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*An algorithm to Detect Geometrical Object in the  
Image*

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

{وَمَا تَوْفِيقِي إِلَّا بِاللَّهِ عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيبُ}

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**An algorithm to detect geometrical object in the image**

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## ***ABSTRACT***

The digital image has touched most aspects of modern life, including entertainment, communication, and scientific research. There has been much recent interest in image analysis, including such topics as detection of object, image segmentation, and reconstruction of two- or three-dimensional image. One of the major challenges in computer vision is to extract the objects automatically from an image. The objects in this thesis, are supposed to be square shape, this is because the motivation of this work is to determine some features that may be appeared as square shape in image. A wide range of algorithms have been proposed to detect geometrical objects in images. However, most of the current approaches are basically (purely) based on location, size, and number of objects in the image to extract object in image.

This work presents an algorithm which combines from some of statistical approaches and image analysis techniques.

This algorithm has been implemented to arrive at the major objectives in this thesis. The algorithm contains of four steps are; segmentation method, Scale-Space method, median filter method and projection method. The algorithm has been evaluated by using simulated data, and yields good results, and then it has been applied to real data.

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## *Dedication*

- *To my dear mother and dear father.*
- *To my sisters and their husbands.*
- *To all friends of statistics department.*

# *Contents*

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	General view .....	1
1.2	Objective and methods.....	2
1.3	Motivation.....	7
1.4	Thesis overview.....	8
<b>2</b>	<b>Some Basic Definitions</b>	<b>10</b>
2.1	Introduction.....	10
2.2	Definitions.....	10
<b>3</b>	<b>Some Methods of analysis</b>	<b>23</b>
3.1	Introduction.....	23
3.2	Segmentation method.....	23
3.3	Scale-space method.....	32
3.4	Median filter method.....	37
3.5	Projection method.....	39

<b>4</b>	<b>Proposal algorithm</b>	<b>42</b>
4.1	Introduction.....	42
4.2	Methods of the proposal algorithm.....	42
4.3	Algorithm.....	45
<b>5</b>	<b>Applications</b>	<b>47</b>
5.1	Introduction.....	47
5.2	Simulated data.....	47
5.3	Application to simulated data.....	49
5.4	Application to real data.....	60
<b>6</b>	<b>Summary and conclusions</b>	<b>69</b>
6.1	Summary.....	69
6.2	Conclusions.....	69
6.3	Future work.....	70

## **References**

## List of Figures

1.1	Image of farm in Tripoli.....	8
2.1	Saja image and graphic form to matrix of Saja image ...	12
2.2	Binary image.....	13
2.3	Gray –level image.....	13
2.4	Multicolor image .....	14
2.5	First order neighborhood.....	15
2.6	Pixel $p$ at the border of image .....	15
2.7	Second order neighborhood.....	16
2.8	(a) Original image of Tiger; (b) Image segmented into regions.....	16
2.9	Diagram to resolution of image.....	18
2.10	(a) High contrast image; (b) Low contrast image....	19
2.11	(a) Low brightness image; (b) High brightness image ..	19
2.12	Salt and Pepper noise.....	20
2.13	(a) Histogram of Gray image for Doaa and her father; (b) Gray –level image Doaa and her father.....	22
3.1	Histogram to Gray-level of Doaa and her father image...	24
3.2	(a) Gray-level image of Saja picture; (b) Histogram of Saja image; (c) thresholded image.....	29
3.3	Local thresholding.....	31
3.4	Simulated density curve with three levels of bandwidth ; (a) Under-smoothing ; (b) optimum smoothing; (c) over-smoothing..	35

3.5	Saja picture with three different scales; (a) Large distance; (b) From close distance; (c) Shorter distance.....	36
3.6	(a) Isolated point (pixel) ; (b) Sorting of values ; (c) Replacing isolated value (pixel) with median .....	38
3.7	Image of object and profile results from horizontal and Vertical projection.....	40
3.8	Reconstructed image.....	41
4.1	Diagram of proposal algorithm.....	44
5.1	Simulated data.....	49
5.2	Binary image of simulated data.....	50
5.3	Noise image of simulated data.....	51
5.4	Density curve of noisy image.....	51
5.5	Scale-Space diagram for data.....	52
5.6	Optimum smoothing density curve .....	53
5.7	Binary image with Salt-and-Pepper noise.....	53
5.8	Filtered image.....	54
5.9	Vertical projection.....	55
5.10	Horizontal projection.....	56
5.11	Reconstructed dataset.....	58
5.12	Image represents square shape in farm .....	60
5.13	Gray-level image to the farm image.....	61
5.14	Density curve of noisy image.....	61

5.15	Scale-Space diagram for data.....	62
5.16	Smoothed histogram.....	63
5.17	Thresholded image.....	63
5.18	Filtered image.....	64
5.19	(a) Vertical projection; (b) Horizontal projection.....	65
5.20	Reconstructed square object in the image.....	68

# *Chapter 1*

## *Introduction*

### *1.1 General view*

Images are the source of the information in many areas of scientific enquiry. Images are produced by a variety of physical devices, such as cameras, X-ray devices, electron microscope, radar, and ultrasound, etc. These images are used for a variety of purposes, including entertainment, medical, business(e.g. documents), industrial, military, acts of civilian , security and scientific. The last decade has seen a considerable growth interest in the statistical methods of study images, the tremendous development in these fields of application of statistical analysis on images, led to innovative powerful techniques in image processing and image analysis by statistics. Goudail (2004)

A digital image can be considered as a matrix of pixels (image elements), each pixel is represented by a numerical value. Statistical methods are able to extract information from digital

image data, because of that, statisticians became interesting in developing techniques to handle the highly structured data of images and dealing with new challenges in image processing and image analysis. In general, statistical methods have been used by many researchers and in several papers in image analysis and image processing studies, For instant, Besag(1986) who presented algorithm for statistical image analysis, Otsu(1979) proposed threshold selection method by using gray-level histogram, further references on the topic can be found in the works by Geman and Geman (1984) and Mardia(1998).

