Improved SIFT algorithm based on image filtering

Mingyu Qiao, Xiao Liang*, Minjie Chen
Computer Science and Technology, North China University of Technology, Beijing, Beijing, 100144, China
*Corresponding author’s e-mail: 18101130104@mail.ncut.edu.cn

Abstract. In this paper, SIFT feature extraction algorithm was optimized through image filtering, so as to highlight the role of stable edge corner and improve the efficiency of stable edge corner collection. Afterwards, the experimental results were compared and verified by the FLANN feature matching method. Experimental results show that the improved SIFT feature extraction algorithm using image filtering can improve the extraction effect of feature points with stable edge response, while suppressing the extraction of feature points with unstable edge response, thus improving the accuracy of matching.

1. Introduction
Feature points are also called interest points in image processing, which refer to the points where the gray value of the image changes drastically or the points with larger curvature on the edge of the image, such as corner points, edge points, bright spots in dark areas, and dark spots in bright areas. These feature points are extracted to identify the image. Therefore, in the image matching process, the quality of the extracted feature points directly affects the effect and performance of the subsequent matching algorithm.

SIFT feature extraction algorithm can be roughly divided into four steps: constructing scale space, detecting extreme value points of DOG scale space, filtering bad feature points, and generating sub-descriptors of key points. Since the edge appears at the place where the first derivative of the image is maximum or minimum (the place where the second derivative crosses zero), that is, the place where the gradient is maximum or minimum. In order to find the extreme value point of the scale space, each sampling point needs to compare the size of the image domain and the scale domain with its neighboring points. SIFT algorithm, through the discrete extremum point fitting three-dimensional quadratic function, and then calculate the extremum of the function, so as to get the feature point sub-pixel precision position and scale. SIFT feature extraction algorithm can remove the extremum points with unstable edge response and low contrast according to the desired extremum.

This paper proposes an improved SIFT feature extraction method based on image filtering, which enables the extraction of edge feature points to be better distributed in regions with strong textures to increase contrast and improve the stability of edge response.

2. Related Work
The SIFT algorithm was proposed and summarized by Lowe. Its characteristics are based on the scale space theory. It has scale invariance, rotation invariance and partial affine invariance, and it has strong adaptability to illumination. Mikolajczyk and Schmid [1] proved that the SIFT operator has the best performance for illumination changes and rotation. In the follow-up, many scholars have successively proposed algorithms such as Affine-SIFT [2], PCA-SIFT [3], SUFT [4] and other algorithms to improve the SIFT matching performance, making the application of the SIFT algorithm more extensive.
At present, the improvement research on SIFT mainly focuses on improving the performance of feature matching [5-7]. Relatively speaking, there are relatively few researches on improving SIFT feature point extraction. Aiming at the problem that SIFT is not sufficiently stable in the extraction of extreme points with insufficient edge response, this paper proposes an improved SIFT feature extraction algorithm based on image filtering. On the basis of the original SIFT feature point extraction, edge detection is performed through image filtering, thereby improving the robustness of SIFT for edge feature point extraction.

3. Algorithm design

3.1. Analysis process
Image filtering, that is, suppressing the noise of the target image under the condition of preserving the image details as much as possible, is an indispensable operation in image preprocessing, and its processing effect will directly affect the effectiveness and reliability of subsequent image processing and analysis. There are many types of image filtering, such as mean filtering, box filtering, Gaussian filtering, median filtering, bilateral filtering, etc. Among them, the median filter replaces the pixel value of the current pixel with the median value of all the pixel values in the neighboring domain. In the median filter processing, noise is difficult to be selected, so all noise can be removed without affecting the original image. Bilateral filtering is a kind of filtering method which takes space information and color information into consideration comprehensively and can effectively protect the edge information in the image during the filtering process. Compared with other filters, bilateral filtering has great advantages in edge information processing.

Therefore, in this paper, in order to better extract edge point information, the median filter is first used to de-noise the image to make the image smoother, and then the bilateral filter is used to enhance the edge effect of the image.

The first median filter is used to denoise, smooth out the noise in the image in the form of low-pass filter, and then pass several times of bilateral filtering, the purpose is to blur the unstable high-resolution edge, so that the left edge is stable, the size is thicker, the resolution edge is lower.

After image output, SIFT algorithm is adopted to extract features, which can effectively reduce the extraction of unstable edge feature points and increase the efficiency and robustness of edge feature point extraction. Thus, the step of removing edge unstable extremum in SIFT is simplified and the efficiency of feature extraction of SIFT algorithm is improved. Finally, FLANN algorithm is used for feature matching to verify our experimental results.

3.2. Experiment procedure
In order to test the effect of the improved algorithm in this paper and the original SIFT algorithm, the camera was used to collect the left and right images from two different angles, which are marked as BM_left and BM_right in turn. As shown in Figure 1 and Figure 2:
At the beginning of the experiment in order to more intuitive to compare the effect of image filtering, we extracted by SIFT feature points respectively, then the feature matching FLANN operator, and calculated the figure 3, figure 4, figure 5, they represent only SIFT treatment, only through a median filtering processing, and after a median filter to a result of a bilateral filtering operation schematic diagram:
Figure 5. The result after a median filter and then a bilateral filter operation.

Obviously, the number of times of performing bilateral filtering will affect the effect of subsequent feature point selection. Suppose there are parameters p, q, f, p representing the number of feature points extracted, and q representing the number of matching points in the matching process, so that:

\[ f = \frac{q}{p}; \]  (1)

The larger the f is, the more useful feature points are extracted. According to the continuous iterative adjustment of the number of times m of the bilateral filtering operation, we obtain the graph of the change of f with respect to m. As shown in Figure 6:

Figure 6. f of h.

It can be seen from Figure 6 that when the number of bilateral filtering times is too large or too small, the parameter f does not have an optimal solution, indicating that the extracted feature points at this time are not suitable; When the number of bilateral filtering times is 4, the parameter f has a peak value, so in the experiment The number of bilateral filtering is selected as 4.

In order to detect the extraction effect of stable edge feature points and the filtering effect of unstable edge feature points, Harris operator was used in this paper to respectively extract corner points of the original image, the image after 1 median filtering and the image after 4 bilateral filtering, and the comparison diagram of extraction results was obtained, as shown in Figure 7 and Figure 8:
Figure 7. The corner extraction effect of the original image.

Figure 8. The effect of corner extraction after image filtering.

It can be seen from Figure 7 and figure 8 that, after processing the image with the improved algorithm, Harris operator does not diverged to extract corner points, but focuses on the edge regions with lower resolution, stronger texture and more stable, and it filters out some corner points in the regions with poor texture and less stability.

After extracting feature points through the improved algorithm, the effect of feature matching using FLANN is shown in Figure 9:

Figure 9. The effect of feature matching using FLANN.

4. Conclusion
In this paper, SIFT feature extraction algorithm is improved through median filtering and bilateral filtering to highlight low resolution edge with high stability. Experiments show that after the improved
algorithm, the useful feature extraction ratio parameter f, stable edge corner point extraction, removal of unstable edge feature points, matching correct points have been improved, but high resolution edge points of feature matching effect has certain influence, in this paper, high-resolution edge points are directly filtered out, and further research will be carried out in the future to effectively improve the stability of high frequency edge points.

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