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Comparative performance analysis of edge and corner detection techniques

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Abstract
From subjective review of published research documents and practical observations, it came into light that edge detection and corner detection are the most prominent feature extraction methods that out-perform the limited scope of the mechanisms implemented to extract other elements within an image. In the sphere of corner detection techniques SUSAN had been suggested as better detector as compared to the Harris detector. An extensive performance analysis of FAST corner detector based on the criterion of Non-Maximal Suppression was carried out to find the finest image features and analyze the advantage of FAST algorithm over the traditional Harris only corner detection method.

Keywords: featured from adaptive accelerated segment test, signal-to-noise ratio, gaussian scale, peak signal-to-noise ratio

1. Introduction

1.1 Machine Learning for High Speed Image Recognition

The digital image processing involves standard techniques for manipulation and enhancement of an image. This is important since an image contains large noise that needs to be filtered to get the most important information. Machine learning for image mapping and recognition allows a detector to be redesigned yielding a set of large speed detectors suitable for real-time tracking [5].

1.2 Edge Detection

Deep Learning is extensively used to derive the interest points in real-time frame-rate applications. For this a high-speed feature detector is designed employing machine learning algorithm that results in a high-speed performance of feature detectors [2].

The edge detection process is used to find the strong edge feature of an image. The edge feature is used to denote the image and provides space for extra opportunities to reveal corners, lines and shapes etc [1].

1.3 Corner Detection

Corner detection is the foremost step of various computer vision system building tasks such as real-time tracking, simultaneous localisation and mapping, image matching and recognition.

The design and efficiency of a corner detector is important as it determines the scope whether the detector if combined with further data processing tools can operate at a particular frame rate.

For real-time frame rate applications, it appears necessary to deploy a fast speed detector that overcomes the computational complexity of traditional detectors like Harris, Moore's and SUSAN [2].

1.4 Performance analysis of edge detection techniques

Edge detection is one of the significant and an effective process in image segmentation for extracting features of interest in an image. Major application areas of edge detection algorithms include texture recognition, shape analysis, image analysis and segmentation. Recent research by scientists and domain experts has established a ground for measuring the effectiveness of different edge detection algorithms.

The list of various edge detection operators comprise of Prewitt operator, Sobel operator, Roberts operator and Canny detector. These detectors are applied directly to the image function unlike learning based image recognition that works on deriving feature points using multilayer computational network. The goal of performance analysis of edge detection methods is to determine the exact degree of variations in the image intensity that further helps in extracting the important interest points.

Using an optimal edge detection method tends to decrease the amount of data contained in an image signal as it filters the same set of information considered as noise [4]. The performance of an edge detection technique is measured based on the algorithm, run time complexity, signal strength and accuracy.

1.5 Performance analysis of corner detection techniques

With its emerging applications in the building computer vision systems using hybrid approach, image analysis using corner detection techniques has drawn a strong interest of researchers across the globe.

A corner is essentially an image point where a sharp change in image intensity is observed the direction of featured image edge. It often correlates to human intuition with respect to visually distinct interest points [7]. In contrast, an interest point doesn't correspond to visually important image points, and thus it becomes complex to measure the performance of a fundamental interest point detector.

More and more research attempts have been made in the field of improvement in corner detection algorithms and new approaches are being formulated to measure the efficiency and accuracy of different detectors. The advanced image corner detection techniques make use of ground truth

criterion to measure the accuracy of an algorithm output.

1.6 Existing criteria for evaluation of edge and corner detection techniques

The majority of published research results on corner detection techniques involve the studies on the effects of noise and parameter variation on the proposed detector. These parameters [7] include Gaussian scale [5], signal-to-noise ratio (snr) [9], cross-region correlation matching [8], threshold [4], and the width of the gray level transitions in original image [6].

Ground Truth Dataset Criterion: Most of the local features are being evaluated based on empirical calculation and their effectiveness is measured in terms of informed recognition performance. Ground truth dataset forms an integral part of rational evaluation and a novel approach is used to describe and evaluate the effectiveness of a given feature point [8] based on the invariance assumptions.

This approach is focused on designing a universal framework for salient feature detection [9] and further enhancing the performance of an existing detection method in terms of speed. The result of experimental observation supports the application of ground-truth datasets for object detection as it demonstrates a more accurate and promising performance.

