A NEW CORNER DETECTOR BASED ON NON-MAXIMA SUPPRESSION

Mohammad A. Abbadi
Computer Science Department, Faculty of Information Technology
Mutah University, Jordan
abbadi@mutah.edu.jo

ABSTRACT: *Image processing applications have emerged in almost most of life aspects and fields. Corners detection techniques are used in many sectors, health, computer science, physics, and pure sciences, in addition to many other aspects. This paper aims at utilizing the non-maxima suppression technique to enhance the time needed for corner detection. Results on some grayscale standard images have revealed that the proposed algorithm outperformed some detectors in time consumed for corner detection and maintained reasonable and stable results in terms of detection accuracy.*

Index Terms*:* Corner detectors, Image processing, Nonmaxima suppression, image analysis, Image corners.

1. INTRODUCTION

Digital images have many important features that can hold important information for some image-related applications. Corners are considered one of the most significant features of images, since they are constant and robust, as well as they represent the base of the information required by many applications in many sectors and fields. Recent image processing techniques depend on the successful detection of the image corners [1,2].

Moreover, the detection of image corners and features matching have gained importance since many analyses depend on those operations, such as spatial analysis, real-time application's requirement, medical images analysis and medical decisions made accordingly, military and many other fields.

Now in the era of big data, corners detection algorithms face the challenge since they can play a vital role in analyzing visual big data, help in big data issues of storage and analysis [3, 5].

Many algorithms were proposed for corner detections, depends on the purpose of what the corners are detected. This paper proposes a fast algorithm for corners detection in digital images based on non-maxima suppression, where the points that do not lie in important edges were eliminated.

2. Related works:

Elsewhere, a comparison between the detection methods of the chosen sub-pixel and the traditional one was proposed [1]. They found that the algorithms use Harris corner detection in order to enhance the accuracy and precision of the detection process. In order to complete the comparison between the two algorithms' performance, a camera was used and two positions were selected for the camera. Many pairs were made and used for more information for the purpose of the comparison. The first test was concerned with the stability of the results, and the second one focused on computational errors.

An enhancement was proposed by others to be done on the Harris corner detection algorithm, to avoid the lack of accuracy that the algorithm suffers[2]. The proposed method used Barron operator for gradient calculations, then the B-Spline function is used for smoothing, and filtering the noise of the image. The image is split into many blocks and a cyclic approach is used to find the threshold value to assure the detection of the real corners of the image. The proposed enhancement and improvement showed efficient extracting of complex corners.

In 1995, others proposed a corner detection technique based on bending value, in which the experiment supposed that the directions of non-corner vectors will cancel each other [3]. The results showed that the proposed algorithm is effective in detecting corners.

Based on the variation of the intensity in the corner area, the intensity-based detection algorithm was proposed, depending on this the famous Harris corner detector was developed later [4].

A curvature corner detection method was proposed by [5], since previous corner detection algorithms showed low performance in calculating curvature. The proposed algorithm worked on redefining the curvature for each point after the smoothing process of edges. Then the algorithm filters the unstable corners and only keeps the invariant ones. The significance of this algorithm was the concept of corner strength. The results showed that the proposed algorithm outperformed the previous methods and enhanced the process of corner detection.

In an attempt to enhance the keypoint-based detection algorithm, some [6], implemented the algorithm with introducing new methods such as new keypoint selecting technique and an optimizing technique to overcome the problem of computing the initial clustering costly method. The results of the experiment showed that the proposed enhancements have improved the performance of the detection algorithm.

Others proposed a new corner detection algorithm that depends on cellular nonlinear/Neural networks [7]. The work concentrated on greyscale images. The algorithm showed significant results in terms of accuracy compared to those used for corner detection in greyscale images.

Corner detection has gained significant importance in medical issues. In [8], others proposed algorithm could be used to enhance and mitigate the risk of failure in locating the optic discs. The proposed algorithm depends on the feature of the eyes vessels to detect the corners of those vessels and choose the right location to plant an optic disc in an operation. Results showed that the proposed algorithm has enhanced the optic discs locating and improved the accuracy of the operation.