## ***1.2 Objective and methods***

The aim of this work is to identify geometrical shape object in an image. In this research the object is considered to be as a square shape. The identification requires find three characteristics, which are number, size, and location of the object.

This thesis presents an algorithm contains methods and steps to achieve the goal of this work. ***Segmentation method*** has been suggested to extract object from the background. ***The Scale-Space method*** is suggested to get optimum smoothing density curve (Histogram) which is needed to obtain optimum thresholding. The thresholded image may contains some isolated pixels, then ***Median filter method*** is proposed to remove these

unwanted pixels. Finally, *projection method* has been proposed to recognize the object from the image.

*Segmentation method* is first step in the proposal algorithm. Image segmentation is often described as the process that subdivides an image into its constituent parts and extracts those parts of interest (objects). It is one of the most important steps in image analysis because the segmentation results will affect all the subsequent processes of image analysis. Segmentation should stop when the object of interests in application have been isolated.

Typical computer vision applications usually require an image segmentation algorithm as a first procedure. At the output of this stage, each object of the image, represented by a set of pixels, is isolated from the rest of the image. The purpose of this step is that objects and background are separated into non-overlapping sets. Usually, this segmentation process is based on the image gray-level histogram. In that case, the aim is to find a critical value or threshold. See Tobias and Seara (2002) for more details.

Thresholding is one of the widely methods used for image segmentation. It is useful in discriminating the foreground from the background. By selecting an adequate threshold value  $T$ , the gray level image can be converted into binary image. The binary

image should contain all of the essential information about the position and shape of the objects of interest (foreground).

The advantage of obtaining a binary image is that it reduces the complexity of the data and simplifies the process of recognition and classification. The most common way to convert a gray-level image to a binary image is to select a single threshold value ( $T$ ). Then all the gray level values below this  $T$  will be classified as white (0), and those above  $T$  will be black (1).

The segmentation problem becomes one of selecting the proper value for the threshold  $T$ . A histogram-based technique (A frequent method) is used to select  $T$  by analyzing the histograms of the type of images that want to be segmented. The ideal case is when the histogram presents only two dominant modes (peaks) and a clear valley (bi-modal). In this case the value of  $T$  is selected as the valley point between the two modes. In real applications histograms are more complex, with many peaks and not clear valleys, and it is not always easy to select the value of  $T$ . The histogram based-technique is dependent on the success of the estimating of the threshold value that separates the two homogenous region of the object and background of an image. For more detail see Khamitkar and Kalyankar (2010).

Glasbey and Horgan (1995) applied segmentation method to segment the muscle fibers image, by using manually selected thresholds, which one of the segmentation techniques.

*Scale-Space method* is second step in the proposal algorithm. Scale-space theory is a framework for multi-scale image representation, which has been developed by the computer vision community. The idea is to handle the multi-scale nature of real-world objects, which implies that objects may be perceived in different ways depending on the scale of observation. Scale is inherently tied up with information. Optimal information extraction can be carried out at certain scales. A simple example is the concept of a branch of a tree, which makes sense only at a scale from, say, a few centimeters to at most a few meters, it is meaningless to discuss the tree concept at the nanometer or kilometer level. At those scales, it is more relevant to talk about the molecules that form the leaves of the tree, and the forest in which the tree grows, respectively. This fact, that objects in the world appear in different ways depending on the scale of observation, has important implications if one aims at describing them, it shows that notion of scale is of utmost importance, Lindeberg (1994).

Curve estimation using nonparametric smoothing techniques is an effective tool for important structures from noisy data. Chaudhuri and Marron (2000), studied nonparametric curve estimation from the view point of the scale-space theory, they focused simultaneously on a wide range of values for smoothing parameter, since different levels of smoothing may reveal different useful information.

The third step in the algorithm is *the median filter*, the median filter is digital filtering technique, often used to remove noise. The median filter has been used extensively for image noise reduction and smoothing by Tukey in the 1970s. The acquisition or transmission of digital images through sensors or communication channels is often interfered by impulse noise. It is imperative, and even indispensable, to remove these corrupted pixels to facilitate subsequent image analysis operations, such as image segmentation and object recognition. Eng and Ma (2001) for more detail.

Lukac (2003) used new adaptive vector median filter scheme for impulse noise (salt and pepper noise) suppression and noise reduction, this scheme yields promising results. The median filter was once the most popular nonlinear filter for removing impulse noise, because of its good denoising power and computational efficiency. This method based on, first identify possible noisy

pixels and then replace them by using median output, this scheme is good because the uncorrupted pixels will not be modified, see Chan and Nikolova (2005) for more detail.

The next method in the algorithm is a *projection method*, this approach has been applied as finally step in the algorithm. Projection method is used to recognize geometrical object in the image after the preprocessing stages done, where a projection is a sum of values along image rows (and columns). Projections are widely used in computer vision algorithms because they give an integral description of images, which can help to detect simple objects. And this method gives a profile of image. Balazs(2007).

### ***1.3 Motivation***

The main goal behind this work is to detect geometrical object in image. This goal is motivated from an image of a farm, as shown in Figure 1.1, this farm in Ian-Zara in Tripoli city, it has a black square shape. This image has been taken from *the googleEarth*.

The ability to collect imagery of the same area (object) of the earth's surface at different periods of time is one of the most important elements, to monitor the changes that may be happened on that object. Also detect the object which has square shape will be useful to detect new building in the cities.



Figure (1.1): Image of farm in Tripoli

## ***1.4 Thesis overview***

This thesis is organized as follows:

Chapter 2 presents briefly some definitions and illustrates some concepts related to image processing and image analysis. Chapter 3, contains methods which will be needed in proposal algorithm, and explains these methods with examples.

