrix} g_x^2 & g_x g_y \\ g_x g_y & g_y^2 \end{bmatrix} \quad (1)$$

$$E = \det(M) - \lambda Tr^2(M) \quad (2)$$

In the equation (1), g_x and g_y refer to the horizontal and vertical gradient respectively, $G(s)$ is the gaussion template. In the equation (2), det and Tr are the determinant and trace of the array respectively. λ is a default constant which normally takes the value of 0.04.

Harris detector is an effective and robust point feature detector. The reason for choosing Harris feature points as the reference for image content synchronization is that it has the following advantages: simple and effective computation with high stability when the image undergoes rotation, grayscale variation, noise and viewpoint changing. It is one of the most stable point feature extractors. Stable image feature detection is very important in image registration. We look for feature points which are perceptually significant and are invariant to various types of common signal processing and geometric distortions. In order to improve the detection accuracy of the image feature points, we use the Harris affine invariant feature point detector by adding the following steps to Harris detector:

(1) Apply a gaussion low pass filter to the original image to avoid detecting corner points due to image noise.
(2) Calculate the corner response image within a circular window to reduce the effect of rotation on the performance of the detector .This circular window centers at the image center and covers the largest area of the original image.
(3) Apply a gaussion low pass filter to the corner response image to achieve the maximum resistance to image compression and interpolation.
(4) According to the local maximum value, find the most important feature points in the circular area centered in every filtered corner responses. Rotation and scaling attacks are applied on the image for several times in order to find a group of common feature points.

Feature points detected by Harris affine invariant feature point detector can be resistant to various attacks and have a strong robustness.

After feature points are detected and determined, in order to be able to take advantage of normalization techniques to match these feature points, these points are used to build Delaunay triangles. We choose the Delaunay triangle for the following important properties:

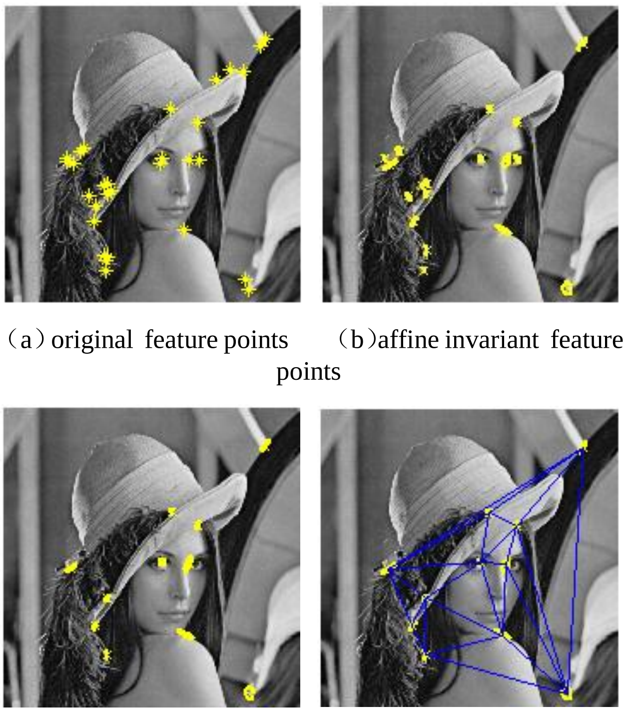
(1) When feature points are evenly distributed in the image, this kind of triangles can avoid forming narrow and too small acute triangle. In addition, each triangle in the mesh does not contain any of the other triangles.
(2) If a vertex of one triangle is disappeared, only those triangles connected to this vertex are affected. If a vertex is added in the triangle mesh, only those triangles connected are affected too.
(3) Each Vertex is associated with a stability area in which the tessellation is not modified when the vertex is moving inside this area.
(4) The computational cost is low: Delaunay triangle can be done with fast algorithms.