Some algorithms were specified for chessboard corner detection. Most of them lack precision and accuracy due to high distortion, low resolution. Others proposed an algorithm for chessboard corners detection based on physical coordinates [9]. This way allowed the algorithm to work on the level of subpixels. Results showed that this algorithm outperformed previous ones in chessboard corner detection, in the scenarios of complex scenes and simple background.

Another corner detection implementation in measuring sound velocity in many materials using echo and reflected waves. Some workers introduced an algorithm that

separated the echo waves resulted from a corner from other echoes and accurately detect the position of the corner by analyzing the reflected sound signals [10]. The introduced algorithm showed accuracy in detecting corner positions, also depending on the phase instead of the amplitude of the wave has improved the reliability of the results.

Xiaochen proposed a Corner Detector based on Global and Local Curvature Properties (CDGLCP), this robust method can detect corners in grey-level images as well as planar curves [12].

As the related works section showed that corner detection has become a significant issue in many fields; physical sciences, medical images and purposes, networks, and multiple image processing applications. The following section illustrated the methodology of this paper.

3. The proposed algorithm

3.1 Methodology

The proposed methodology of this paper goes as the following steps:

1. Find the edge image using the Sobel edge detector (x, y).
2. Extract edges (curves) from the edge image:
   a) Fill gaps if they are within a range and select long edges.
   b) Find T-junctions and mark them as T-corners.
   c) Obtain the `status' of each selected edge as either `loop' or `line'.
3. Smooth using a small width Gaussian kernel in order to remove quantization noises and trivial details. This small scale Gaussian smoothing also offers good localization of corners.
4. Select significant points on the smoothed curve using scale evolution technique.
5. At each selected point of the smoothed curve, compute three discrete curvatures following the CPDA technique using three chords of different lengths.
6. Find three normalized curvatures at each selected point of and then multiply them to obtain the curvature product.
7. Find the local maxima of the absolute curvature products as candidate corners and remove weak corners by comparing with the curvature-threshold
8. Calculate angles at each candidate corners obtained from the previous step and compare them with the angle-threshold to remove false corners.
9. Find corners, if any, between the ends of smoothed `loop' curves and add those corners which are far away from the detected corners
10. Compare T-corners with the detected corners and add those T-corners which are far away from the detected corners.

The proposed corner detection Algorithm is as follows:

input: a grayscale digital image
output: a star is drawn on each located corner
1- do xs=sobel on x-axes
2- do ys=soble on y-axes
3- r=xs/ys
4- if r=1 then corner
else
do
s45 =sobel 45 degree
.
do
s_45=sobel -45 degree
r= s45/s_45
if r=1 then corner
else
not corner
5-end
// this is a Matlab code to show the dection results
C = corner(I);
Subplot (1,2,1);
imshow(I);
hold on
plot(C(:,1), C(:,2), '*', 'Color', 'c')
title ('Maximum Corners = 200')
hold off

3.2 DATA

For the purpose of this study, particularly to measure the performance of the proposed method we used 7 grayscale images from the standard image database, namely, House, Chess, Block, Artificial Blocks, Black star, White star and Human face.

4. RESULTS AND DISCUSSION

Non-maxima suppression and threshold were used for points generated by a feature or corner detector.

Non-maxima suppression is often used along with edge detection algorithms. The image is scanned along the image gradient direction, and if pixels are not part of the local maxima they are set to zero. This has the effect of suppressing all image information that is not part of local maxima.

An issue with integer-valued images is that if there are multiple pixels all with the same value within distance 2*radius of each other then they will all be marked as local maxima.

