Scholars Journal of Engineering and Technology (SJET)
Abbreviated Key Title: Sch. J. Eng. Tech.
ISSN 2347-9523 (Print)
ISSN 2321-435X (Online)

A Unit of Scholars Academic and Scientific Society, India
www.saspublishers.com

An Adaptive SUSAN Algorithm for Corner Detector Based on Lifting Wavelet Transformare

Limin Shen*
The Information Engineering University, Luoyang Campus, Luoyang Henan 471000, China

Original Research Article

***Corresponding author**
Limin Shen

Article History
Received: 08.07.2018
Accepted: 18.07.2018
Published: 30.07.2018

DOI:
10.36347/sjet.2018.v06i07.004

Abstract: Aiming at the limitations of using fixed threshold and the complex calculation process in SUSAN operator. An adaptive SUSAN corner detector based on lifting wavelet transform is proposed in the paper. According to the corner properties in an image, the theory of lifting w- avelet transform is adopted to process the image. It will be more effective that the corner candidates are obtained from the high frequency information, which can reduce the searching range for corners. The new algorithm is self-adaptive to adjust the intensity discrepancy between the core point and its epsilon neighborhood pixels. Experiment demonstrates that the proposed corner detector is faster and more effective than traditional SUSA N algorithm.
Keywords: corner detection; SUSAN algorithm; lift wavelet; Self-adaptive.

INTRODUCTION

Corner points are important features of images, and their information content is rich and the number of pixels relative to the total number of pixels is small, which is robust to perspective transformation and deformation [1]. Therefore, corner points play an important role in target recognition, image matching, motion estimation, 3D scene reconstruction, machine vision, etc. The current corner detection algorithms are mainly divided into image edge based methods and image gray based methods. The image edge based method first divides the image, extracts the boundary and forms a chain code, and marks the point where the curvature is sufficiently large as a corner point. This method relies too much on the effects of image segmentation and edge detection, and is computationally intensive.

There are two main methods based on image grayscale: considering the grayscale variation in the neighborhood of the pixel and the grayscale contrast based on the image [2,3]. The former extracts corner points by calculating the curvature of the points and the gradient, such as the Harris algorithm but is sensitive to noise. The latter is a Smallest Univalue Segment Assimilating Nucleus (SUSAN) algorithm proposed by Smith and Brady. Which has the characteristics of simple method and strong anti-noise ability. However, its operation speed is slow and cannot meet the real-time requirements. The gray threshold of the algorithm is fixed and the adaptability is not strong. In this paper, the principle of SUSAN algorithm is deeply studied, and the adaptive threshold selection method is proposed. The candidate corner points are filtered and the corner point detection is accelerated by the wavelet lifting framework theory. The experimental results demonstrate the effectiveness of the proposed method.

An Algorithm of SUSAN

A corner detection method has been proposed based on image geometry observation by Smith and Brady. Moving on the image with a circular template, if the gray level difference between the pixel point in the template and the center pixel of the template is less than a certain threshold, the point is considered to have the same gray level as the core, and the area composed of the points satisfying such conditions is called the SUSAN area[4]. As shown in Figure 1. When the template is completely in the target or background, the USAN area is the largest; when the template center moves to the target edge, the USAN area is halved; when the template center is at the corner position, the USAN area reaches the local minimum[5,6]. Therefore, the size of the same value kernel it reflects the intensity of the local features of the image and is used to measure the description of the feature.

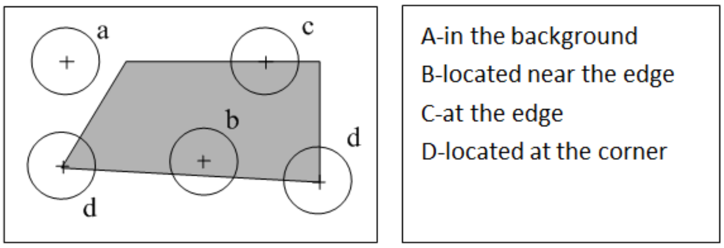

Fig-1: The schematic diagram of SUSAN corner detection

During the detection, the entire image is scanned with a 7 × 7 circular template, and the gray value of any pixel in the template and the center pixel of the template is compared. The threshold t is given to determine whether the pixel belongs to the USAN region. The comparison function is:

$$c(\vec{r},\vec{r}_0)=\begin{cases}1 & if \ \ |I(\vec{r})-I(\vec{r}_0)|\le t \\ 0 & if \ \ |I(\vec{r})-I(\vec{r}_0)|> t\end{cases} \qquad (1)$$

