2D Geometric Object Shapes Detection and Classification

Mokhtar M. Hasan
Department of computer Science, College of Science for Women, University of Baghdad, Baghdad, Iraq.

Noor A. Ibraheem*
Department of computer Science, College of Science for Women, University of Baghdad, Baghdad, Iraq.
E-mail: nooraibraheem@csw.uobaghdad.edu.iq

Noor M. Abdulhadi
Department of computer Science, College of Science for Women, University of Baghdad, Baghdad, Iraq.

Received August 30, 2021; Accepted December 06, 2021
ISSN: 1735-188X
DOI: 10.14704/WEB/V19I1/WEB19113

Abstract

In computer vision, object detection is a basic process for advanced procedure forms such as object detecting, analyzing, tracking, etc., for further processes, features extraction play a vital part to identify the objects accurately. Most of the existing frameworks may not be able to distinguish the objects appropriately when different objects have a place to a single frame. In this work, an automatic detection and recognition system of two-dimensional geometric shapes have been proposed. Firstly applied Genetic Algorithm (GA) to fill the shape after performing proper segmentation pre-processing method. The proposed framework is able of identifying numerous objects in the input image, determining the sort of the identified object, and labeled the recognized objects. Statistical method has been applied for each shape to extract the objects corners’ points by calculating the largest boundary to form the features vector. Ultimately, the identified objects are classified as geometrical shapes such as square, rectangular, triangular, or circular. The proposed method achieved high accuracy around 98.3%, and an average computational time 0.521 sec. as an effective classification technique.

Keywords

Genetic Algorithms, Geometric shapes, Feature extraction, Object identification.
Introduction

In the surrounding environments, there are various objects, these objects are different in shapes mainly, color, texture, shape or size. Identification of objects for humans is quite simple despite different circumstances, various forms, probably are upside down, or, partly occluded by Vries (2006), some objects might have deviations in shapes such as trees or vases but still can easily by recognized by human brain as by Vries (2006).

Object detection and tracking considered a vital field; an advanced component are required for motion object detection, recognition, and tracking as in Hemalatha, Muruganand and Maheswaran (2014). These systems demanded developed hardware techniques such as cameras and computers.

In videos, object locating include the tracking of moving object(s) in each video frame sequence over a period of time, however, which in turn required high quality camera and an intelligent object tracking algorithm, besides it demanded an examination of object analysis as by Kothiya and Mistree (2015). Many algorithms are utilized with regard to object representation utilized, appearance and shape of the object be displayed for locating as explained by Hemalatha, Muruganand and Maheswaran (2014).

Many theories have been evolved to understand the operation of recognizing human's brain to objects especially if that objects are overlapped with other objects. Many efforts have been conducted to model human behavior by computerized object detection and identification as demonstrated by Zein, Yakoub, Adl, Hassanien and Snasel (2015), all these efforts need to touch and deeply understand digital image processing techniques, which considered as a challenging process as by Roy, Hossin, Uddin, Al Mamun, Afjal and Nitu (2019). Emerging aspects of artificial intelligence (AI) algorithms can perform detection and recognition of objects with image processing methods as shown by Vries (2006).

Feature Extraction is an imperative component for any object identification and image recognition system, feature extraction can be defined as the mapping of picture's pixels into a feature space as explained by Ibraheem (2016).

After the detection of the specified object, the preeminent basic part (features extraction stage) is discussed to remove the undesired information requested to classify the recognized object accurately.

The most utilized AI algorithms are artificial neural networks (ANN) as explained by Roy, Hossin, Uddin, Al Mamun, Afjal and Nitu (2019), and Hesamian, Jia and Kennedy (2019),
Genetic Algorithm (GA) by Khan and Ibraheem (2013), Chabrier, Rosenberger and Laurent (2008), and Ghosh and Mitchell (2006), Support Vector Machine (SVM) as explained by Roy, Hossin, Uddin, Al Mamun, Afjal and Nitu (2019), etc. these algorithms are suggested to either detects the objects or recognize them. The detected objects might be different geometrical shapes such as triangular, rectangular, or circular. The applications are extend to include various physical objects appearance such as, intelligent robotics, computer vision, vehicles recognition by status determination, etc. as explained by Rege, Memane, Phatak and Agarwal (2013). The main emphasis of this work is on its genetic points (elements) that permit the system to determine the centre of each particular object with no earlier information, to simplify the process of recognizing objects.