2. Related Work

FAST algorithm is suggested as the backbone of SIFT technique by Wu Lifang, Gao Yuan and Zhang Jingwen in [4] that relies on accelerated segment test algorithm. The modified Featured from Adaptive Accelerated Segment Test (FAAST) has been introduced by Yenewondim Biadgie and Kyung-Ah Sohn in [3] that reduces the time complexity of FAST algorithm and improves the output of the unique response. A brief review of An Improved Canny Algorithm based on adaptive threshold selection was carried out in [1]. Here, J. Duan and X. Gao, Y. Wang and Jiangyun Li throw light on the comparison and performance analysis of traditional Canny Operator and adaptive filtering method for Canny edge detection. Further in literature [2], Miaomiao Zhao, Hongxia Liu and Yi Wan have proposed the scope of improvement in Canny Edge Detection algorithm practices using DCT techniques. Amruta L Kabade and Dr. VG Sangam in [7] Introducing the performance analysis of edge detection using improved block level Canny algorithm, five threshold values are considered to implement block level Canny method. This methodology is implemented to remove false edges in the image and smooth the region so it can meet the VLSI requirements as desired. The final edge map of the various edge detectors viz., Prewitt, Robert, Canny and Sobel has been compared with the proposed block level Canny edge detector on the ground of the perceptual analysis. Dharampal and Vikram Mutneja in [8], an explanatory organization of edge detection methods is found that also motivates the proposed research work in the field of digital image processing. The authors have provided deep insights of edges and edge detection. The document offers an inclined review of characteristic types of edges and fundamental steps involved in edge detection. The methods of edge detection are further classified into three categories-gradient based edge detection, Laplacian edge detection algorithm and fuzzy logic-based edge detection method. Shravani S. Rao and co-authors in [9] have described the implementation of sobel edge detection technique using MATLAB-XILINX co-simulation. The research work contributes to solving the problem of image recognition using HDL. Here, the team has advocated in favor of application of Sobel detector in the field of medical imaging, video surveillance, and departure warning system for its peculiar property of less deviation at high levels of impulse noise.

3. Proposed Work

3.1 Edge Detection

The traditional Canny edge detection algorithm is sensitive to noise. In response to these problems, proposed an improved algorithm based on Canny algorithm. The gravitational field intensity was introduced in this to replace image gradient, and the 2×2 operator was extended to 4×4 operator. Two adaptive double-threshold selection methods for two kinds of typical images are based on the mean and standard deviation of image gradient. The improved algorithm not only keeps the advantages of the traditional Canny algorithm, but also it enhances the ability of noise suppression and keeps more edge information, i.e. it has higher SNR.

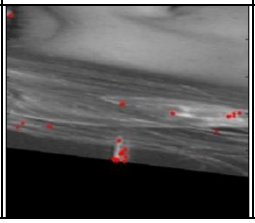
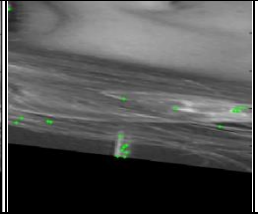
3.2 Corner Detection

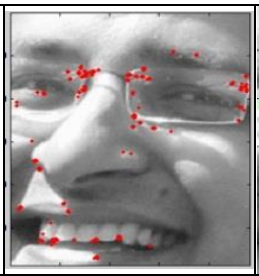
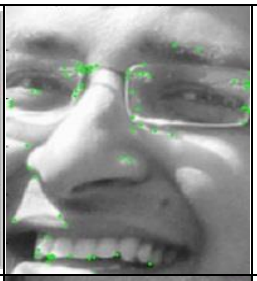
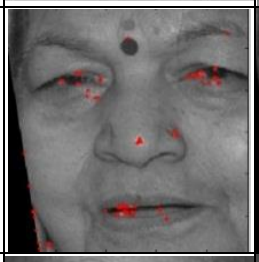
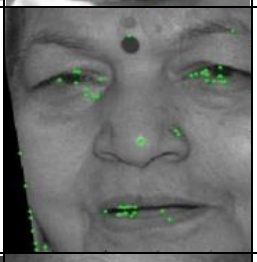
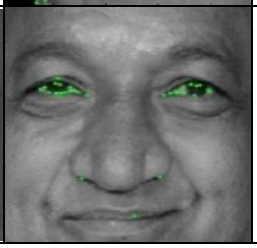
Corners detected include correct corners. This is sufficiently fast that it allows on-line operation of the tracking system. A test is performed for a feature at a pixel c by examining a circle of 32 pixels (a Bresenham circle of radius 3) surrounding p. A feature is detected at c if the intensities of at least 24 contiguous pixels are all above or all below the intensity of c by some threshold t.