When detecting feature points, it is very important to determine the diameter of the circular neighbourhood. If the neighbourhood is too small, feature points will concentrate on the texture area, resulting in too small area of triangle. If the neighbourhood is too large, the number of feature points will be too small to meet the requirements. In order to obtain even distribution of feature points, a circular area with Harris point to be the center will be chosen and its diameter is determined by the following equations:

$$D = \frac{(l_x + l_y)}{\rho} \quad (3)$$

Where l_x and l_y are the width and height of the image respectively, ρ is a constant value based on empirical processing.

In order to demonstrate feature detection and triangulation, 512×512 Lena gray level image is utilized as the test image and the simulation results are shown in Figure 1. The value of ρ parameter is 15 in the simulation.



(a) original feature points (b)affine invariant feature points

(c)Feature point distribution (d)Delaunay triangle after region division

Fig. 1 Affine invariant feature points & Delaunay triangle

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 3, March 2016

3. REGISTRATION BASED ON IMAGE NORMALIZATION

When Delaunay triangle is formed by the detected feature points, Image normalization algorithm proposed by Pei [11] will be utilized to make the correct association between the original triangle and the transformed triangle. In order to reduce the information storage, the shape of the Delaunay triangle is used when retrieving the Delaunay triangle and the value inside the triangle is replaced by 1.

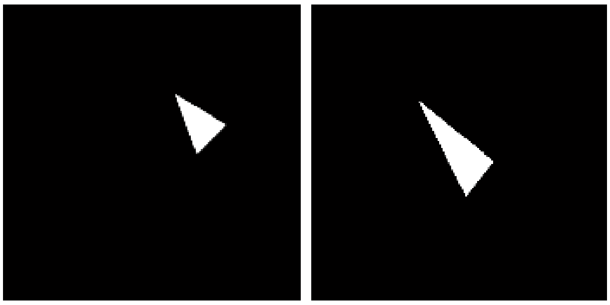
In order to demonstrate the normalization results, a triangle normalization example under different affine transformation is given in figure 2. In the figure, (a) is a triangle extracted from the original Lena gray scale image's Delaunay triangulation and filled the value inside the triangle by 1; (b), (c), (d) shows the original triangle rotated by 60 degrees, scaling down by 0.5 times as well as scaling down by 0.75 time plus rotated by 135 degrees and their normalized image. As we can see from the results, the triangle's direction and position with different affine transform is the same after utilizing image normalization, which indicates that it is not affected by rotation and scaling, so it can be used to identify the same triangle among the triangle set.

Affine parameter estimation can be done by comparing the corresponding three vertexes of each pair of matched triangles before and after geometry transformation. A_{ori} includes the normalized triangles from original image and A_{aft} includes the normalized triangles from image undergoing geometry transformation。We use the principle of similarity to match triangles between A_{ori} 和 A_{aft}, and set a threshold value ε and only the vertexes of those triangles pairs whose similarity higher than ε are used to calculate affine parameters. When there are many matched triangles, mean values will be taken as the final affine parameters.

（a）original and normalized triangle

（b） triangle rotated by 60°and its normalized triangle

（c） triangle scaling down by 0.5 times and its normalized triangle



（d） triangle scaling down by 0.75 times plus rotated by 135 degrees and its normalized triangle

Fig. 2 Triangle normalization examples

4. SIMULATION RESULTS

In order to illustrate the effectiveness of proposed algorithm, images having different textures are used as test image. We use 512×512 Lena, Baboon and Peppers images as an example. Image feature points before and after geometric transformations are detected by Harris affine invariant feature point detector. Delaunay triangles are constructed and normalized and the coordinates of matched triangle's three vertexes are used to calculate affine transformation parameters. The Delaunay triangular configurations for Lena, Baboon and Peppers grayscale images are shown in Fig. 3.

