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Overview of an Improved and Speedy Features Detection Method for Digital Imagery

Abstract. *In this paper, we were interested in the analysis of the visual field in the captured images, and information on the correct movement of the vision system in its environment to facilitate the analysis and detection of objects. Various feature extraction techniques for objects are discussed in this paper with the intention of doing a comparative study about edge and POIs detection methods to try to develop a novel algorithm that merges point and edge detection.*

Streszczenie. *W niniejszej pracy interesowała nas analiza pola widzenia w przechwyconych obrazach oraz informacje na temat prawidłowego poruszania się układu wizyjnego w jego otoczeniu, aby ułatwić analizę i wykrywanie obiektów. W tym artykule omówiono różne techniki ekstrakcji cech obiektów z zamiarem przeprowadzenia badania porównawczego metod wykrywania krawędzi i punktów POI w celu opracowania nowego algorytmu, który łączy wykrywanie punktów i krawędzi. (**Przegląd ulepszonej i szybszej metody wykrywania funkcji obrazów cyfrowych**)*

Keywords: image processing, object recognition, features, POIs, edges, features detector, PSNR, MSE, SC.
Słowa kluczowe: przetwarzanie obrazu, rozpoznawanie obiektów, cechy, punkty POI, krawędzie, detektor cech, PSNR, MSE, SC.

Introduction

In image analysis, feature detection of an object is one of the most used tools in image processing. It is a very large research line, so many researchers are interested in it. A lot of methods and algorithms have been used in computer vision for object recognition by image analysis in wide applications. In this work, we have evaluated several methods of edge and interest point detection by using different types of visual data. Here, these features studied are the edge and interest point primitives, we can use them in different fields by using different images like digital images, satellite images, ariel images, etc.

The purpose of features is to analyze visual data and identify all object information in images in order to detect object shapes because image edge and point features contain a lot of information [1]. We can use these primitives to recognize for example the characteristics of the tea leaves to identify defective leaves [2], or edge detection in satellite images [3, 4], or in digital images to extract all edges in visual data [5, 6], also the edge and interest point extraction in an image is rest on objects with noise and blur [7], or also another category to detect the face for images with lighting problems [8], etc. There are various edge detection methods and various interest point detection techniques, each detector has its own characteristics [11,12].

We always try to improve these detectors to obtain a good level of processing, with regard to also interest point detection because it is an important step to recognize an object. There are a lot of key points extraction techniques that are based on the detection of the corners in any image, comparative study of FAST, MSER, and HARRIS techniques for palmprint extraction [13], the HARRIS algorithm extracts the most number of points than others detectors [9]. But the FAST and Canny detectors take lesser time for object detection.

In this paper, various techniques of edge and interest point detection are studied for improved our comparative analysis, and proposed an algorithm that combines the two-step of detection for identifying the edges and the key points in digital visual data, and our comparative analysis is also performed to improve the number of point and edge extraction.

This paper is organized as follows: Section II illustrates a generality of used methodologies on detectors of features, all methods for predicting the quality of images, and our proposed algorithm. Section III presents all comparison experimental results. Discussion of obtained results and validation of our proposed algorithm in section IV. In the end section V, some conclusions are presented.

Methodology

Image feature:

Point extraction:

The point is the most important characteristic [1,4]. Several techniques have been developed for the detection of points of interest (POIs) that are described as follows:

- Harris Detector: It is based on the Moravec detector, it extracts a corner detection of an object [9]. It is based also on the computation of the quality C of the POI by an approximation to the second derivative H, as shown in equation (1):

$$C = |H| - k * (trace\ H)^2 \quad (1)$$

Where H is the local covariance matrix has two eigenvalues $\lambda 1$ and $\lambda 2$. By which the classification of the pixel Pi in the image by the analysis of the eigenvalues of H, is presented in Table 1:

$$H = \begin{pmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_x^2 \end{pmatrix} \quad (2)$$

Ix and Iy are the gradient components of the image, and k represents the sensitivity factor. By analyzing $\lambda 1$ and $\lambda 2$ we have three cases :

Table 1. Classification of image point based on eigenvalues of H

Cases	Regions	Eigenvalues of H
(1)	Edge	$\lambda 1 >> \lambda 2$ or $\lambda 1 << \lambda 2$
(2)	Corner: POIs	$\lambda 1$ and $\lambda 2 >> 0$
(3)	Flat region	$\lambda 1$ and $\lambda 2 \approx 0$