Chapter 4, presents proposal algorithm which will be applied to attain the objective from this work. The algorithm is combined of methods that explained in chapter 3. Chapter 5, includes applications to the algorithm. Firstly, a simulated data is

used to evaluate the suggested algorithm, then the algorithm is applied to real data. Finally, conclusion of this work and recommendation for future work are presented.

## ***Chapter 2***

### ***Some Basic Definitions***

#### ***2.1 Introduction***

Digital images are now presented in many human activities, such as medicine diagnostic, remote sensing for earth monitoring, scientific instrumentation for astronomy or biological research and etc. Because that study digital image is important, where operations on digital images can be classified into two categories according to the objective, they are digital image processing and digital image analysis.

There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other. However, a useful paradigm is to consider three types of computerized processes in this continuum: low-, mid-, and high-level processes. *Low-level* processes involve primitive operations, such as image preprocessing to reduce noise, contrast enhancement, and image sharpening. A low-level process is characterized by the fact that both its inputs and outputs typically are images. *Mid-level* processes on images involve tasks such as segmentation (partitioning an image into regions

or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects. A mid-level process is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images (e.g., edges, contours, and the identity of individual objects). Finally, *high-level* processing involves “making sense” of an ensemble of recognized objects, as in image analysis, and, at the far end of the continuum, performing the cognitive functions normally associated with human vision. Gonzalez (2008)

This chapter presents definitions for some terminology and concepts related to digital image.

## ***2.2 Definitions***

*Image processing*: Digital image processing is being used in many domains today, which is process of improving the quality of an image, where a variety of methods now exist for removing image degradations and emphasizing important image information. In image processing it is quite common to use simple statistical descriptions of images and sub-images.

*Image analysis*: Image analysis is simply the extraction of information from images, involves investigation of the image data for a specific application. Wherein, the image is converted

to an array of small integers. In the image analysis input generally are images, but its outputs are attributes extracted from those images. Image analysis can provide several measures of an object's structure by defining its characteristics in terms of area, perimeter, and texture.

*Digital image:* Digital image can be defined as a two dimensional function,  $f(x,y)$ , where  $x$  and  $y$  are spatial coordinates and the value of  $f$  at any pair of coordinates  $(x, y)$  is called the intensity of the image at that point  $(x, y)$ .

Note that a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as image elements (picture elements).

Figure 2.1 shows image of little girl (Saja), which has been taken by 8 mega pixels camera. This image is converted into two dimensional matrix  $M$ . the matrix is  $Z \times k$  dimensions.

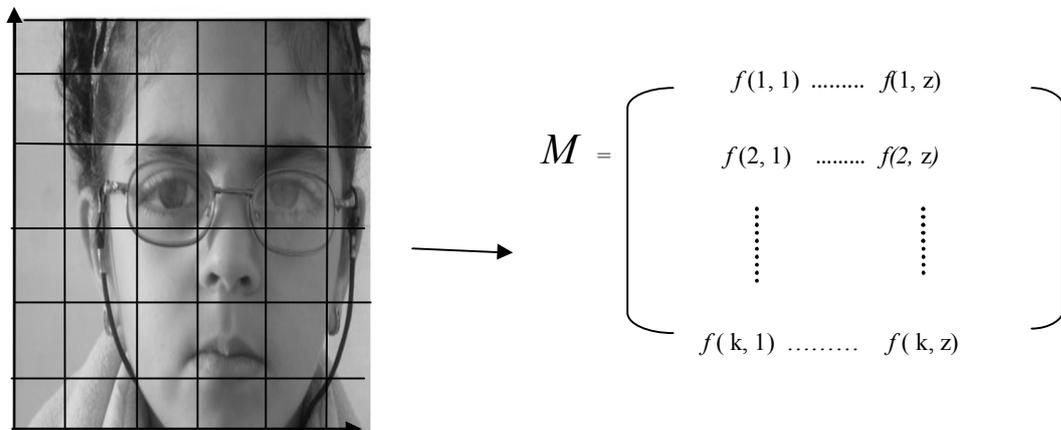


Figure 2.1: Saja image and graphic form to matrix of this image

A digital image has different types, some of them are:

*Binary image:* This is the simplest type of image. The image is called a binary image if it contains two colors (black and white) without any other levels, as in Figure 2.2.



Figure 2.2 : Binary image

*Gray-level image:* The image is called a gray-level image if it contains the gray level colours between black and white that means between 0 and 1 there are approximately 256 levels of gray, see Figure 2.3.



Figure 2.3 : Gray-level image

*Multicolor image:* When the image contains all the colors from 0 to 255 then it could be called as a multi color image. Figure 2.4 represents multicolor image.



Figure 2.4 : Multicolor image

*Pixel:* This term comes from two words, which are *pictures* and *element* (Contraction of pictures element), pixel is smallest unit of information in image, each pixel contains number which describes intensity image, more pixels more details of the image is clear. The digital image's pixel is a unit of measurement for resolution or size of a digital image.

### *Neighborhood*

*First order neighborhood:* A pixel  $p$  at coordinates  $(x, y)$  has four *horizontal* and *vertical* neighbors whose coordinates are given by

$$(x+1, y), (x-1, y), (x, y+1), (x, y-1)$$

This set of pixels, called the first order neighborhood, it is denoted by  $N_4(p)$ . Each pixel is a unit distance from  $(x, y)$ .

Figure 2.5 shows first order neighborhood.

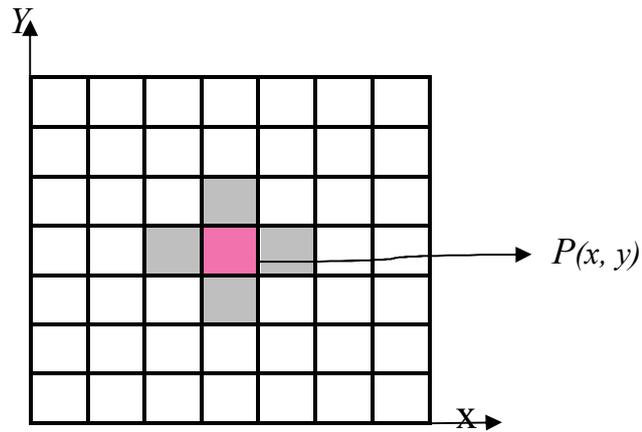


Figure 2.5: First order neighborhood

Some of the neighbors of  $p$  may lie outside the digital image if  $(x, y)$  is on the border of the image, Figure 2.6.

