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Extraction and segmentation process for the Iraqi paper currency

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ABSTRACT

Different application like image segmentation, moving objects detection and objects tracking, required an object detection and segmentation techniques. Recently, these techniques become so important especially when only a specific part of image is important. This research paper presents an efficient algorithm that employed for objects detection and extraction process. This algorithm consists of a several steps and the validity of this algorithm is measured based on different denomination of Iraqi currency. These steps arrange as following: image conversion, deleting small and unnecessary objects from images, extraction of interest objects boundary, finally calculating the rotation angle automatically, and rotate image based on the calculated angle. The validity of algorithm measured on the seven denominations of Iraqi currency (250, 500, 1000, 5000, 10000, 25000, and 50000). This image saved in a database that contain 40 images for each denomination and the total images for all denominations are 280 images. After testing the validity of designed algorithm on all captured image, the algorithm shows high accuracy which equally to 99.6%.

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1. INTRODUCTION

In the field of image processing, objects detection and extraction take a great interest in different area that related object monitoring object tracking and localization and tracking, detects and identifications of objects such as persons, animals and vehicles from images and videos. Object detection process mean detection the interested objects from images or in other meaning, determine the foreground pixels from the background pixels [1], [2]. In the recent years, the number of available image increased significantly. The most important things that not all these images are important and interest, only a specific part from these images are important [1]. For this reason, the process of image-object extraction become interested in different failed that related to image processing. Therefore, different algorithms implemented for achieving object extraction but until now, there is no standard algorithm [3].

Object detection usually combine with image segmentation. You only look once (YOLO) used as the main algorithm for object detection. The main advantage of YOLO is the ability for fast detection based on convolutional neural networks (CNNs). For the process of objects extraction based on using segmentation the improved K-means algorithm was used for this purpose. Both semantic information and depth information are used to determine the acceptable number of segments for the specified scene [4]. Image

processing application widely use image object extraction. Moreover, many algorithms were designed for this and used in different applications after the input image are pre-processed and these image must include – class similarity is enhanced and between – class similarity is reduced [5]. The process of extracting objects of interest in input image mean determining these object form the complex background. These interested objects usually placed in the center of image and it have a significant color intensity. The selected object is automatically extracted with a cooperation of manually selection [6]. The captured image cannot be used directly for different image processing applications like image compression and recognition without using pre-processing step. For pre-processing step it's likely to use either edge detection or segmentation. The simple definition about segmentation is the process of partitioning or dividing the image into a number of segments and placing the similar segment into one class [7], [8]. Dividing the input image into specific parts is performed with the help of interaction between image segmentation (using different edge detection methods) and object detection. Edge detection methodology such as Sobel, Prewitt, Roberts, Gaussian are applied for the purpose of segmentation. Expectation-maximization (EM) algorithm, fast discrete curvelet transform (FDCT) method, Otsu method and Genetic algorithms were used to demonstrate the synergy between the segmented images and object recognition [9].

For the image, when the resolution increase the level of important information also increase. When these image apply for the segmentation and object extraction steps it will provide more information for the subsequent step. Different algorithms are proposed for object segmentation and extraction that try to find a solution to the problems that address with remote sensing and monitoring [10]. The essential operation for object extraction process is to extract or highlight the important objects in the processed image. Image extraction algorithm depend on two steps. First, determine the position of important objects in image, second, is extracting these object [11]. The accuracy of image extraction techniques are measured as presented in [12]-[14].

The aim of this study is designing a new methodology of currency extraction by using new proposed method based on directional gradient. The main advantage of the design method are: i) high accuracy, ii) high detection level and recognition, and iii) low computation time. This algorithm was used to identify the Iraqi currency because of different domination, complication of features, and size. No similar study was reported to the time of writing this research. The paper is divided into five sections. The first section describe segmentation process with detail, the second section show edge detection and the used method for edge detection, the last section shoe the details of the designed method that used for paper currency extraction. The remaining two sections show the results of the proposed method and the conclusion of this study.