- FAST (Features from Accelerated Segment Test) Detector: The basis of the FAST algorithm is the final decision on whether or not the pixel is a POI according to criteria that consist of classifying all the POIs detected in the images to be tested [13], it is faster and robust [4, 12]. Considering the center pixel P with Ip its intensity, P belongs to a circle from 12 to 16 pixels which contains surrounding points with which the candidate POI can be compared. In this algorithm a fixed threshold value to be selected T, if the pixel P has a POI in the area from 12 to 16 pixels, so there are all brighter than $Ip + T$, or all darker than $Ip - T$. Each pixel P has a position X and in these 16 pixels has can have one of the following states:

$$S_{P \to X} = \begin{cases} I_{P \to X} \le I_p - T\, (Draker) \\ I_p - T \le I_{P \to X} \le I_p + T\, (Similair) \\ I_p + T \le I_{P \to X}\, (Brighter) \end{cases} \quad (3)$$

Edge detector:

Numerous algorithms of Edge detection have been proposed, among them are as follows:

- Sobel detector: It is based on the pair of 3x3 convolution masks which are presented in figure Fig.1.

Horizontal

1	2	1
0	0	0
-1	-2	-1

Vertical

-1	0	1
-2	0	2
-1	0	1

Fig.1. Masks used for Sobel detector for X and Y direction

- Robert detector: It is using a pair of 2x2 convolution masks which are illustrated in figure Fig.2. The vertical and horizontal edges are detected individually and after combining all two for edge detection of output result.

G_x

1	0
0	-1

G_y

0	1
-1	0

Fig.2. Gx, Gy masks used for Robert detector for X and Y direction

- Prewitt detector: Prewitt's technique has the 3x3 convolution mask as shown in Fig.3. The Prewitt operator is easy to implement, but sometimes it is noise sensitive.

G_x

-1	0	1
-1	0	1
-1	0	1

G_y

1	1	1
0	0	0
-1	-1	-1

Fig.3. Gx and Gy masks used for the Prewitt method

- Canny algorithm: It is another technique of edge extraction, where different steps can be used to facilitate edge detection in images [1, 3]. Its pairs of 3x3 convolution masks are shown in Fig.4. Level one of this algorithm is to apply a Gaussian filter in order to eliminate blur and noise. Afterward, this technique imposes to calculate the gradient and edge orientation at each pixel in the two directions. Finally, it detects the strong edges and weak edges by removing the weak edges in the final result.

G_x

-1	0	1
-2	0	2
-1	0	1

G_y

1	2	1
0	0	0
-1	-2	-1

Fig.4. Gx and Gy Canny Kernels for X and Y direction

Methods for predicting the quality of images:

Peak Signal Noise Ratio measurement (PSNR):

The $PSNR$ is used to evaluate image quality and it was introduced in [11, 13]. It can be expressed as follows, f is the original image:

$$PSNR = 10 \log \frac{max(f)^2}{\sqrt{MSE}} \quad (4)$$

Mean Square Error Metric (MSE):

MSE is the best parameter for the evaluation of image quality [7, 15]. It is defined as:

$$MSE = \frac{1}{NM} \sum_{i=1}^{N} \sum_{j=1}^{M} [f(i,j) - \hat{f}(i,j)]^2 \quad (5)$$

Where $(N \times M)$ is the size of images, f is the original image and $\hat{f}$ the estimated image.

Structural Content (SC):

This parameter is based on the correlation measure [14, 15]. It can be defined by the following expression:

$$SC = \frac{\sum_{i=1}^{N} \sum_{j=1}^{M} (f(i,j))^2}{\sum_{i=1}^{N} \sum_{j=1}^{M} (\hat{f}(i,j))^2} \quad (6)$$

Total Edge Difference (TED):

This parameter is used to calculate error sensitivity measures, especially edge-based measurements [14]. It can be defined by the expression:

$$TED = \frac{1}{NM} \sum_{i=1}^{N} \sum_{j=1}^{M} \left| f_E(i,j) - \hat{f}_E(i,j) \right| \quad (7)$$

Total Corner Difference (TCD):

It is another image quality assessment technique based on the computation of the number of POIs detected in input and output images [14]. The mathematical definition for this method is :

$$TCD = \frac{\left| N_{cr} - \hat{N}_{cr} \right|}{max(N_{cr}, \hat{N}_{cr})} \quad (8)$$

Proposed Method:

This paper concentrates on a comparison of techniques for feature detection in order to propose a new improved algorithm. In the classical algorithms in Figure Fig.6, classical architecture has been found to detect each type of feature separately.