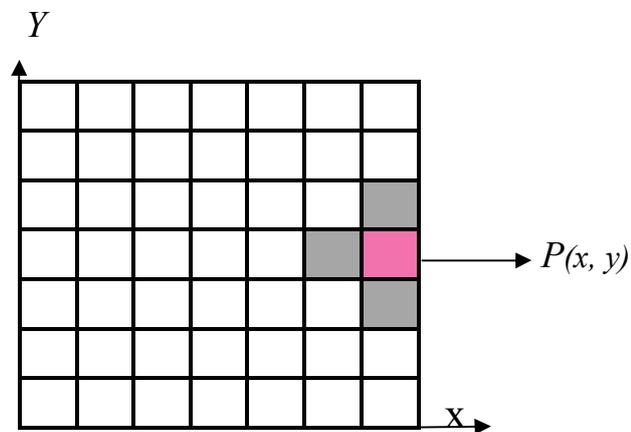


Figure 2.6: pixel  $p$  at the border of image

*Second order neighborhood:* The four diagonal neighbors have coordinates define as

$$(x+1, y+1), (x+1, y-1), (x-1, y+1), (x-1, y-1)$$

These points together with the first order neighborhood, are called the second order neighborhood, denoted by  $N_8(p)$ , Figure 2.7 shows second order neighborhood.

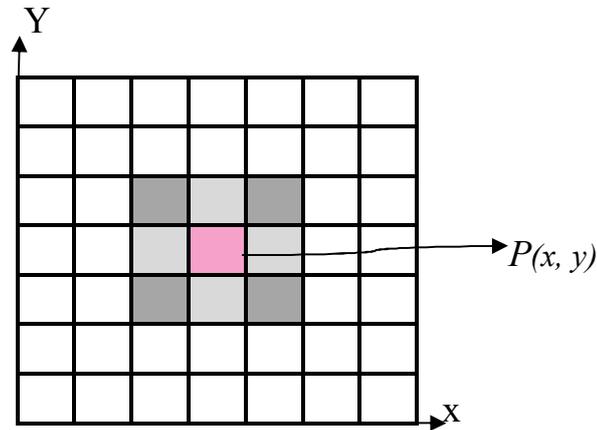


Figure2.7: Second order neighborhood

*Region:* is a group of connected set of pixels with similar properties, it is important in interpreting an image because they may correspond to objects or parts of object in image. Figure 2.8(a) represents the original image of Tiger, (b) shows the image of Tiger is partitioning into regions done often by using gray-levels of the image pixels.

(a)

(b)

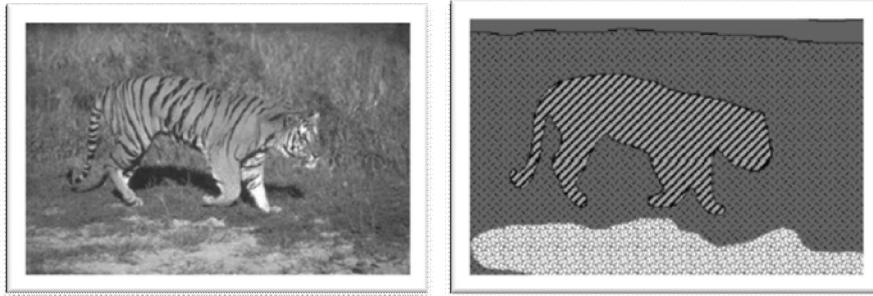


Figure 2.8(a); Original image; (b) Image segmented into regions

*Foreground and Background:* The pixels in any image are classified into two groups. One group consists of all pixels that falls inside all the objects in image, are called foreground. While the other group includes the rest is called the background.

*Intensity:* The value associated with a pixel in a digital image, representing the brightness of the image at that point, is called intensity.

*Resolution:* This term often refers to the number of pixels in an image, it used to display an image. Resolution is sometimes identified by the width and height of the image. For example, an image that is 24pixels wide and 20 pixels high (24×20) contains 480 pixels, higher resolution means more image detail or mean that more pixels are used to create the image. this image has been taken from *Featurepics.com*

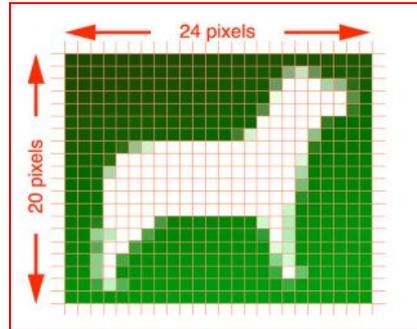


Figure 2.9: Diagram to resolution of image

Without loss of generality, it will be assumed that the image is rectangular, consisting of  $x$  rows and  $y$  columns, the resolution of such an image is written as  $(x \times y)$ .

*Contrast:* Contrast in an image is determined by the difference between light (white) and dark (black) areas in an image, high contrast images will have high levels of black and white, while fewer gray values as in Figure 2.10 (a), low contrast images have many pixels stacked together in the mid-tone (similar shades of gray), see Figure 2.10 (b). Increasing contrast increases the apparent difference in lightness between lighter and darker pixels.



Figure 2.10(a): High contrast image ;(b): Low contrast image

*Brightness* makes the image lighter or darker overall. Low brightness will result in dark tones as in Figure 2.11 (a), while high brightness will result in lighter Figure 2.11(b) shows high brightness.



Figure 2.11(a): Low brightness image ; (b): High brightness image

*Noise in image:* Digital images are composed of millions of pixels that are captured by a camera that images might contain noise, image noise is a random, usually unwanted. Caused missing information in a digital image, as a result of such

problems as variation in brightness or sudden transitions inherent in digital representation of color, these responses degradation of quality of images.