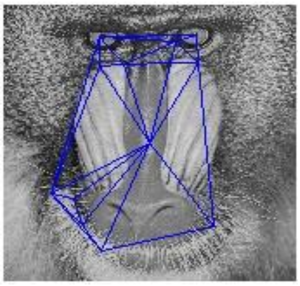
（a） Lena image

（b） Peppers image

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 3, March 2016



(c) Baboon image

Fig.3 Delaunay triangular configurations for different images

Due to the noise and lossy compression are very common in the process of image transmission, in order to illustrate the impact of noise and loss compression on affine transformation parameter estimation, Table 1 shows the estimated affine transformation parameters of these three images processed by Gaussian noise, Salt & pepper noise JPEG compression and JPEG2000 compression. Triangle matching threshold ε is 0.95. As we can see from Table 1, the noise and JPEG compression has little effect on the accuracy of affine transformation parameter estimation.

Because in practical applications, rotation and scaling attack is often accompanied by a small amount of cropping, therefore, in order to demonstrate the effect of cropping on Delaunay triangulation and parameter estimation, Table 2 shows the impact of internal cutting and edge cropping on the accuracy of the estimated parameters, where internal cutting ([128, 128], 128) indicates the pixel position in row 128, column 128 using as a center , a square area of 128 pixels around the center are cut.

The simulation results show that the effect of cutting out few feature points of Delaunay triangulation on the accuracy of parameter estimation is very small, only the triangles connected with cut vertex are affected , other triangles remains unchanged.

Therefore, as long as the number of matched triangles is larger than 1, we can deal with the parameter estimation. Table 3 shows the estimated affine transformation parameters of Lena, Baboon and Peppers images subjected to various degrees of scaling and rotation (with and without cropping) attack . As we can see from Table 3, the affine transformation parameter estimation method proposed in this paper has high estimation accuracy when the image suffered scaling, rotation and cropping attacks.

Table 1 Estimated affine transformation parameters under noise and image compression

Attack Type		Lenna image		Pepper image		Baboon image	
		Rotation(°)	Scaling	Rotation(°)	Scaling	Rotation(°)	Scaling
20db gaussion noise		-0.0004	0.9996	0.0129	1.0005	0.0431	1.0006
15db gaussion noise		-0.0408	1.0012	-0.0402	0.9995	0.0595	0.9992
20 db salt& pepper noise		-0.0254	0.9994	-0.0254	0.9999	-0.0069	1.0004
15 db salt& pepper noise		-0.0550	1.0007	0.0145	1.0008	-0.0431	1.0006
JPEG compression	90	0.0097	1.0000	0.0000	1.0000	0.0000	1.0000
	70	-0.0040	1.0007	0.0195	1.0008	-0.0147	1.0003
	50	0.0386	1.0010	-0.0327	0.9996	0.0000	1.0000
	30	-0.0518	0.9996	0.0089	1.0001	0.0170	0.9995
JPEG 2000 compression	（5:1）	-0.0185	1.0000	-0.0120	1.0002	0.0090	0.9998
	（10:1）	0.0130	1.0000	-0.0320	1.0002	0.0000	1.0001
	（20:1）	0.0226	1.0001	-0.0462	0.9995	-0.0723	1.0000

Table 2 Estimated Image affine transformation parameters under cropping attack

Attack Type		Lenna image		Pepper image		Baboon image	
		Rotation(°)	Scaling	Rotation(°)	Scaling	Rotation(°)	Scaling
Edge cropping	32 Pixel	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
	48 Pixel	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
	64 Pixel	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
	72 Pixel	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
Internal cropping	([128,128], 128)	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
	([378,256], 128)	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
	([256,398], 144)	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

DOI 10.17148/IJARCCE.2016.53135

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 3, March 2016

Table 3 Estimated Image affine transformation parameters under scaling, rotation and cropping attack