Comprehensive review of shape analysis techniques is available in reference Kaiser, Zepeda and Boubekeur (2019), Loncaric (1998), Nayagam and Ramar (2015), and Hemalatha, Muruganand and Maheswaran (2014). In this work, a geometric object detection and recognition technique has been proposed in which a GA was applied to fill the shape s in the input image after performing segmentation preprocessing method, then the edge detection schemes and statistical methods as explained by Hasan and Mishra (2012) are utilized to classify the detected objects, determine the type of the detected object, and counts the number of detected objects, or even a data structure method as shown by Ibraheem and Hasan (2020). The rest of the paper is organized as follows, section 2 discusses the related work, section 3 describes the proposed approach and its phases, section 4 presents the experimental results, and finally conclusion and future work are explained in section 5.

Related Works

Lots of investigates have been committed to discover object recognition problems. The PicSOM is an amazing application of artificial intelligence and image substance recognizable proof as explained by Vries (2006). Shape depiction strategies are classified into two strategies: form-based strategies and region-based strategies. For each strategy, there are two diverse approaches inside, structural approaches and global approaches as explained by Kothiya and Mistree (2015), and Pham (2018).

Many of artificial algorithms were initially created for visual pattern recognition. Feed forward systems like Adaline and the Perceptron were two early adaptations that served this objective as demonstrated by Vries (2006).
In Pham (2018), authors presented a quick object shape locating strategy based on the geometry of Delaunay triangulation, which can consequently identified, captured the boundary point of the object shape and surrendered it to cover picture object shape. GA has been used for image segmentation as natural evolutionary method by Singh and Garg (2014). Deep learning-based image segmentation is presently immovably set up as a strong device in picture division. It has been broadly utilized to partitioned homogeneous zones as the primary and basic component of conclusion and treatment pipeline by Hesamian, Jia and Kennedy (2019). Authors Crandall, Felzenszwalb and Huttenlocher (2006) applied statistical models are used where a part-based object recognition is suggested by parameterizing according to the presented degree of spatial structure of the object, the recognized objects are motorbikes, faces and airplanes.

Authors Anwar, Kamal, Ghany and Elmahdy (2015) presented an algorithm for ear recognition using geometrical features extraction for biometrics recognition. The overall system use the snake model to detect human ear then some preprocessing and noise removal filter were applied then the image is converted into binary format, after that largest boundary of the shape is calculated and create a distance matrix for feature extraction which would be used for shape classification by performing nearest neighbor distance. 3D geometry shapes are introduced by Liebelt and Schmid (2010) from synthetic into a 2D part-based appearance detection method. While the researchers Hammond, Logsdon, Paulson, Johnston, Peschel, Wolin and Taele (2010) presented an application that permits, military commanders to hand-draw may of Military course-of-action (COA) diagrams that allow to draw many battle scenarios symbols directly on a digital map.

Researcher Moscatelli (1994) suggested two fundamental approaches for performing recognition and labelling task:

a) Matching of an unequivocal geometric portrayal to an image in order to discover an Instance of the object pattern within the image as well as its location.

b) Basic knowledge for matching depiction is the database of object models, and its indexation that increments the speed of recovery.

The first system generates geometric models of objects from a set of images. The second and the third ones are oriented toward operationalization of object models. Their roles are to speed up model recognition engines by providing an efficient indexation and an ordering of the models. The fourth system was devoted to target recognition; it is based on a multi-strategic learning and acquires both target models and indexation knowledge in an increasing way. Domain-Constraint Image Interpretation in which constraints between
different objects are used to identify them in an image. Basic information for the domain-constraint approach is composed of the imperatives on the objects' depictions as well as on the relations between scene objects as demonstrated by Jorge and Fonseca (1999). We might outline this approach by an information procurement device that points at obtaining information for naming images, i.e., relegating labels to the objects portrayed in complex images as demonstrated by Moscatelli (1994).

![Proposed system block diagram](image)

**Proposed System Formulation**

The proposed system consists of preprocessing, object segmentation and detection, feature extraction and finally classification as explained below and shown in Fig. 1.

1. **Preprocessing**

In this phase, some input images may require a smoothing operation; this is performed efficiently using Gaussian filter, as shown in the following equation:

\[
G(x, y) = \left(\frac{1}{2\pi\sigma^2}\right) e^{-\frac{(x^2+y^2)}{2\sigma^2}}
\]  

(1)

2. **Object Detection**

In this stage, an arrangement is utilized to deliver as much data as conceivable from an environment, multi-components pictures. Within the final decade, multi-components pictures division has gotten an extraordinary deal of consideration for farther detecting and mechanical applications since it essentially makes strides the segregation and the recognition capabilities compared with gray-levels pictures segmentation strategies as shown by Chabrier, Rosenberger and Laurent (2008).