2. MATERIALS AND METHODOLOGY

2.1. Image segmentation

In image processing area the segmentation process is so important and widely applied in different application [15] like: image analysis, content-based image retrieval (CBIR), medical image analysis and pattern recognition. The simple description about segmentation is the process of dividing image into a number of segments. When image applied to segmentation it become more meaningful, understand, simply to process and analyze [16], [17]. In computer vision, the segmentation process applied in pre-processing step. The basic idea of this process is to group similar pixels in the image into one cluster. When grouping these pixels togetherin single cluster it mean these pixels sharesame properties in texture, color and intensity. Different algorithms applied to this process but until now, there is no general stander algorithm that when applied for different images give better results. The segmentation process divided into two types, either edge-base techniques or region-base techniques [18], [19].

The most widely used technique for the recent studies is the active contours method. The main advantage of this method is the ability to divide the input images into different sub-regions and each sub-regions have a continuous boundary. There are two type of active contours, these are: edge-base active contours and region-based active contours [9].

2.2. Edge detection

Edge detection process simply define as the process of determining and locating any sharp transition in the input image [20]. These transition represent changes in pixels intensity which describe boundaries of any objects in an image. Edge in the digital image or usually refer as image boundary that occurred when there is a noticeable change in some physical aspect of an image, like the surface reflectance and illumination. These changes are happen in color, intensity and texture. Edges are detecting based on applying mask on the input image and mask is applied like convolutional kernel that basically use convolution process between mask value and the value of the interested pixel with respect to its neighbors. The methods of edge detection are divided into two categories: the first one is gradient-based edge detection that depend on

compute the gradient that computed from first derivative of the image. Second, Laplacian based edge detection that based on Laplacian method that searches for zero crossings in the second derivative of the image [21].

2.2.1. Sobel edge detection

Sobel-Feldman operator or simply refer as Sobel operator, the Sobel filter is widely applied for per-processing the input image. Figure 1 shows Sobel operator for edge detection, Figure 1(a) and Figure 1(b) shows Sobel operator compute the first-order derivatives horizontal (G_x) and vertical (G_y) [22]:

- To detect horizontal edge (G_x) the input image was convolved with the convolutional mask in the left side
- To detect vertical edge (G_y) the input image was convolved with the convolutional mask in the right side
- To detect edges in both directions (horizontal and vertical), three step are performed. First compute G_x, second, compute G_y and finally compute g as following:

$$g = \sqrt{G_{x^2} + G_{y^2}} \quad (1)$$

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

(a)

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

(b)

Figure 1. Sobel operator for edge detection in (a) horizontal and (b) vertical directions

2.2.2. Prewitt edge detection

Prewitt operator applied in the same way to the Sobel operator in computing G_x and G_y, but they different in the mask weight [23]. Figure 2 shows the form of prewitt operator for detecting image edge, Figure 2(a) in horizontal direction dan Figure 2(b) in vertical direction. The Prewitt operator produces noise in its results compeer with the Sobel detector, because of the coefficient of value 2 in the Sobel operator that provides smoothing in their results [24].

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

(a)

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

(b)

Figure 2. Prewitt operator for edge detection in (a) horizontal and (b) vertical directions

2.2.3. Canny edge detection

Canny operator usually used to find edge through isolating noise from input image. This step done without any modification in image features. Canny operator calculates slop to detect edge in the image [9], [25]. This work uses the Gradient-based edge detection method and the prewitt operator is used [26].

3. PROPOSED METHOD

In image processing technique the process of objects extraction is an important step. This study introduce a new technique for object extraction from background. The detail for this methods shown in Figure 3.

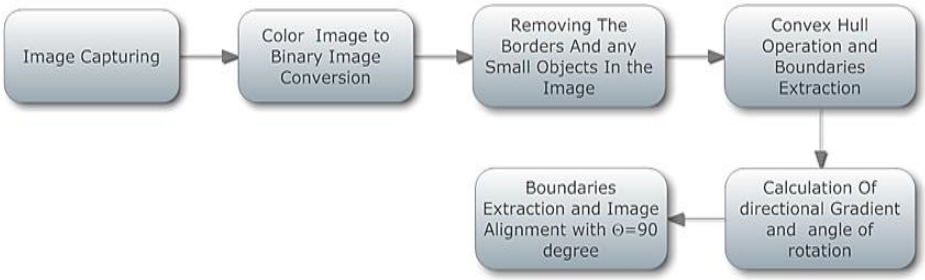

Figure 3. Image extraction flow chart

The following steps represent the proposed method of object extraction process:

– The images of paper currency are captured using scanner. The used scanner for this study is brother DCP-T310, the specifications of this scanner are shown in Table 1. This study perform on the seven denominations of Iraqi dinnar, and a total captured samples or images are 280 image. Moreover, all images were saved in JPEG format, as shown in Figure 4.

