Image stitching technology based on Corner detection

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Abstract. Image mosaic technology is the popular research direction of the computer graphics and the computer vision, it is widely applied in the area such as the remote sensing, the space exploration, the medical image analysis, the virtual reality and the super resolution. In this paper, an image mosaic algorithm based on the Harris is proposed after the theory research. Through the key algorithm of Harris corner detection, image matching and fusion, the image mosaic is realized. The experimental results show that it is an effective way to get the desirable image mosaic.

Keywords: Corner Detection, Image registration, Image mosaic.

1. Introduction

Image mosaic is a group of image sequences overlap each other spatially matching parts aligned, forming a fusion after resampling contains a wide viewing angle for each image sequence information of the scene, complete, new high-definition images. By image stitching technology that can eliminate redundant information, compressing information storage capacity, and thus more effective representation of information. Image registration and image fusion are the two key technologies of image stitching, image registration is the basis of image fusion. As a method of image features for image registration with the matching process can reduce the amount of calculation; improve matching accuracy and reduce the effects of noise and other advantages, it has been widely used in image registration techniques.

Common methods of feature extraction are mainly two: First, a template matching method, the method of detecting the characteristic point is more accurate, but the fixing of the template used in the method, the processing is not applied to the actual image. The second is based on edge detection method, because this method needs to detect the boundary, while it is easy to detect the boundary introduce errors, and therefore poor accuracy of this method.

In this paper, image stitching algorithm based on corner matching by Harris operator corner detection image, the image corner matching, can effectively reduce the amount of computation, while improving accuracy. Image fusion using the weighted average method. Enabling image stitching algorithm based on corner detection. The experimental results show the feasibility and efficiency of the method.

2. Harris corner detection

Harris defines a set of autocorrelation values in a square region of the image in any direction on the gradation of the error sum. Through a point to determine whether a small shift in either direction will cause a change of gray to determine whether the point is the corner. The algorithm is characterized by analyzing the correlation matrix of pixel values of the autocorrelation function of the surrounding area to determine whether a point is the corner. Autocorrelation function defined:

$$E(u,v)=\sum_{x,y} w(x,y)[I(x+u,y+v)-I(x,y)]^2 \tag{1}$$

u,v is a slight offset in x,y directions, $I(x,y)$ is Gray value of Pixel for x,y, $[I(x+u,y+v)-I(x,y)]^2$ is Gradient values of Image Gray, $w(x,y)$ is Gaussian filter. Its Taylor expansion is:

$$E(u,v) \cong (u,v)M\begin{bmatrix} u \\ v \end{bmatrix} \quad (2)$$

M is a symmetric matrix of 2×2 :

$$M = \sum_{x,y} w(x,y) \otimes \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} \quad (3)$$

I_x and I_y are the gradient of X and Y direction . M describes the shape at this point.

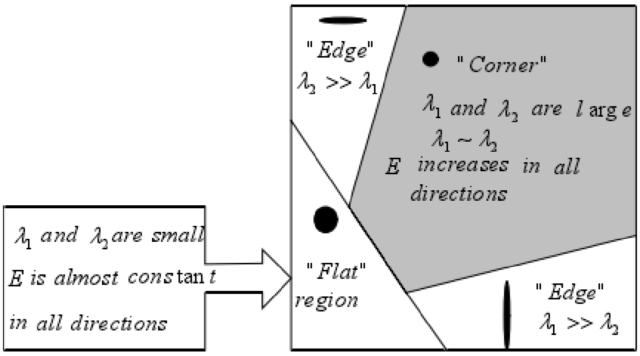

Fig. 1 Harris detection schematics

Let λ_1, λ_2 be two eigenvalues of the matrix M, λ_1, λ_2 may represent the local autocorrelation function of the curvature. Because Harris operator isotropic, so M has rotational invariance. Through the analysis of the eigenvalues of the matrix M can be drawn from the following three conditions:

If two eigenvalues are very small, this means that the window is approximately constant gray area. Move in any direction function E minor changes have occurred, is described in which the smooth region of the window region.

If a feature value is large, the other characteristic value is small, indicating a ridge shape. Along the edge direction E such that the function change is small, and large changes in the moving vertical edge, is described in which the edge area of the window region.

If the two eigenvalues are large, show a spike-like, are moved in any direction will cause a sharp increase in E, is described in which the corner region of the window region.

Analysis of these three cases, we can detect the corner, but the practical application of computing corner response function to be written as:

$$R = \lambda_1 \lambda_2 - k(\lambda_1 + \lambda_2)^2 \quad (4)$$

k to take 0.04-0.06.The actual calculation, in order to reduce the impact of noise on the extracted corner, the need for image Gaussian smoothing, and then set a reasonable threshold, if the actual value is greater than the calculated threshold is the corner, otherwise not. The following diagram is the corner points detected by this method.