Attack Type			Lenna image		Pepper image		Baboon image	
			Rotation(°)	Scaling	Rotation(°)	Scaling	Rotation(°)	Scaling
Scaling factor	without cropping	0.5	0.0783	0.5036	0.0042	0.4993	-0.0532	0.4991
		0.75	0.0123	0.7510	0.0129	0.7510	-0.0194	0.7490
		0.9	0.0381	0.8997	0.0195	0.8979	0.0548	0.8994
		1.1	0.0175	1.0998	0.0482	1.1005	0.0028	1.1004
		1.2	-0.0749	1.1999	0.0221	1.2006	0.0456	1.1992
		1.5	0.0360	1.5001	-0.0446	1.4994	-0.0045	1.5009
	With cropping	1.1	0.0089	1.1002	0.0575	1.0996	0.0382	1.0997
		1.2	-0.0749	1.1999	-0.0340	1.2007	0.0082	1.2007
		1.5	-0.0302	1.5006	0.0710	1.4992	-0.0061	1.5019
Rotation angle	without cropping	5°	5.0067	0.9999	5.0150	1.0007	4.9545	1.0006
		10°	10.0186	1.0004	9.9986	0.9999	10.0460	0.9995
		45°	44.9771	0.9993	45.0671	1.0003	45.0376	0.9992
	With cropping	5°	5.0441	0.9990	5.0760	0.9999	5.0066	0.9997
		10°	10.0260	1.0003	10.0119	0.9997	10.0227	1.0001
		45°	45.0033	1.0009	44.9712	1.0002	45.0301	1.0005

5. CONCLUSIONS

An image registration algorithm based on image normalization is proposed in this paper. Harris affine invariant feature point detector is utilized to detect invariant feature points from the original image and image undergoing geometric transformation. These detected feature points are used to build Delaunay triangles. According to the similarity between triangles, three vertexes of each pair of matched triangles are used to estimate the affine transformation parameters. Since feature points extracted by Harris affine invariant feature point detector has strong robustness while suffering rotation, scaling, noise attacks and etc, Delaunay triangles constructed based on these feature points are unique, the loss of a small number of feature points due to cropping only affects triangles connected to these points, other triangles are not affected, therefore estimation accuracy of affine transformation parameters is relatively high. Simulation results show that the algorithm performance is better for parameter estimation under noise, image compression and geometry attacks.

REFERENCES

[1] ZITOVA B, FLUSSER J. Image registration methods: a survey. Image and Vision Computing, Vol.21, No.11, pp. 977-1000, 2003.
[2] Modersitzki J. Numerical Methods for Image Registration. Oxford University Press, 2004, pp 199.
[3] Gonzalez. R.C, Woods R.E. Digital Image Processing, 2nd Ed Prentice Hall, 2002.
[4] Josien P, Antoine J, Max V. Image registration by maximization of combined mutual information and gradient information. IEEE Trans on Medical Image, Vol. 19, No.8, pp. 809-814, 2000.
[5] Cao Wen,Li Bicheng,Deng zijian. An image registration method based on wavelet transform. Bulletin of Surveying, Vol.2, No.1, pp.16-19, 2004.
[6] Liu Qiong, Ni guoqiang,Zhou shengbin. Experiments and analysis of several feature extraction methods for image registration Optical Technique, Vol.33, No.1, pp.62-64, 2007.
[7] I. Elhanany, M.Sheinfeld, Y.Kadmon,et al. Robust image registration based on Feed forward Neural networks, 2000 IEEE International Conference on Systems, Man, and Cybernetics, Vol.12,pp. 1507 –1511, 8-11 Oct., 2000.
[8] P.BAS, J.M.CHASSERY, B.MACQ. Geometrically invariant watermarking using feature points. IEEE Trans. on image processing, Vol.11, No.9, pp. 1014-1028, 2002.
[9] C. HARRIS, M. STEPHEN. A combined corner and edge detector. 4th Alvey Vision Conf, Manchester, pp. 147-151, 1988.
[10] H. MORAVEC. Obstacle avoidance and navigation in the real world by a seen robot rover. Technical Report CMU-RI-TR-3, Robotics Institute, Carnegie-Mellon University, September 1980.
[11] S.C.Pei and C.N.Lin. "Image Normalization for Pattern Recognition". Image Vision Computing, Vol.13, No.10, pp.711-723, 1995.