The algorithm extracts local maxima by performing a greyscale morphological dilation and then finding points in the corner strength image that match the dilated image and are also greater than the threshold, then make a mask to exclude points within a radius of the image boundary. Figure 1 shows the Black Star Example from the performed experiment

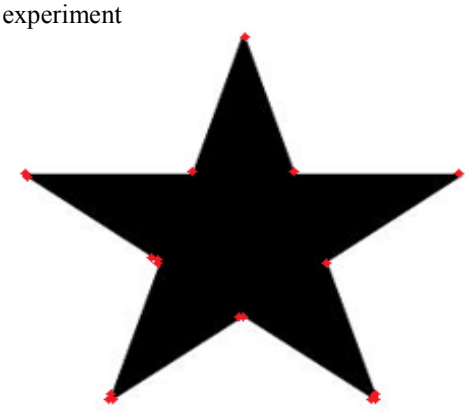

Figure 1: The Black Star Example from the performed experiment

Table 1: Proposed Algorithm Results

Proposed method	Time of detecting corner (sec.)	Number of corners detected	Number of corner not-detected	The real number of corners
House	0.0372	75	6	81
Chess	0.0487	96	-15	81
Blocks	0.0143	51	8	59
ARTIFICIAL BLOCKS	0.0287	51	10	61
Black star	0.0171	12	-2	10
White star	0.0134	9	1	10
Human face	0.0151	17	1	18

As can be seen from Table 1, the proposed algorithm performed well on finding most of the corners in all of the 7 tested images, with some false accepting and rejecting errors, the negative numbers show that the algorithm detected more edges (false acceptance).

Table 2: Comparison between the proposed algorithm and other algorithms (House image)

	Time of detecting corner (sec.)	Number of corners detected	The real number of Stars	Accuracy
Proposed Algorithm	0.0372	75	81	
harris_corner	0.5079	26	55	
CDGLCP	0.6184	51	59	
Noble	0.3284	39	42	
SUSAN	0.1625	52	29	
CSS	0.1885	62	19	
Code	0.3100	105		

As can be seen from Table 2, the proposed algorithm outperformed other state-of-the-art methods in terms of the detected corners and the time consumed when applied on the house image.

Table 3: Comparison between the proposed algorithm and other algorithms (Chessboard image)

	Time of detecting corner (sec.)	Number of corners detected	Number of corner not-detected
Proposed Algorithm	0.1495	96	-15
harris_corner	7.8154	92	-11
CDGLCP	1.3901	109	-28
Code	0.4414	101	-20

As can be seen from Table 3, the proposed algorithm obtained reasonable results compared to the other methods when detecting the corners in the chessboard image, Harris-corner worked better on this image, however it consumed a very long time comparing to the proposed method and to the other methods as well.

Table 4: Comparison between the proposed algorithm and other algorithms (Blocks image)

	Time of detecting corner	Number of corners detected	Number of corner not-detected
Proposed Algorithm	0.0759	51	8
Harris_corner	0.5966	38	21
CDGLCP	0.1901	58	1
Noble	0.3904	46	13
SUSAN	0.1460	39	20
CSS	0.1685	47	12
Code	0.3998	70	-11

As can be seen from Table 4, again the results show the high speed of the proposed method in addition to its reasonable ability to detect the corners in Blocks image. It is interesting to notice the consistent performance of the proposed method comparing to the other methods, for example, the winner in this experiments is the CDGLCP, while it performed the worst in the previous experiment (see Table 3), on the contrary, Harris-corner was the winner in Table 3 and performed the worst in Table 3. However, the stability of the performance of the proposed method is another of using the proposed corner detector, in addition to its speed and reasonable detection results.

5. CONCLUSION

As image processing applications have increasingly become significant and important in many fields and life aspects. It raises the trend in research to seek accurate algorithms, that helps in getting results that are more realistic and achieve accuracy.

This paper proposed a new algorithm that detects corners based on Non-maxima suppression. As results indicate, the proposed algorithm outperformed some of the state-of-the-art algorithms stated in the tables above, such as Harris corner detection, SUSAN, CSS and more in terms of time required for detecting corners. The proposed algorithm obtained reasonable and stable results in terms of detection accuracy, however, it needs to be enhanced to outperform the number of detected corners by the stated algorithms while maintaining time efficiency. In order to achieve this goal, we are going to use other image processing methods such as those found in [12, 13, 14, 15 and 16].

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