In the formula (1), $c(\vec{r},\vec{r}_0)$ is the discrimination result, $I(\vec{r}_0)$ is the gray value of the center pixel of the template, $I(\vec{r})$ is the gray level of any pixel in the template, and t is the gray threshold. The formula (1) is simplified to the following formula (2).

$$c(\vec{r},\vec{r}_0)=\exp\{[\frac{I(\vec{r})-I(\vec{r}_0)}{t}]^6\} \qquad (2)$$

Calculate the size of the USAN region of the pixel, which can be obtained by equation (3)

$$n(r_0)=\sum_{r\in c(r_0)} c(r,r_0) \qquad (3)$$

$c(r_0)$ is a template with r_0 as the center. After obtaining the USAN region of each pixel, $n(r_0)$ is compared to a predetermined geometric threshold g:

$$R(r_0)=\begin{cases} g-n(r_0) & n(r_0)<g \\ 0 & otherwise\end{cases} \qquad (4)$$

Here $R(r_0)$ is the corner point response function. Threshold g determines the maximum value of the USAN region of the output corner, that is, as long as the pixel in the image has a smaller USAN region than g, the point is determined to be a corner point.

The SUSAN algorithm has the following disadvantages: (1) Generally, the number of corner points in the image only accounts for a very small part of the total number of image pixels, and the corner point response function is generally complicated. Therefore, detecting each pixel increases the burden of the algorithm. (2) The detected angular distribution is uneven, resulting in complicated image processing.

An improved algorithm

It can be concluded from the analysis that if the diagonal points are pre-detected, a large number of background points are removed first, and only a small number of candidate points are finely judged, which can greatly save time. The purpose of this paper is to construct high-frequency information that is used to extract wavelets to extract images, and to screen candidate corners in high-frequency regions. Therefore, the paper focuses on the positive transformation of the wavelet lifting algorithm.

Parameter determination

In the SUSAN algorithm, the geometric threshold g and the grayscale difference threshold t need to be determined. The geometric threshold determines the size of the output corner USAN area, that is, the sharpness of the corner point. The g is smaller, the corner points are the sharper. When performing corner extraction, g is usually taken as 1/2 of the template area.

The grayscale difference threshold t determines the minimum contrast that the SUSAN operator can detect and the ability to remove noise points. t is smaller, the more features can be extracted from the image with lower contrast, and the more features are extracted. In order to solve the above problem, the following method is adopted in this paper: first, the image is divided into N sub-blocks, and then the gray threshold of the region is calculated by using equation (5) in each sub-block.

$$N_{i_t} = a \times [\frac{1}{n}\sum_{k=1}^{n} N_{i_{\max}} - \frac{1}{n}\sum_{k=1}^{n} N_{i_{\min}}] \qquad (5)$$

According to the improvement of the above formula, the gamma difference between the template core and the pixels in the neighborhood can be automatically adjusted according to the different contrast of the image block when calculating the USAN region, so that the detected corner points are more accurate and the distribution is more uniform.

Algorithm design

The principle of the improved algorithm is shown in Figure 2. Algorithm steps:

- Divide the original image into sub-blocks based on the size of the image data. Calculate the gray threshold in the region according to formula (5) in each sub-block;
- Perform a linear lifting wavelet transform on the image;
- Mark the high-frequency area coefficient value that satisfies the formula in the high-frequency area of the image. According to the characteristics of the linear wavelet in-place calculation, find the 9 related points corresponding to the original image, which is the candidate corner point;
- For the extracted candidate corner points, select the threshold according to the sub-block interval in which it is located, and then accurately locate the corner points by using the SUSAN principle;
- Output the result.
-

