Research on Image stitching Based on Surf Algorithm

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Abstract

With the development of computer vision and image processing technology, image stitching technology has been realized, and it has gradually become a research hotspot in digital image processing. Image stitching refers to stitching two or more images with a certain overlap into a complete higher resolution image. Image mosaic technology is widely used in the fields of virtual reality, medical image processing, military, and remote sensing technology. Aiming at the problems of large amount of calculation, complicated algorithm and low matching efficiency of the commonly used image stitching algorithms, this paper mainly studies the image stitching method based on the sobel operator and SURF algorithm, derives its theoretical process, and performs simulation experiments. It can reduce the amount of calculation without reducing the quality of image stitching.

Keywords

Image stitching; Sobel operator; Surf algorithm.

1. Introduction

Image stitching technology is an important branch of computer vision for image processing, which can solve problems such as insufficient viewing angle width of a single image sensor. It is mainly used in medical, scientific research, military, drone aerial imagery, virtual reality, and unmanned driving. Currently commonly used image stitching algorithms include: APAP (Approximation Projection Transform) image registration algorithm, AANAP (as natural as possible projection) algorithm, SIFT algorithm and SURF algorithm, etc.

2. Common Image Sitching

2.1 Image stitching based on gray information

The image stitching method based on gray information does not need to extract the features of the image. This method uses the gray information of the image to measure the similarity of the image. The general process is to intercept a region from the image as a template, and then compare the template with the same region in the search image to determine whether it is the best match based on the calculated similarity. Image matching algorithms based on gray information include: MAD (Average Absolute Difference) algorithm, SAD (Absolute Error Sum) algorithm, NCC (Normalized Product Correlation) algorithm, SSDA (Sequential Similarity Detection Algorithm), etc.

2.2 Image stitching based on transform domain

The Fourier transform can be used to register in the frequency domain. After the two images are Fourier transformed, the amount of transform in the time domain can determine their relationship in the transform domain. For two images that are rotated, they can be rotated invariant in the Fourier transform domain. The scaled image can be converted to horizontal processing. Therefore, Fourier transform can be used to register image translation, rotation, and scaling.

2.3 Feature-based image registration

Feature-based registration method is the process of registration according to the features (points, edges) of the image. The steps are roughly to first extract the features in the image, then register the two images with the extracted features, and finally use the image transformation relationship between the two images to obtain the mapping relationship, and finally obtain the registered map.

3. Sobel Operator

Sobel operator is a first-order differential operator (discrete difference operator)[1]. It uses the adjacent (upper, lower, left and right) pixel values (gray value) to calculate the current pixel value (gray value), Because the gray at the edges in the image The change is relatively fast and shows a step phenomenon. Sobel algorithm edge detection uses this feature to calculate the difference value of the remaining neighboring pixels for each pixel in the image to determine whether the pixel point is an edge.This can be selected based on the threshold. The theoretical derivation process is as follows:
Sobel operator convolution template:

$$G_X=\begin{bmatrix}-1 & 0 & +1\\ -2 & 0 & +2\\ -1 & 0 & +1\end{bmatrix}\quad G_Y=\begin{bmatrix}+1 & 0 & +1\\ 0 & 0 & 0\\ -1 & -2 & +1\end{bmatrix}$$

Sobel operator contains two three-row and three-column matrices, which represent the horizontal and vertical directions, respectively. By convolving the target image and the matrix, the horizontal and vertical brightness difference values can be obtained respectively. Let A represent the original image, G_x and G_y represent the horizontal and vertical edge detection gray values. Its expression is as follows:

$$G_x=\begin{bmatrix}-1 & 0 & +1\\ -2 & 0 & +2\\ -1 & 0 & +1\end{bmatrix}*A\quad G_y=\begin{bmatrix}+1 & 0 & +1\\ 0 & 0 & 0\\ -1 & -2 & +1\end{bmatrix}*A$$

The derivation process is as follows:

$$\begin{aligned}G_x &= (-1)*f(x-1,y-1)+0*f(x,y-1)+f(x+1,y-1)\\ &+(-2)*f(x-1,y)+0*f(x,y)+2*f(x+1,y)+\\ &(-1)*f(x-1,y+1)+0*f(x+1,y)+f(x+1,y+1)\\ &=[f(x+1,y-1)+2*f(x+1,y)+f(x+1,y+1)]\\ &-[f(x-1,y-1)+2*f(x-1,y)+f(x-1,y+1)]\end{aligned}$$

$$\begin{aligned}G_y &= 1*f(x-1,y-1)+2*f(x,y-1)+f(x+1,y-1)\\ &+0*f(x-1,y)+0*f(x,y)+0*f(x+1,y)+\\ &(-1)*f(x-1,y+1)+(-2)*f(x,y+1)+(-1)f(x+1,y+1)\\ &=[f(x-1,y-1)+2*f(x,y-1)+f(x+1,y-1)]\\ &-[f(x-1,y+1)+2*f(x,y+)+f(x+1,y+1)]\end{aligned}$$