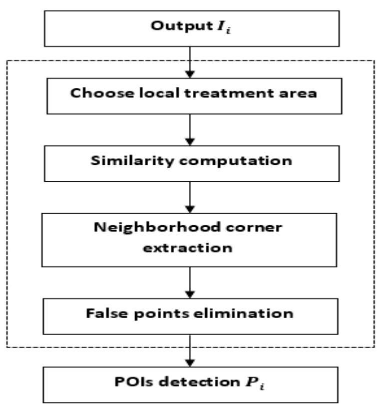

Fig.5. Flow chart of the classical detector

Feature detection is one of the most tasks for image processing applications, such as object recognition and target tracking, for example, Unmanned Aerial Vehicle (UAV), etc. We tried so to compare the selected techniques in order to improve the classical algorithm in Fig.5 by the addition of an edge detection algorithm to obtain a new algorithm that makes it possible to extract the POIs and the edges of the images, which is presented in figure Fig.6.

An algorithm proposed because the importance of edge detection is the same as the importance of point detection, allows us to propose an algorithm to extract edges and points in another different way compared to other methods studied.

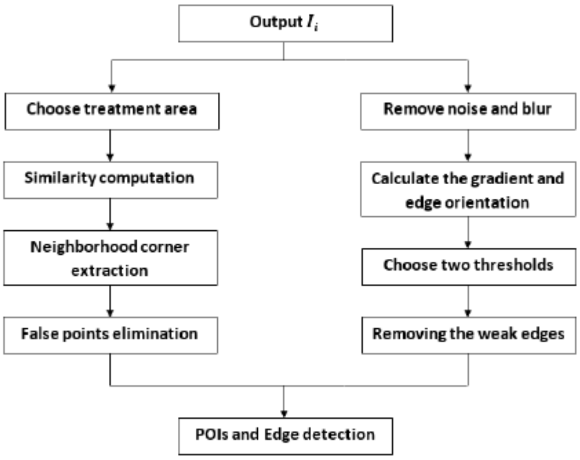

Fig.6. Flow chart of the proposed detector

Experimental Results

In this part, implementation of the methods was tested, on a system having i5, 2.71 GHz processing with 8 GB RAM using 7 various images on a grayscale. For the Harris detector, the sensitivity factor k is set as 0.04, and for the Fast detector, the value of n = 16 pixels. An example of a dataset of images is tested by the analysis of their primitive and object recognition by applying Moravec, Harris, FAST, Sobel, Roberts, Prewitt, and Canny detectors.

For each technique of these, we obtained different outputs which are shown in Fig. 7, Fig.8, and Fig.9. Our images tested in this work were different sizes to obtain an efficient comparison, so we had 7 images numbered from 1 through 7. To choose the best detectors for our proposed algorithm in Figure Fig.6, we use different parameters of comparison such as the image quality parameters, which are presented in the undermentioned tables numbered from 2 to 7. We used also all the advantages and disadvantages of all used techniques in this work to validate our comparison.

Table 2. Image quality parameters of Sobel Detector

Images	(1)	(2)	(3)	(4)	(5)
MSE	2.55e4	2.57e4	2.6e04	2.579e4	2.58e4
PSNR	28	28.009	28.2	28.51	28.008
SC	0.9	0.85	0.92	0.95	0.87

Table 3. Image quality parameters of Robert Detector

Images	(1)	(2)	(3)	(4)	(5)
MSE	1.9e02	1.7e02	1.8e02	1.83e2	1.69e2
PSNR	10	9.2	10.09	10.095	9.20
SC	0.51	0.50	0.67	0.70	0.62

Table 4. Image quality parameters of Prewitt Detector

Images	(1)	(2)	(3)	(4)	(5)
MSE	2.6e04	2.58e4	2.6e04	2.64e4	2.49e4
PSNR	28.52	28.01	28	28.78	27.02
SC	0.921	0.835	0.94	0.95	0.827

Table 5. Image quality parameters of the Canny Algorithm

Images	(1)	(2)	(3)	(4)	(5)
MSE	2.8e04	2.7e04	2.8e04	2.76e04	2.67e04
PSNR	30.05	29.871	30.01	30.07	29.004
SC	0.96	0.87	0.97	0.975	0.9

Table 6. Total number of POIs detected

Images	Moravec	Harris	FAST
(1)	78	223	113
(2)	67	169	89
(3)	79	200	100
(4)	78	227	100
(5)	66	178	79
(6)	66	176	79
(7)	71	178	100

Table 7. Time POIs detected in Second (S)

Images	Moravec	Harris	FAST
(1)	0.1	0.61	0.59
(2)	0.28	0.51	0.50
(3)	0.12	0.572	0.570
(4)	0.1	0.52	0.51
(5)	0.22	0.585	0.58
(6)	0.22	0.585	0.58
(7)	0.15	0.51	0.50

Discussion

Our objective in this work is to extract image features by using the principal points and edge features of an image for an embedded camera. Here, we tested three methods for POIs detector and four methods for edge detection. So, the Harris technique extracts the highest number of points than the Moravec and FAST algorithms, then the detectors Moravec and FAST are faster than the Harris detector and detect the least number of POIs.