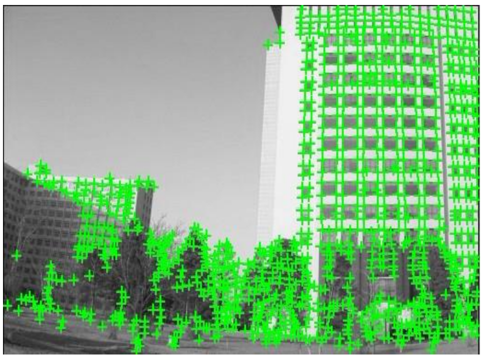

Fig. 2 Corner of the reference image

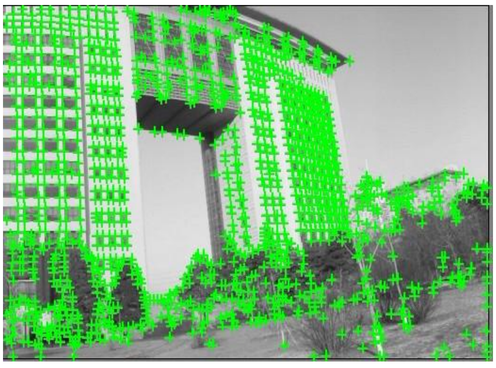

Fig. 3 Corner of the image to be matched

3. Corner matching

We can be seen from the two figures, the relatively large number of feature points, matching calculation capacity, directly affects the speed of image stitching. In order to improve the speed, in this paper , Image matching algorithm using cross-correlation. In the reference image and the image to be registered to each feature point serving as the center of a (2N + 1) x (2N + 1) gradation window, then the reference image of each feature point as a reference point to be image registration to find the corresponding match point, Matching is based on the calculated correlation coefficient between the feature points of the window.

$$R=\frac{[\sum_{i=-N}^{N}\sum_{j=-N}^{N}(I(x-i,y-j)-\bar{I})(I'(x'-i,y'-j)-\bar{I'})]}{\sqrt{\sum_{i=-N}^{N}\sum_{j=-N}^{N}(I(x-i,y-j)-\bar{I})^2\sum_{i=-N}^{N}\sum_{j=-N}^{N}(I'(x'-i,y'-j)-\bar{I'})^2}} \tag{5}$$

$\bar{I}$ and $\bar{I'}$ are the average brightness of all pixels in the gray scale window. Correlation values obtained by the formula R, its threshold processing for 0.8, for all R> 0.8 is regarded as a candidate corner points.

The results were as follows:

Fig. 4 reference image

Fig. 5 images to be matched

4. Image fusion

Image fusion is completed after the image matching, image stitching, stapling and the boundary of the smoothing processing, so that a natural transition suture. Because there will be uneven illumination when shooting, will cause the brightness of the two images overlap caused by inconsistent or image distortion due to the lens distortion, so the image will appear after stitching obvious stitching seams appear. To achieve visual consistency, we need to eliminate seams. Image fusion technology can be divided into three levels: pixel level fusion, feature level fusion and decision level fusion. In this paper, weighted average method of pixel-level fusion for image fusion.

The weighted average method is an improved method of average. This method is for seam image gray value weighted neighborhood first and then superimposed average, not just the pixel values of the overlap region to make a simple addition. Let I_1 and I_2 denote the images stitching, I is fused image, then

$$I(x,y)=\begin{cases} I_1(x,y) & (x,y)\in I_1 \\ \omega_1(x,y)I_1(x,y)+\omega_2(x,y)I_2(x,y) & (x,y)\in I_1\cap I_2 \\ I_2(x,y) & (x,y)\in I_2 \end{cases} \tag{6}$$

Where $\omega_1+\omega_2=1$, $0<\omega_1\omega_2<1$ are the weights of the overlapping area of the pixel. Reasonable choice of weights can be an ideal fusion effect, part of the overlap region to achieve a smooth transition to complete the "seamless" stitching purposes. Choose different weights according to the distribution function, the weighted average method is divided into: hat function weighted average method and fade-out. Comprehensive imaging conditions, and demand for precision image feature considering the selection of fade-out. As shown in Figure6.

In the image overlap region, with a corresponding change in the gradient factor of d as the pixel positions are constantly changing, When moved to the position of the pixel boundary line, the value of d is slowly reduced to zero, thus achieving a smooth transition of the image. Figure 7 is an image after stitching.

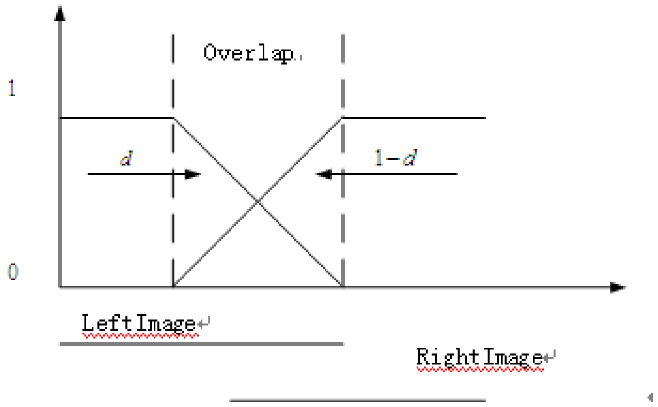

Fig. 6 Schematic of weighted smoothing method

Fig. 7 Mosaic image after merge

5. Experimental Analysis

Experiments done on 3.1G frequency, 2.00G memory PC. Experimental images using tripod real photos taken at a fixed viewpoint.

Table 1 splicing analysis of the experimental results

Camera Type	Source image quality	Number of image stitching	Spend time	Success rate
Fuji S205	Good	12	4.7 Second	over95%

6. Conclusions

Through the experimental analysis, it shows that through the key algorithm of Harris corner detection, the image matching and fusion, which are proposed in this paper, the mosaic trace could be erased and the smooth vision effect could be got .This method is high precision and less calculated, the desirable mosaic result could be got.

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