There are many types of noise in image analysis, one of these types are

*Salt and pepper noise* are a form of noise typically seen on images. It represents itself as randomly occurring white and black pixels. An image containing salt-and-pepper noise usually have dark pixels in the bright regions and bright pixels in the dark regions. Salt-and-pepper noise sometimes called "impulsive" or "spike" noise, Figure 2.12 illustrates the salt and pepper noise.



Figure 2.12: Salt and Pepper Noise

## ***Pattern recognition***

Pattern recognition as a field of study developed significantly in the 1960s. The goal of pattern recognition is classification of objects into classes or categories. The applications of pattern recognition can be found everywhere. Examples include fingerprint verification, face recognition, Chromosome shape discrimination, texture discrimination, speech recognition, and etc. The design of a pattern recognition system should consider the application domain. A universally best pattern recognition system has never existed.

## ***Object recognition***

The identification of objects in the images could be by their shapes, color, surface texture, perimeter or other attributes. This process of identifying objects in image is called ***object recognition***.

An object in an image is formed by a set of geometric structures, extracting the objects automatically from an images one of the major challenges. Determining the objects from the image could be useful in many areas such as medical, geology, etc.

## *The histogram*

In digital image processing context, the histogram of an image normally refers to a histogram of the pixel intensity values. This histogram is a graph showing the number of pixels in an image at each different intensity value found in that image.

Gray -levels there are 256 different possible intensities, and so the histogram could graphically display 256 numbers showing the distribution of pixels amongst those gray levels values. Figure 2.13(a) shows the intensity histogram for the image in Figure 2.13 (b).

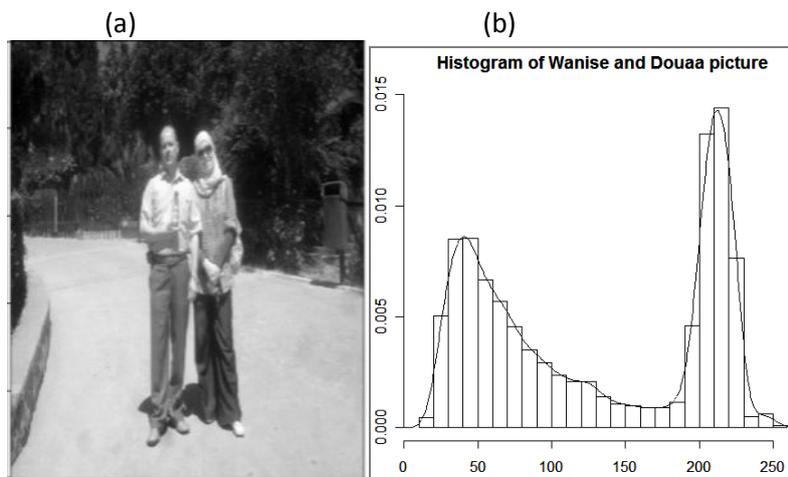


Figure 2.13(a) : Gray-level image  
For Doaa and her father

(b) Histogram of Gray image  
Doaa picture and her father

The histogram provides a convenient summary of the intensities in an image, and histograms can be used to decide what value of threshold should be used when converting a gray-level image to a binary one.

# ***Chapter 3***

## ***Some Methods of analysis***

### ***3.1 Introduction***

As mentioned early, this thesis seeks to present an algorithm to detect the geometrical object in the image, this algorithm will be built by using some methods. It is helpful to explain the methods, which may be needed in this thesis in the following chapters. These methods are explained with examples in this chapter.

### ***3.2 Segmentation:***

This method, focus on partitions a digital image into disjoint (Non-overlapping) regions, each of which typically corresponds to one object or parts of object in image. Once isolated, these objects can be measured and classified, see Qiang and Castleman(2008) for more details.

Some of the practical applications of image segmentation are; Medical imaging, Face recognition and Fingerprint recognition,

Locate objects in satellite images (roads, cars, buildings, stadiums,..) and other applications.

The purpose of image segmentation is to subdivide an image into meaningful non-overlapping regions, which would be used for further analysis. Errors in the segmentation process almost certainly lead to inaccuracies in any subsequent analysis.

There are several image segmentation techniques, in this chapter three general approaches to segmentation will be briefly explained; Thresholding, region-based segmentation and edge-based segmentation. Since, the thresholding method will be used in the algorithm in this project, then it will be explained again with details.

One of the most common methods to obtain the thresholding is by using the histogram of the image for locating peaks and valleys. The valleys can be used for selecting thresholds, where the pixels have similar intensity values located in the same region. Figure 3.1. shows histogram to Doaa and her father image, which displayed in Figure 2.3.

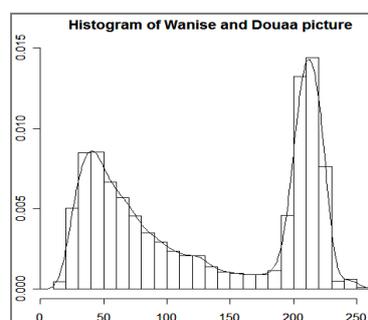


Figure (3.1) Histogram to gray-level of Doaa and her father image.

In addition to this method, there are several other methods to determine the threshold, such as iterative method.

*In the region-based segmentation*, partition an image by grouping similar pixels together into identified regions. Regions are important in image because they typically correspond to objects or part of objects in image. This method considers each pixel in the image and assigns it to a particular region or object.

*In edge-based segmentation*, seek to extract object edges directly, based on identifying the edge pixels located at the edges in the image. Then link them together to establish the required edges of object and all the pixels are non edge collected to construed same region.

### ***Thresholding***

Thresholding essentially involves turning a color or gray-level image into binary image. This is done by allocate every pixel in the image either black or white, depending on their value. The technique that is used to separate the objects of interest from the rest of image are usually referred to as thresholding technique, Huang (1995) presented image thresholding which extracts the object from the background in an input image is one of the most common applications in image analysis.

