Corner Detection Algorithms in Text of Natural Scene Images

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***Abstract*— Corners in images represent a lot of important information. Extracting corners accurately is significant to image processing, which can reduce much of the calculations. In this paper, three widely used corner detection algorithms, FAST (Features *from Accelerated Segment Test)*, Eigen Value and Harris corner detection algorithms which are all based on intensity, were compared in stability, noise immunity and complexity via stability factor η, anti-noise factor ρ and the runtime of each algorithm. It concluded that FAST corner detection algorithm was superior to Harris and Eigen Value corner detection algorithm on the whole. Moreover, FAST, Eigen Value and Harris detection algorithms were improved by selecting an adaptive gray difference threshold and by changing directional differentials, respectively, and compared using these three criterions. In addition, FAST, Eigen Value and Harris corner detectors were applied to text detection experiment. It was verified that the quantitative evaluations of the corner detection algorithms were valid through calculating efficiency, which can reflect the performances of a corner detection algorithm comprehensively. Furthermore, the better corner detector was used into image mosaic experiment, and the result was satisfied. The work of this paper can provide a direction to the improvement and the utilization of these three corner detection algorithms.**

Keywords—Corner detection algorithms; comparison of algorithms.

I. INTRODUCTION

Corners are very important local features in digital images. Generally, they are the points that have high curvature and lie in the junction of different brightness regions of images. In an image features variety, corners are not affected by illumination and have the rotational invariance property. Without losing image data information, extracting corners can minimize the processing data. Therefore, corner detection has practical value and it plays an important role in scale space theory [1], moving object detection [2,3], image matching [4,5], building 2D mosaics and stereo vision [6-8], preprocessing and representation [9-12].

A Potential number of corner detectors have been proposed by researchers. These methods can be divided into two main classes: contour based and intensity based. Contour based methods first recover image contours and then search for curvature maxima or inflection points along those contours. For example, Masood et al. detected corners for planar curves by sliding set of three rectangles along the curve and counting number of contour points lying in each rectangle [13]. Peng et al. introduced a boundary-based corner detection method using wavelet transform for its ability for detecting sharp variations [14]. The extended curvature scale space corner detectors [15] also belong to the category of contour based methods. Intensity based methods estimate a measure which is intended to indicate the presence of a corner directly from the image gray values [16-19]. This kind of method is characterized by its fast speed and its independence to other local features, using corners' own features to detect corners directly. three widely used corner detection algorithms, FAST (Features *from Accelerated Segment Test)*, Eigen Value and Harris corner detection algorithms, which are the most widely used corner detection algorithms in practice. In this paper, these three corner detection algorithms were compared and analyzed quantify. The compared result was applied to an image matching experiment, which verified that the quantitative evaluations of these three corner detection algorithms were valid.

II. THREE CORNER DETECTION ALGORITHMS

A. Eigen Value Corner Detection Algoritm

Tsai [20] proposed a boundary based corner detector using the eigenvalues of covariance matrices of contour coordinate points over the Region of Support (ROS). It requires that the radius of the ROS is large enough to suit the statistical characteristic of Tsai's detector. However, too large a radius may miss small features and cause aliasing to appear; while too small a radius may cause the detector to suffer from sensitivity to noise. In addition, exact computation of the eigenvalues of covariance matrices is computationally expensive. Classical methods for corner detection of planar curves include: Curvature Scale Space (CSS), wavelet transformations of contour orientation, and eigenvectors of covariance matrices.

B. *Harris Corner Detection Algorithm*

Harris corner detection algorithm is implemented by calculating each pixel's gradient [21]. If the absolute gradient values in two directions are both great, then judge the pixel as a corner.

C. *FAST Corner Detection Algorithm*

FAST is an algorithm proposed originally by Rosten and Drummond [22] for identifying interest points in an image. An interest point in an image is a pixel which has a well-defined position and can be robustly detected. Interest points have high local information content and they should be ideally repeatable between different images. Interest point detection has applications in image matching, object recognition, tracking etc. The idea of interest point detection or corner detection (both are interchangeably used in literature), is not new. There are several well established algorithms like: Moravec corner detection algorithm, Harris & Stephens corner detection algorithm, SUSAN corner detector. The reason behind the work of the FAST algorithm was to develop an interest point detector for use in real time frame rate applications like SLAM on a mobile robot, which have limited computational resources.