Selecting the correct edge detection Handling and analysis is the center of the work. The discovery of standard geometric features like triangles, squares, rectangles, and polygons
in computerized pictures is an imperative practice in image investigation and computer vision applications such as programmed assessment and gathering. Different strategies for standard geometric shape discovery have been inquired about to date. The Hough Change (HT) method, one of the foremost well-known methods, has been utilized broadly to extricate expository highlights, such as straight lines, circles, and circle since of its vigor against clamor, clutter, protest imperfection, shape mutilation as demonstrated by Kumar, Pandey, Pal and Sharma (2016).

3. Modeling Object Shape

In this stage, the object shape morphology was modeled using the adopted Genetic Shape Fitting using Variable Length Chromosome (GSF_VLC) presented by Khan and Ibraheem (2013), and Ibraheem and Khan (2014), which is used to capture full hand morphological representation by strengthening the chromosome length increasingly, and to conclude the fitted length of the chromosome. Fig. 2 shows a portray description of the applied algorithm.

![Figure 2 Final individual result for pixels distribution model on the object. (a), rectangle. (b). circle](image)

The applied algorithm makes it certainly effective to extract appearance-based features and spotting the fundamental features relevant for classification purposes. Besides, it is useful for object center extraction.

**Features Extraction**

After isolating the geometric objects in the image, and the maximum Euclidean distance is calculated between each pixel and all objects' pixels. Then all the computed distances are arranged in an descending order of a matrix as demonstrated by Anwar, Kamal, Ghany and Elmahdy (2015) which is performed for one object, but for detecting multiple objects in the image, a checking for the difference between the most top distances is performed so that
the difference between them should be converging in their values, and when there is a gap in the value is discovered, then the counting is stop and determines the number of borders for that object. The number of borders for that image is considered as a feature for that object, after that the recognition process is applied to discover the type of that object. The highest distances calculated to identify the object, is by applying Euclidean equation and K nearest neighbour as shown in equation (3).

For example, Distance_Length D1 refers to the first computed value as a distance between two pixels (the center pixel and the edge pixel) with coordinates \((x_c, y_c)\) and \((x_1, y_1)\) respectively in matrix's distance, Distance_Length D2 refers to the second computed value in matrix's distance, Distance_Length D3 refers to the third computed value in that matrix, and so on as explained in Fig. 3. In summarization, the feature vector is consisted of maximum five values:

- Distance_Length D1
- Distance_Length D2
- Distance_Length D3
- Distance_Length D4
- Distance_Length D5
Figure 3 Applying the suggested algorithm. (a), and (c), the algorithm generates all the possible distances between the center and the object contour for rectangle and circle. (b), and (d), after applying the algorithm only the highest distances considered to identify the object

Object Classification

According to the extracted features vector, the classification process is performed by Ibraheem (2016), and Teutsch, Berndt, Trostmann and Weber (2013), two types of classifiers are used, which are, nearest neighbor (Euclidean) and K nearest neighbor (minimum absolute difference).

\[ D(x, y) = \sum_{i=1}^{n} |x_i - y_i| \]  

(2)

1. Suggested Algorithm

Geometric Shape identification algorithm steps for 2-D Object:

Isolate the object from the background using the GA as referred by Khan and Ibraheem (2013).
1. Extract the edges of the isolated object.
2. Determine the center $c$ of the object by calculating the mean of the points inside the object.
3. Compute the farthest point from the center $c$.
4. Compute the farthest point comparing with the center $c$ of the object $D_c$ using Pythagorean Theorem which defines the distance between these two points, as shown in Fig. 3.

$$D_c = \sqrt{(x - x_c)^2 + (y - y_c)^2}$$

(3)

Where $D_c$ represents the Distance of the center point.

1. Compute the second farthest point (side) from the center of the object $D_{ca}$, and the point extracted previously in step (4) using Pythagorean Theorem $D_c$, Fig. 4 shows Pythagorean Theorem.

$$\text{Distance} = \sqrt{(x - x_c)^2 + (y - y_c)^2} + \sqrt{(x - x_{ca})^2 + (y - y_{ca})^2}$$

(4)

2. Repeat the algorithm steps with adding the calculations of the new points.
3. The algorithm stops when the distance of the new calculated point comparing with the nearest computed point is less than the distance of the calculated point from the center.

In step (5), discovering the new farthest point (which will represent the new boundary of any flanged shape like triangle, rectangle, etc.), with the application of Pythagorean theorem applied in step (4) and step (5).