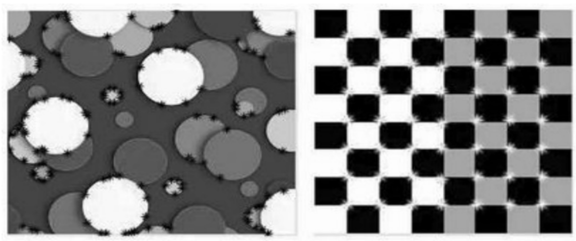

Fig.7. The detection results of Image (3) and Image (4), Left Image (3): FAST method, Right Image (4): Harris Detector.

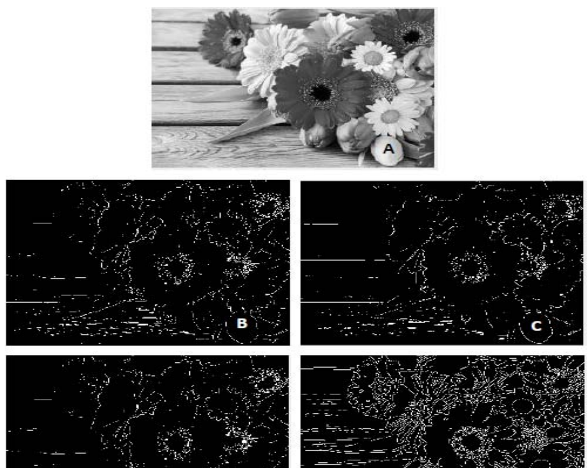

Fig.8. The detection results of four detectors for Image (1), A: Original Grayscale Image, B: Sobel Detector, C: Robert Detector, D: Prewitt Detector, E: Canny Algorithm.

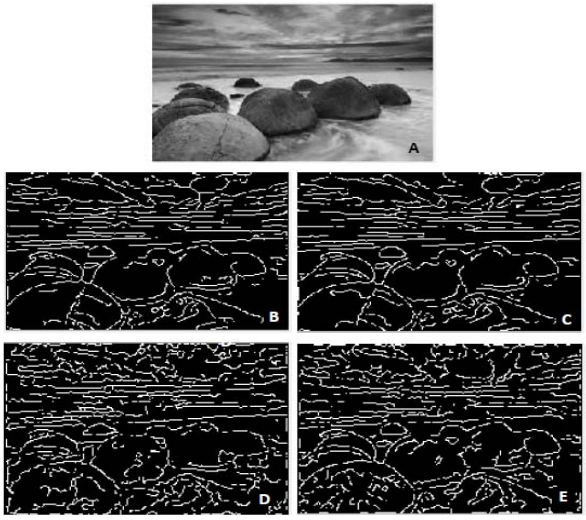

Fig.9. The detection results of four detectors for Image (5), A: Original Grayscale Image, B: Sobel Detector, C: Robert Detector, D: Prewitt Detector, E: Canny Algorithm.

So, Figure 7 shows the POIs detected for recognizing the selected features of objects in test images (3) and (4), where the POIs for the FAST method are shown with black color and for the Hrarirs algorithm with white color.

On the other hand, Robert's algorithm is very sensitive to noise and produces weak responses to edge detection in Fig.8.C, Fig.9.C, and poor values of MSE, PSNR, and SC. Sobel's algorithm and Prewitt operators are the best values for parameters of image quality but are slower and more sensitive to noise in Fig 8. (B and D), and Fig.9 (B anD).

But in Fig.8.E and Fig.9.E for the detection of objects in our test image, better results were obtained for Canny's algorithm, which also gives high and good parameters of MSE, PSNR, and SC. So this work uses MATLAB to compare these methods to build a novel algorithm proposed for POIs and edge extraction.

Conclusion

The originality of this work is based on a detailed study of edge and POIs detection techniques. The results of our studies allow us to choose the best techniques to propose a method that combines edge and POIs extraction to make feature detection even better.

These methods and approaches are applied to the whole used images. Our results of the simulation display a complete analysis to propose an improved algorithm combination that produces better results.

The proposed combination takes a lot of time but we got obtained an efficient feature detection as compared to other methods.

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