Zhang (2000), show that thresholding methods can be classified as either global or local thresholding. In global method a single thresholding is used for the entire image, local thresholding allows a different threshold values to be applied at each pixel. Global threshold works well when image contains one object and object's intensity is distinct from background's intensity, but if there is non-constant (contrast) of intensities using one threshold value is difficult to segment that image, local thresholding is more suitable because every threshold is calculated by local information on any region and its surrounding. Thus each pixel belongs only to a single region.

In this project histogram based-thresholding approach has been used, because it is the simplest method in the implementation and yields good result, it used to help for extract the object from the background.

*Global thresholding:* The simplest of all thresholding techniques is to partition the image histogram by using a single thresholding "T", as illustrated in Figure 3.2. Segmentation is then accomplished by scanning the image pixel by pixel and labeling each pixel as object or background, depending on whether the intensity of that pixel is greater or less than the value of T. As indicated earlier, the success of this method depends entirely on how well the histogram can be partitioned.

Qiang and Castleman(2008) applying global thresholding for segmentation of human chromosomes in a microscope image.

Global thresholding can be described mathematically as:

$$G(x, y) = \begin{cases} F, & \text{If } I(x, y) \geq T \\ B, & \text{If } I(x, y) < T \end{cases}$$

Where;

***I(x, y)***: intensity (point) of the image.

***T***: the threshold,

***G(x,y)*** : the thresholded image,

***F***: corresponds to the foreground,

***B***: corresponds to the background.

Thus all pixels at or above the threshold are assigned to the foreground and all pixels below the threshold are assigned to the background.

## How does it work?

Suppose that, the gray-level image  $z(x, y)$ , contains an object. To separate the object in the image, apply the following steps.

- 1- Plot the density curve (Histogram) for the intensities of the gray-level image, and let  $f(x)$  denote to the frequencies.
- 2- Subtract the value  $f(x)$  from  $f(x+1)$ , and store the result in vector  $d_i$ .

$$d_i = f(x+1) - f(x) \quad i=1,2,\dots,n$$

- 3- If  $d_i < 0$  and  $d_{i+1} > 0$ , then store  $x$  in vector  $U$ .
- 4- Number of values in  $U$  represents to the number of thresholds, and the values of thresholds are equal to the values in  $U$ .
- 5- These values in  $U$  will be used to segment the image into different regions.

### *Example 1*

This image of little girl Saja, it has been taken by Sony Camera, which has one object to extracted it, the global threshold will be applied.

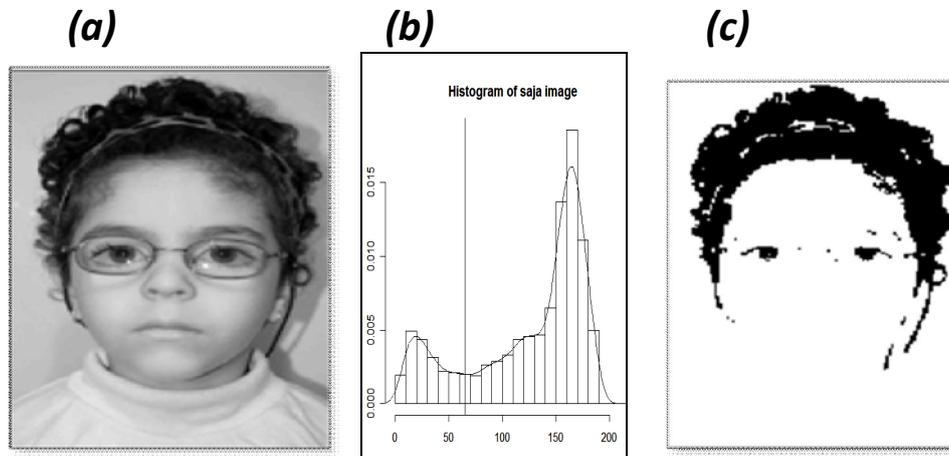


Figure 3.2 (a); Gray-level image of Saja picture;(b) Histogram of Saja image (c) Thresholded image

Figure 3.2(a), presents image of a little girl (Saja), which converted to gray-level image by using MATLAB software. Histogram of the pixels intensities of Saja image plotted in Figure 3.2(b). The minima point in the histogram (valley point) will be corresponded to value of thresholding in horizontal axis, as in Figure 3.2 (b), thresholding is determined at  $T=(65.32)$ .

Then all pixels which have intensity greater than this threshold will set as foreground pixels, otherwise will be defined as background, thresholded image shown in Figure 3.2 (c).

*Local thresholding:* Thresholding is called local or adaptive thresholding when a different thresholds are used for different regions in the image. Due to uneven illumination and other factors, the background gray level and the contrast between the objects and the background often vary within the image. In such cases, global thresholding is unlikely to produce satisfactory results, since a threshold that works well in one area of the image might work poorly in other areas. To cope with this variation, one can use an adaptive, or variable threshold. Liu (2002)

When histogram of image contains many peaks and valleys, in this case local thresholding will be used.

$$G(x, y) = \begin{cases} L_1 & \text{if } T_1 < I(x, y) \leq T_2 \\ B & \text{if } I(x, y) \leq T_1 \\ L_2 & \text{if } I(x, y) > T_2 \end{cases}$$

Where;

$I(x, y)$ : intensity of (any point) the image.

$G(x, y)$  : the thresholded image.

$T_1$  : first local threshold.

$T_2$  : Second local threshold.

$L_1$  : first object class in the image.

$L_2$  : second object class in the image.

$B$ : Background pixels.

Suppose that an image composed of light objects on a dark background to extract the objects from the background local thresholds have been applied to separate these objects from background, then, any point (intensity value)  $(x, y)$  belonging to first object class " $L_1$ ", if  $T_1 < I(x, y) \leq T_2$ , to the other object class " $L_2$ ", if  $I(x, y) > T_2$ , and to the background if  $I(x, y) \leq T_1$ . See Figure 3.3. This image taken from digital image processing book.