![Figure 4 Pythagorean theorem between two points](image)

**Experimental Results**

The proposed algorithm tests each detected shape in the input image and measure the accuracy. Multiple shapes in the input also are detected successfully. Fig. 5 shows different input shapes, Fig. 6 demonstrates the results of performing modeling process for multiple objects, while Fig. 7, demonstrates the output of identifying and classifying objects using
suggested algorithm where a labeling is used to identify each geometrical object in the input image. The suggested system achieved high accuracy around 98.3%, and an average computational time 0.521 sec., Table 1 shows the number of points in each geometric shape and the number of selected points.

**Table 1 Shows the number of points in each geometric shape and the number of selected points**

<table>
<thead>
<tr>
<th>Shape name</th>
<th>Length of object’s side</th>
<th># Points on the edges of the shape</th>
<th># Selected points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square</td>
<td>44</td>
<td>176</td>
<td>4 (all the points are equal in distance)</td>
</tr>
<tr>
<td>Rectangular</td>
<td>44x82</td>
<td>252</td>
<td>4 (each two points are equal in distance)</td>
</tr>
<tr>
<td>Polygon</td>
<td>44 for each side</td>
<td>220</td>
<td>5</td>
</tr>
<tr>
<td>Triangular</td>
<td>44x 50</td>
<td>1100</td>
<td>3</td>
</tr>
<tr>
<td>Circular</td>
<td>50x 56</td>
<td>1963</td>
<td>1</td>
</tr>
</tbody>
</table>

Furthermore a comparison among various previous methods according to the type of the objects utilized and the method applied for identification process is presented in Table 2.

**Table 2 Comparison among various previous methods**

<table>
<thead>
<tr>
<th>Reference No.</th>
<th>Type of recognized objects</th>
<th>Method applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vries (2006)</td>
<td>Recognize free shapes, 3D-objects</td>
<td>Both supervised techniques, (feed-forward networks with error back-propagation), and unsupervised techniques, (self-organizing map)</td>
</tr>
<tr>
<td>Hoang Dat Pham Pham (2018)</td>
<td>Recognize free shapes, shape descriptors, Tracking the persistence of a shape over sequences of image</td>
<td>Contour-based shape descriptor, region-based shape descriptor, geometry-based shape descriptors</td>
</tr>
<tr>
<td>Anwar, Kamal, Ghany and Elmahdy (2015)</td>
<td>Ear human object</td>
<td>snake model, canny edge filter largest boundary</td>
</tr>
<tr>
<td>Liebelt and Schmid (2010)</td>
<td>3D geometry from synthetic CAD models into a 2D</td>
<td>part-based appearance detection method</td>
</tr>
<tr>
<td>Kumar, Pandey, Pal and Sharma (2016)</td>
<td>2-D Shapes</td>
<td>Calculate the area of the object of a specified shape</td>
</tr>
<tr>
<td>Proposed method</td>
<td>2-D geometric shapes</td>
<td>Genetic Algorithm, and statistical methods</td>
</tr>
</tbody>
</table>
Figure 5 Multiple different input shapes

Figure 6 Results of applying modeling process for multiple objects

Figure 7 Output of identifying and classifying objects using suggested algorithm
We have depicted a straightforward and fast recognizer for rudimentary geometric shapes. The results utilizing this recognizer reveal that the output identified recognized objects to make it usable for various input.

**Conclusions and Future Works**

For any shape that has closed bend in an image, it is simple to calculate the centroid of the object. In case that the shape could be any geometric shape, it is possible to discover its geometrical center, and after that calculated the negligible distance from the border points to the calculated center. In this work, objects recognition method have proposed based on genetic algorithm (GA) based technique to determine the form of the dominant object after performing proper segmentation preprocessing method. Subsequently, the output of image segmentation is applied for feature extraction and object recognition stages that can be utilized in image processing, computer vision fields, etc. An effective classification algorithm was performed to improve the segmentation results.

The algorithm proposed in this work is simple, effective for analyzing the shapes of the objects. These outcomes will be a premise for our future work by applying some statistical calculations methods and artificial algorithms such as Gaussian classifier and deep learning computing algorithms, support vector machine (SVM) or neural networks (NN).

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

**Author Contributions**

The contribution of Mokhtar M. Hasan, Noor A. Ibraheem, and Noor M. Abdulhadi in this research article are done by Conceptualization, methodology, software, validation, formal analysis.

**References**


https://www.academia.edu/19611602/A_Sketch_Recognition_System_for_Reco


http://www.ajournal.co.uk/pdfs/BSvolume10(1)/BSVol.10%20(1)%20Article%201.pdf