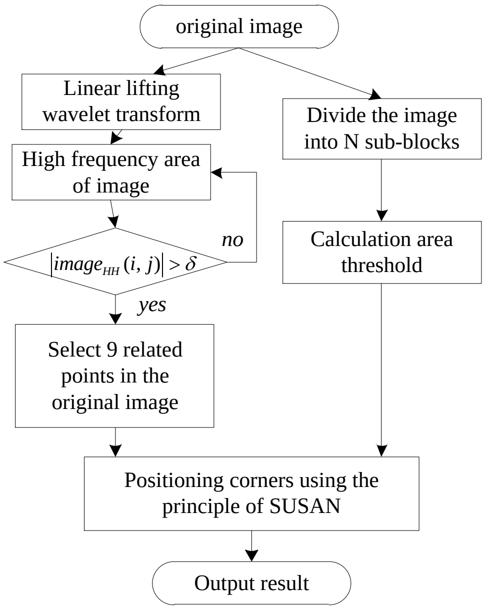

Fig-2: The flow char of improved algorithm

EXPERIMENTAL RESULTS AND ANALYSIS

In order to verify the performance of the algorithm, this paper uses MATLAB 2016 programming to achieve the above algorithm. Two test images of size 256×256 are applied to the SUSAN algorithm and the improved algorithm proposed in this paper. The corner points are automatically extracted based on the image information without manual intervention, and the results are shown in Fig. 3.

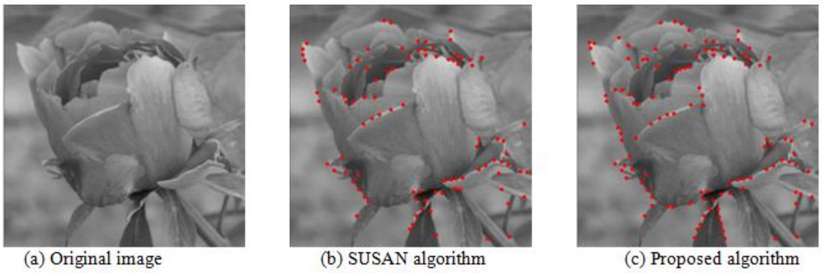

Fig-3: Effect drawing of corner point detection

Tab-1: Performance parameter comparison of Fig.3

	SUSAN algorithm	improved algorithm
Image size	256×256	256×256
Gray threshold t	t=25	Self-adaptive selection
Geometric threshold g	19	19
Non-maximum suppression window	7×7	7×7
Algorithm time consuming (s)	5.3750	1.8750
Detecting the number of corner points	92	115

Based on the experimental results in Figure 3 and Table 1, it can be seen that for a typical test picture, Figure 3(b) uses a single threshold, and the contrast is low in the gradual area on the left side of the original image, failing to detect the corner point. The improved adaptive threshold algorithm can extract the corner points of these regions well. From the perspective of algorithm time, the method of this paper has a significant improvement under the premise of achieving good results.

CONCLUSION

In this paper, an adaptive SUSAN corner detection algorithm based on linear lifting wavelet transform is used to extract features from images. According to the characteristics that the corner point is mainly located in the high-frequency part of the image, the image is pre-processed by using the lifting wavelet transform idea to extract the candidate corner points, which significantly improves the algorithm speed. It also improves the shortcomings in the SUSAN algorithm and solves the problem better. Grayscale threshold adaptive selection problem. The experimental results show that the method is fast and effective and suitable for real-time processing. However, the algorithm needs further simplification in calculation to improve operational efficiency and reduce computational complexity.

REFERENCES

1. Szeliski R. Image Alignment and Stitching: A Tutorial [J]. Foundations and Trends in Computer Graphics and Vision. 2006, 2(1):1-10.
2. David PC. Image Mosaicing and Super-Resolution [D]. University of Oxford. Robotics Research Group Department. 2001.
3. Hua Shungang, Zeng Lingyi. Ou Zongying. Fast Algorithm for Cylindrical Panoramic Image Mosaic[J]. Shuju Caiji Yu Chuli. 2016, 21(4):434-438.
4. Lie WN, Chuang CH. Contour-based image registration with local deformations. Optical Engineering. 2003 May;42(5):1405-17.
5. Jarc A, Rogelj P, Kovacic S. Texture feature based image registration. InBiomedical Imaging: From Nano to Macro, 2007. ISBI 2007. 4th IEEE International Symposium on 2007 Apr 12 (pp. 17-20). IEEE.
6. Shih FY, Chuang CF, Gaddipati V. A modified regulated morphological corner detector. Pattern Recognition Letters. 2005 May 15;26(7):931-7.