Table 1. Scanner specification

Color/Black	Color/Black
Resolution	DCP-T310/DCP-T510W prints up to 1200×1800 dpi DCP-T710W/MFC-T810W/MFC-T910DW prints up to 1200×2400 dpi
Gray scale depth	8 bit
Color depth	30 bit color processing (input), 24 bit color processing (output)

– The captured images in the first step are directly converted to binary format in which each pixel in the image can have one of two values either 0 for black color or 1 for white color. Figure 5 show the binary image for the 10,000 IQD. To convert red, green, blue (RGB) image to the binary form by applying threshold on the input image. Any pixel value lower than threshold the value of the pixel become dark color, for pixel value greater than threshold it become white.

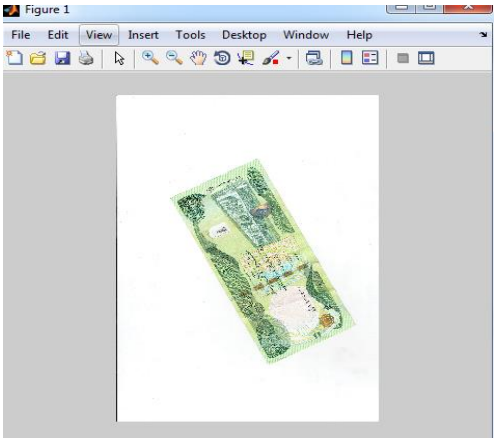

Figure 4. Original image from scanned to the Iraqi paper currency

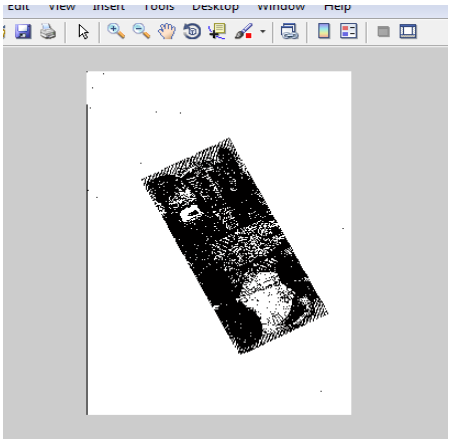

Figure 5. Color to binary image conversion

– There is black lines at the border of paper currency this line result from the scanner. This line have a width and high about 100 rows and columns from the original image. These black lines have black color and to remove this it necessary to make them white or ones. The result from this operation show in Figure 6.
– After removing black lines from border, it is necessary to remove some small objects that appear in the binary image. To remove them it essential to use area open operation that removes all small objects that have a number of pixels lower than threshold. The result of application of area open operation can see in Figure 7.

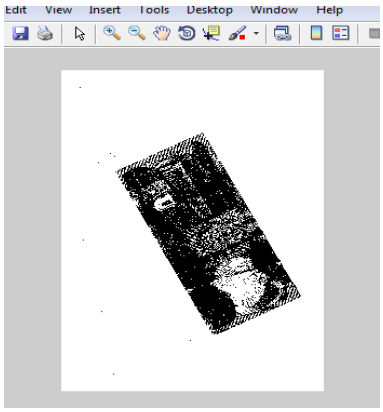

Figure 6. Removing black border from binary image

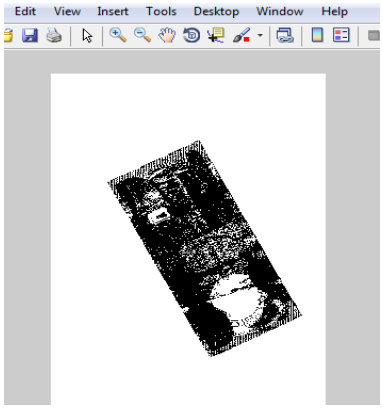

Figure 7. Removing small objects from the binary image

– In this step, border extraction of the paper currency image must be done. For extraction, convex hull must be used. This operation take actual boundaries of input image in the consideration to ensure accurate extraction, Figure 8 shows the application of this operation on the resulted image from the previous step.