III. Evaluation Of Corner Detection Algorithms

In the comparison experiment of corner detectors, 50 pairs of images with different contrast and brightness were gathered. Corners were detected by Eigen value, Harris and FAST algorithms respectively. Stability factor and anti-noise factor were calculated, and the runtime of each corner detector was counted to measure the complexity of its algorithm. The comparison result of stability factor, where the horizontal axis represents the serial number of images and the vertical axis represents the value of stability factor. The average stability factor of FAST detector was 86.45%, Harris detector was 75.41%, yet that of Eigen value detector was 57.82%, which illustrates that the stability of FAST algorithm is better than that of Harris and Eigen Value algorithm. In the experiment of anti-noise comparison, the images were added different Gaussian white noise whose variance is 0.5% and 1%.

The anti-noise factor curves are shown in Fig. 1. The anti-noise performance of FAST algorithm is also better than that of Harris algorithm on the whole, but both of them are lower when the noise is increased. In order to compare the complexity of these two algorithms, counted the runtime of the test images (320×240 in size), 50 pairs in all, and the average runtime of FAST, Harris and Eigen value corner detectors was 1.0111, 1.8686s and 4.2125s respectively in Microsoft Visual Studio and OpenCV environment. The speed of FAST algorithm is much faster than that of Harris and Eigen value algorithm. As stated above, it can be concluded that FAST corner detection algorithm is superior to Harris and Eigen value corner detection algorithm whether on stability, or anti-noise ability, or complexity. However, FAST corner detector is better because it draws a Gaussian smoothing into the detector, which makes great contribution to improving the stability and reducing the impact of noise.

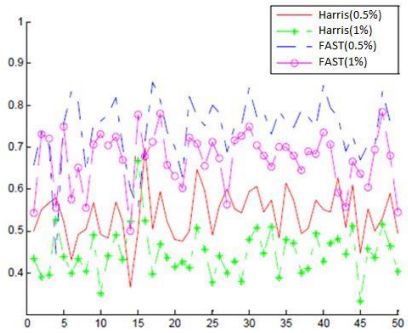

Fig. 1. FAST and Harris algorithm for anti noise comparison.

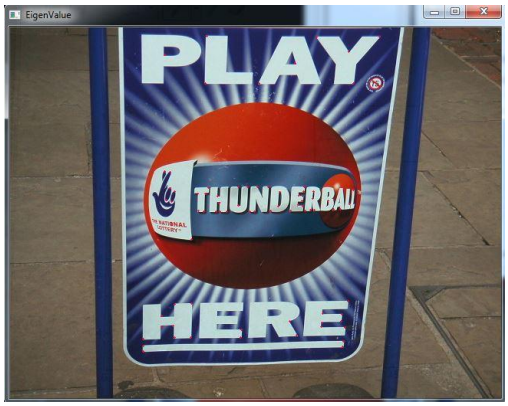

Fig. 2. Eigen value corner text detection in natural scene image.

Fig. 3. Harris corner text detection in natural scene image.

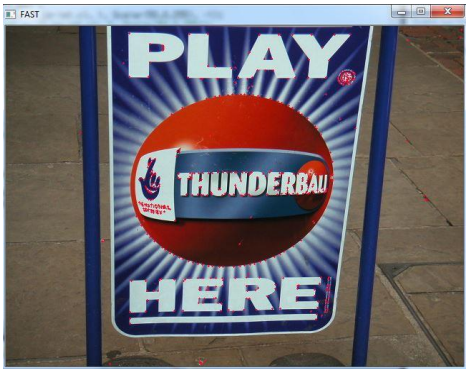

Fig. 4. FAST corner text detection in natural scene image.

To evaluate corner detection algorithm is ultimately to guide utilizations. Text detection algorithm, is an important application field of corner detection through which can greatly reduce the data. In this paper, the text detection in natural scene image experiment firstly used Eigen value, Harris and FAST corner detectors to extract key points of text in image. Fig. 2, Fig. 3 and Fig. 4 show the results of corner detection and text detection in natural scene image by Eigen value, Harris and FAST corner detectors respectively can reflect the performances of a corner detector comprehensively. The text detection efficiency of FAST is higher than that of Eigen value and Harris algorithm, which verifies the comparison result of these three corner detection algorithms.

IV. Conclusions

From the above comparison results of these three corner detection algorithms, it is known that FAST algorithm is superior to Harris and Eigen value algorithm on the whole. The main disadvantages of Eigen value algorithm are first, a fixed global threshold is not suitable for general situation. The corner detector needs an improved adaptive threshold and the shape of mask can be improved, too; second, the anti-noise ability is weak and the robustness of the algorithm should be strengthened. Similarly, there is still much space for FAST and Harris algorithm to be enhanced, such as how to choose difference operators and Gaussian smoothing filter operators better and so on. The work of this paper can provide a direction to the enhancement and the utilization of these three corner detection algorithms.