We propose an improved corner detection method based on the ideal of FAST to improve detection rate for next feature extraction. First, the image is detected for corners using Harris algorithm. Second, using the FAST for reference, the false corners are removed.

4. Results

Table 4.1: Performance Analysis of FAST Algorithm

S. No	Original image	Segmented image using Fast	Segmented image using FAST with Non-Max	No. of Coordinates without Non-Max	No. of Coordinates with Non-Max
1.	F1			54	19

2.	F2			245	68
3.	F3			109	47
4.	F4			121	30

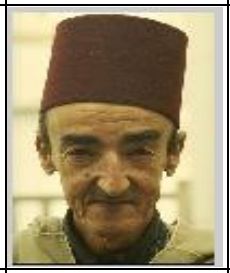
The Non-Maximal Suppression is an approach to filter false or weak edge pixels and improve the quality of output image so that strongly connected interest points are viewed on the screen. This non-maximal suppression is often used while executing edge detection algorithms to filter the pixels that are not a part of local maxima. A threshold value is set to screen the pixels with certain gradient value.

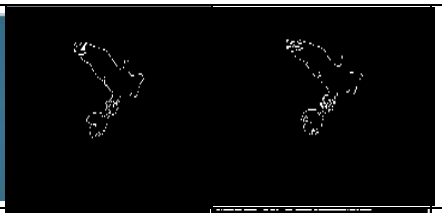
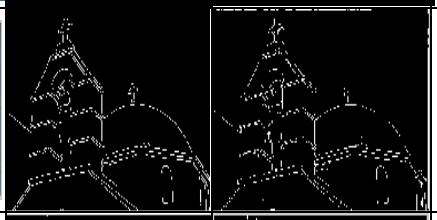
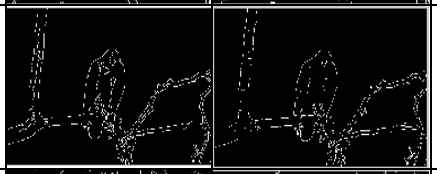
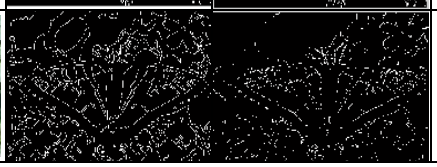
Table 4.2: Observation Results for Non-Max Suppression Using Fast

Image	No. of Coordinates Without Non-Max	No. of Coordinates with Non-Max	No. of Unwanted Coordinates Suppressed
F1	54	19	35
F2	245	68	177
F3	109	47	62
F4	121	30	91

The pixels which do not appear in the direction of image gradient are set to zero. Thus, all the unwanted image information is suppressed.

Table 4.3: Comparative Performance Analysis of Canny and Sobel Edge Detector: (a) Performance Ratio (b) Peak Signal to Noise Ratio

S. No	Original image	Canny Output	Sobel Output	Performance Ratio (a)		PSNR in db (b)	
				Canny	Sobel	Canny	Sobel
1.				69.7224	23.3611	20.6788	20.6626
2.				99.3278	33.0511	19.0853	19.0698

3.			173.913	28.6957	23.5955	23.5779
4.			15.2432	11.170`	19.9279	19.9181
5.			116.5778	29.4162	17.7326	17.7138
6.			45.9005	25.3503	15.8545	15.8354

From the above table, it is concluded from the above observation that Canny edge detector outperforms Sobel

5. Conclusion and Future Scope

An extensive performance analysis of FAST corner detector based on the criterion of Non-Maximal Suppression was carried out to find the finest image features and analyze the advantage of FAST algorithm over the traditional Harris only corner detection method. The comparative results of FAST corner detection algorithm using the Non-Maximal criterion reveals the filtering of unwanted image pixels present in the form of noise while performing FAST without Non-Maximal Suppression. Also, it is undoubtedly clear from the previous and present research experiments that Canny operator provides better results in optimal edge detection and overcomes the limitation of over-segmentation of the pixels centered around the object.

Further research scope has room for the implementation of these parameters to quantify performance analysis using same parameters for other detection techniques like Prewitt and Robert. The fast-emerging image segmentation technique - Fuzzy Rule Based Feature Detection is assumed to have a vast scope of extra research and applications as the algorithms imply image processing in run time and overcome the drawbacks of hardware needs that is often seen in the classical techniques used for edge detection in particular.

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