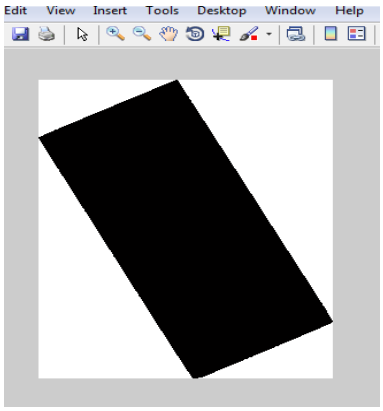

Figure 8. The application of convex hull operation

– Evaluate the line with the longest edge from the extracted image boundary as shown in Figure 9. Then this line is divided to ten line segments, and calculating the slop of these segments using first-degree polynomial of the (2) and (3) in order to find coefficients (a and b). The slop calculation according to (4). From each slop there is an angle so the result are ten angles for each image.

$$\gamma(x) = \gamma \quad (2)$$

$$\gamma = a\,x + b \quad (3)$$

$$\frac{dy}{dx} = a \quad (4)$$

- The next step is to count the most repeated angle, in order to take it as the candidate rotation angle for that image. The rotation angle is represent with symble θ, the calculation of θ is described in (5).

$$\theta = \tan^{-1}(a) \quad (5)$$

- After the angle of rotation is computed, as shown in Figure 8. The image is rotated according to it. Performing boundary extraction in order to extract paper curacy accurately. For display purpose, rotate the image with $\theta = 90^{\circ}$ just for display purpose, as shown in Figure 10. Figure 11 shows the final view for the extracted Iraqi paper currency.

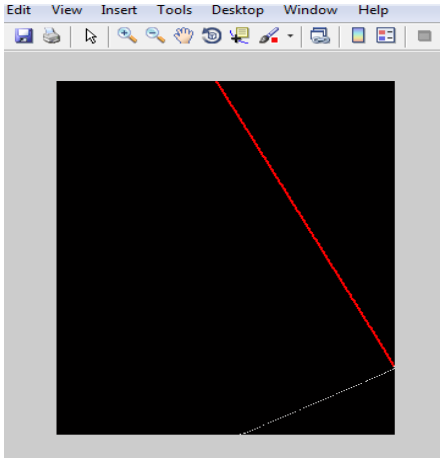

Figure 9. Directional gradient calculation

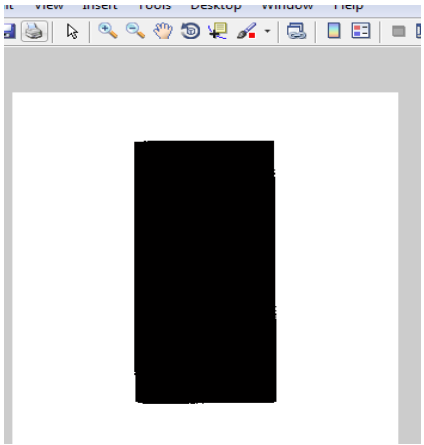

Figure10. Image rotation according to the calculated angle and boundary extraction

Figure11. The output image

4. RESULTS AND DISCUSSION

This method was used to extract the important currency note images from the complete scanned images, carried out on 280 banknotes of different denomination of IQD, all captured and stored in a large database called IQPC. The banknote images were extracted with very precise and accurate results in which the extraction rate was 99.6%, with only eight banknotes failing to be extracted correctly. The reason for the

incorrect image extractions was incorrect scanning, in which apart of the banknote was outside of the scanner bedthus making the dimensions of the actual banknote difficult to determine and affecting the calculation of angle of rotation. The incorrect calculation of θ led to incorrect image extraction. This problem can be eliminated by scanning the banknote images horizontally without any angle of rotation.

Khleif and Ahmed [1] and Gould *et al.* [3] discuss more complicated algorithms that are used in image processing for object extraction. In addition, they use multiple stages in order to improve results, however, the experimental result for Khleif and Ahmed [1] was still less than 100%, while therate for Gould *et al.* [3] was between 91.27% and 99.34%. From these results, the proposed algorithms are still less efficient and accurate when compared with our method.

5. CONCLUSION

Image object extraction become essential processing step in different applications like diseases detection, object tracking and localization. This work show an efficient algorithm for object extraction based on finding and calculating both directional gradient and angle of rotation. The designed algorithm show a high accuracy when tested on a database that contain 280 images about Iraqi dinar of different denominations, the final accuracy of the designed algorithm is equally to 99.6%.

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