In the formula $f(x,y)$ is the gray value of the image point (x,y). The horizontal and vertical gradient values of the image can be obtained by the above formula.

$$\begin{aligned}|G| &= \sqrt{G_x^2+G_y^2}\\ &\approx |G_x|+|G_y|\end{aligned}$$

Gray value of image point (x,y) Can be obtained from the above formula. When $|G|$ is larger than the the set threshold, the image point is regarded as an edge point.

4. Surf Algorithm

Surf (Speeded-Up Robust Features) algorithm is a feature-based image matching algorithm proposed by Herbert Bay in 2006. This algorithm is improved on the basis of SIFT algorithm. Surf algorithm has excellent scale, rotation, and lighting Invariance, computing speed advantage is its most outstanding performance. The advantage of the Surf algorithm over the SIFT algorithm lies in the rapid matching of the matching stage. This article uses the idea of the Surf algorithm to describe the detected feature points using the improved Surf algorithm. The extreme point detection process of the SURF algorithm is to construct the scale space of the image, and then use the Hessian matrix and the integrated image to detect the feature points[2]. The purpose of constructing the scale space is to obtain stable feature points, which are obtained using Sobel operators Extreme points have good stability.

The core of the Surf algorithm is the Hessian matrix, which has very good accuracy. The Hessian determinant can detect small areas that are brighter or darker than the surrounding area. Assuming the function f (x, y), the Hessian matrix H is composed of functions and partial derivatives.

$$H\left(f\left(x,y\right)\right)=\begin{bmatrix}\frac{\partial^2 f}{\partial x^2} & \frac{\partial^2 f}{\partial x\partial y}\\ \frac{\partial^2 f}{\partial x\partial y} & \frac{\partial^2 f}{\partial y^2}\end{bmatrix}$$

The H matrix discriminant is:

$$\Delta\left(H\right)=\frac{\partial^2 f\partial^2 f}{\partial x^2\partial y^2}-\left(\frac{\partial^2 f}{\partial x\partial y}\right)^2$$

The value of the discriminant is the eigenvalue of the H matrix. You can use the sign of the result to classify all points, and use the value of the discriminant to determine whether the point is an extreme point. In the SURF algorithm, the image pixel l (x, y) is used instead of the function value f (x, y), and the second-order standard Gaussian function is used as a filter. The second-order partial derivative is calculated by the convolution between specific kernels, thereby calculating H matrix:

$$H\left(x,\sigma\right)=\begin{bmatrix}L_{xx}(x,\sigma) & L_{xy}(x,\sigma)\\ L_{xy}(x,\sigma) & L_{yy}(x,\sigma)\end{bmatrix}$$

$$L\left(X,t\right)=G(t)*I(X)$$

$$G(t)=\frac{\partial^2 g(t)}{\partial x^2}$$

$L(X,t)$ is the representation of an image at different resolutions, which can be achieved by convolution of the Gaussian kernel $G(t)$ and the image function $I(X)$ at point (x, y). $g(t)$ is a Gaussian function and t is the Gaussian variance[3]. In this way, the decision value of the H determinant can be calculated for each pixel in the image, and this value can be used to determine the feature points. In order to facilitate the application, Herbert Bay proposed to replace with $L(X,t)$. In order to balance the error between the accurate value and the approximate value, a weight value is introduced. The weight value changes with the change of scale. The H matrix discriminant can be expressed as:

$$\Delta(H_{approx})=D_{xx}D_{yy}-(0.9D_{xy})^2$$

The value of the discriminant is used to determine whether the point is an extreme point. Using this approximation method greatly reduces the amount of calculation, and experiments have shown that the accuracy is not reduced.

5. Conclusion

This paper introduces commonly used image stitching techniques, studies the implementation process of the sobel operator and the surf algorithm, and uses formulas to deduce the implementation principles. It is concluded that the surf image stitching algorithm has the characteristics of small calculation volume and high operation efficiency.

References

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