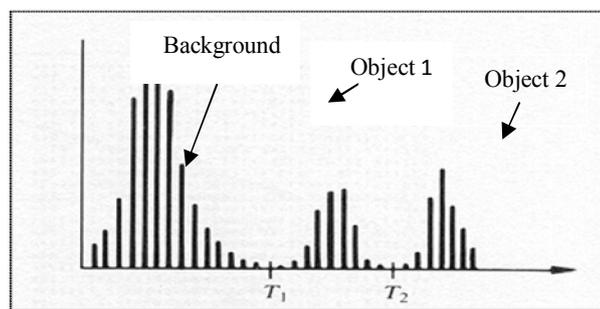


Figure 3.3: Local thresholding

Since this research aims to detect one object in the image, then the global thresholding will be used, this threshold will be determined by using density curve or the histogram. This curve may be unsmoothed, the smoothing curve is needed to find optimum threshold.

Then the Scale-Space method will be presented as a method to get optimum smoothing density curve, the next section explains this method.

### ***3.3 Scale-Space method***

Scale is of vital importance in the analysis and understanding of images. The classic example of a problem of scale. A forest can only be recognized as such within a particular range of distance (scales). If you are too close, the forest appears as a single branch, piece of bark or collection of molecules. From a distance of hundreds of kilometers the forest just becomes a small part of the shape and texture of the landscape. The idea that all information in an image is not contained at only one scale is of crucial importance. It has been shown that to fully analysis the structure of the image is necessary to relate information from a number of different scales. Bradly (1995)

Scale-Space first remanded term by Witikin (1983) who proposed treats scale as a continuous variable rather than a parameter. Lindeberg (1994) used Scale-Space as a basic tool for analyzing structures of objects in image at different scales. The idea is to handle the multi-scale nature of real-world objects, this implies that objects may be perceived in different ways depending on the scale of observation.

The Scale-Space is a family of smooth curve estimates indexed by the smoothing parameter (bandwidth), see Chaudhuri and Marron (2000) for more detail.

In this work Scale-Space method is used to smooth the density curve of noisy image, by choosing optimum smoothing parameter (bandwidth). When smoothing parameter is very small, as a result the density curve appears "undersmoothing", and if smoothing parameter is large yields "oversmoothing"

### **3.3.1 Scale-Space algorithm;**

In many cases the density curve is unsmoothing (wiggly), and this leads to give unimportant minima which cause to detect misleading thresholds. To avoid this, the curve will be smoothed by using optimum bandwidth. The Scale-Space method suggested to find optimum bandwidth. The method is explained as follows:

- 1- Plot the density curve with initial bandwidth (automatic bandwidth ),  $b_a$ .
- 2- Set a limited sequence of bandwidth values with initial bandwidth in the middle of the sequence  $B$ .
- 3- Plot the density curve with each value in the sequence, and count numbers of minima (thresholds), which resulted from each bandwidth, and store the result in vector  $y_u$  .
- 4- From the sequence  $B$ , find the bandwidth values corresponding to the values, which has most frequencies in the vector  $y_u$  , store the results in vector  $B_u$ .
- 5- The optimum bandwidth is obtained as a median of values in  $B_u$  .

The optimum bandwidth is used to plot optimum density curve. Then optimum threshold will be obtained from the optimum density curve. (Elramly 2005)

### *Example 2*

This example presents simulated histogram (Density curve), with three levels of bandwidth, to faithful data from R software. The first bandwidth very small, it is equal to 0.03 and it gives undersmoothing curve, as shown in Figure 3.4(a). The curve in Figure 3.4(b) smoothed by using a optimum bandwidth which equal to 0.33 and this curve has two peaks and one valley. Figure 3. 4(c) shows oversmoothing curve with large bandwidth which equal to 2.

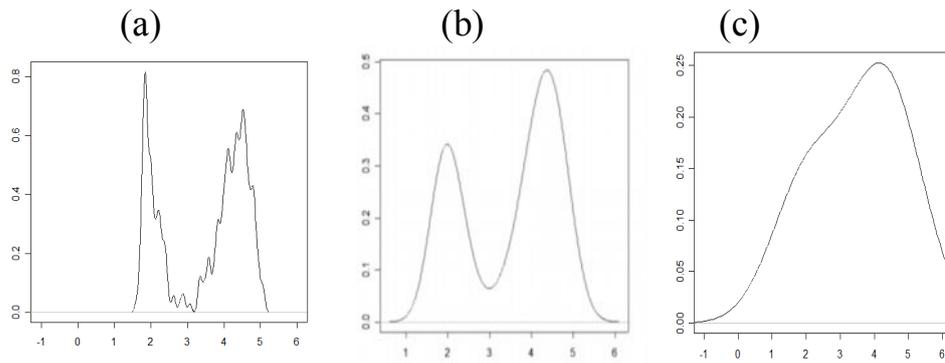


Figure3.4 : Simulated density curve with three levels of bandwidth;(a) under smoothing; (b) optimum smoothing; (c) over smoothing

### Example 3

This example shows image of a little girl (Saja) with different scales, in Figure 3.5(a) Saja is completely appear when picture will be taken at certain distance, but when this distance closer, parts or some features of the body disappears as seen in Figure 3.5(b), and becomes shorter and shorter, more features will disappear at each distance, cause change of scale which images taken from. As seen in Figure 3.5 (c).