References

[1] F. Mokhtarian, A.K. Mackworth, "A theory of multiscale, curvature based shape representation for planar curves," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 14, pp.789-805, 1992.

[2] H. Wang, M. Brady, "Real-time corner detection algorithm for motion estimation," *Image and Vision Computing*, Vol. 13, No. 9, pp. 695-703, 1995.

[3] W. Yang, L. Dou, J. Zhang, J. Lu, "Automatic Moving Object Detection and Tracking in Video Sequences," *SPIE Fifth International Symposium on Multispectral Image Processing and Pattern Recognition*, pp.676-712, 2007.

[4] E. Vincent, R. Laganiere, "Detecting and matching feature points," *Journal of Visual Communication and Image Representation*, Vol. 16, No. 1, pp.38-54, 2005.

[5] T. Kim, Y.J. Im, "Automatic satellite image registration by combination of matching and random sample consensus," *IEEE Trans on Geoscience and Remote Sensing*, Vol. 41, No. 5, pp.1111-1117, 2003.

[6] I. Zoghlami, O. Faugeras, R. Deriche, "Using geometric corners to build a 2D mosaic from a set of images," *Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, pp.420-425, 1997.

[7] E. Vincent, R. Laganire, "Matching feature points in stereo pairs: a comparative study of some matching strategies," *Machine Graphics and Vision*, Vol. 10, pp.273-259, 2001.

[8] R. Hartley, A. Zisserman, *Multiple view geometry in computer vision*. Cambridge University Press, Cambridge, 2000.

[9] M. Sarfraz, M.R Asim, A. Masood, "Capturing outlines usin cubic Bezier curves," *Proceedings of IEEE 1st International Conference on Information & Communication Technologies: From Theory to Applications*, pp.539-540, 2004.

[10] W. Zhenghua, C. jie, D. Lihua, "Extracting Footprint Contour Rapidly by Curve Evolution via Level sets," *Journal of Computer-Aided Design & Computer Graphics*, Vol. 19, No. 10, pp.1269-1273, 2007.

[11] C. Jie, W. Zhen-hua, D. Li-hua, "A Scale Adaptive Canny Edge Detection Method," *Opto-Electronic Engineering*, Vol. 35, No. 2, pp.79-84, 2008.

[12] C.A. Cabrelli, U.M Molter, "Automatic representation of binary images," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 12, No.12 pp.1190-1196, 1990.

[13] A. Masood, M. Sarfraz. "Corner detection by sliding rectangles along planar curves," *Computers & Graphics*, Vol. 31, pp.440-448, 2007.

[14] X. Peng, C. Zhou, M. Ding, "Corner detection method based on wavelet transform," In: *Proc. SPIE*, Vol. 4550, pp.319-323, 2001.

[15] F. Mokhtarian, N. Khalili, P. Yuen, "Multi-scale free-form 3D object recognition using 3D models," *Image and Vision Computing*, Vol. 19, No. 5, pp.271-281, 2001.

[16] I.N. Bankman, E.W. Rogala, "Corner detection for identification of man-made objects in noisy aerial images," In: *Proc. SPIE*, Vol. 4726, pp. 304-309, 2002.

[17] R. Elias, R. Laganiere, "Cones: a new approach towards corner detection," *Proc Canadian Conference on Electrical and Computer Engineering*, Vol. 2, pp.912-916, 2002.

[18] S. Bae, I.S. Kweon, C.D. Yoo, "COP: a new corner detector," *Pattern Recognition Letters*, Vol. 23, No. 2,pp.1349-1360, 2002.

[19] A. Quddus, M. Gabbouj, "Wavelet-based corner detectiontechnique using optimal scale," *Pattern Recognition Letter*, Vol. 23, pp.215-220, 2002.

[20] T. Tsai, D. M., Hou, H. T., H. J. Su, "Boundary-based corner detection using eigenvalues of covariance matrices," Pattern ecognition Letters, vol. 20, pp.31-40, 1999.

[21] C. Harris, M. Stephens. "A combined corner and edge detector," *Proceedings of the Fourth Alvey Vision Conference*, University of Sheffield Printing Unit, Manchester, pp.147-151, 1988.

[22] E. Rosten and T. Drummond,"Machine learning for high speed corner detection," Proceeding of European Conference on Computer Vision, pp. 430-443, 2006.