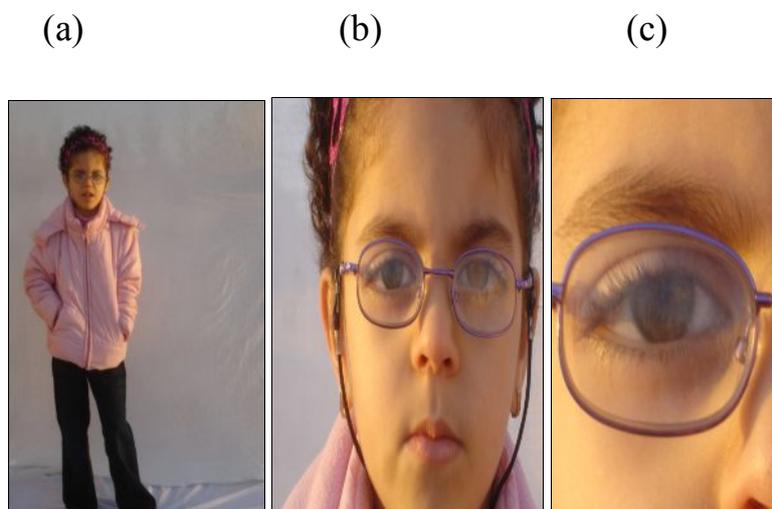


Figure 3.5: Saja picture with different scales; (a) large distance;(b) from close distance ;(c) shortest distance.

### ***3.4 Median filter method***

Some images are affected by noise. The term noise is generally taken to mean an undesired additive component of an image. Filtering (smoothing) is an image processing operation that is normally used to remove noise in an image or to enhance the information already present for better appearance of certain features, to facilitate subsequently more accurate image analysis.

Several methods can be used to smooth images, such as, mean filter, max-min filter, and median filter. In this work median filter has been suggested to remove Salt-and-Pepper noise, in the image under processing. Median filter is particularly effective in the presence of impulse noise, also called Salt-and-Pepper noise because of its appearance as white and black dots superimposed on image.

Median filter not only smoothes noise in image regions, it also tends to produce regions of constant or nearly constant intensity. One of the main reasons for the popularity and wide-spread use of median filter is its computational simplicity and good performance in remove noise, see Pitas and venetsanopouls for more detail (1992).

In order to perform median filtering at pixel in an image and its neighborhood, first sort the value of the pixel and its

neighborhood, then determine median of this set, and replace the value of pixel with median value, Gonzalez and Woods (2008).

*Example 4*

Suppose that the matrix of data as in Figure 3.6 (a), the value in the center is considering as isolated pixel, this value is equal to 0 between the neighbors equal to one's. To remove this isolated value, the median filter is applied. So, the median, of the sorted values as in Figure 3.6 (b), the median of these values are equal to 1, then the value of median is assign to the isolated pixel as Figure3.6(c).

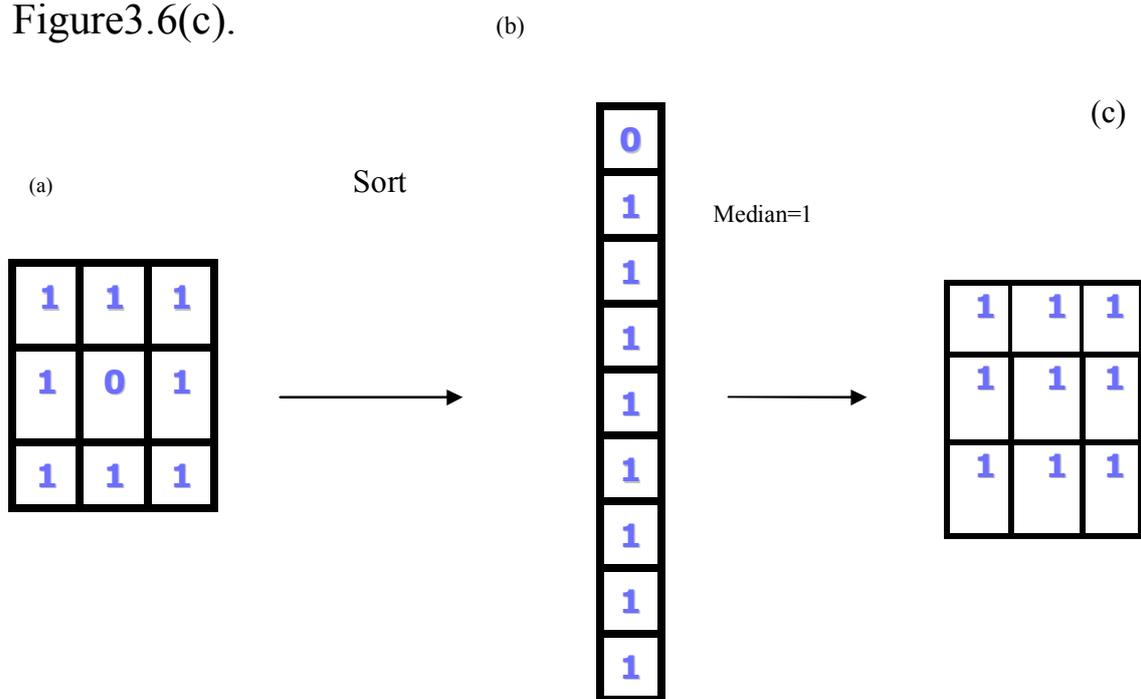


Figure 3.6 (a): isolated point (pixel); (b) sorting of values ;(c) replacing isolated value (pixel) with median.

### ***3.5 Projection method***

Projections transform points from  $n$ -space to  $m$ -space, where  $m < n$ . Projections are a small set of transforms often used to show profile of images. The concept of projection, normally employed in Tomographic imaging (medical imaging), which is the formation of an image of the slice of the body from a series of projections through the body, also for displaying graphical data.

Lehmann, et al. (2004) compared between two methods to reconstructed image, which is Filter Back Projection (FBP) and Algebraic Reconstruction Techniques (ART), both techniques are tested by reconstructing a simulated object, showing that the FBP technique yields images with better resolution and higher contrast, thus resulting in more accurate information than obtained by ART.

The goal of image reconstruction is to detect the object, by using projection method, to reconstruct the image from projection. Let an input image be defined by a discrete function  $f(x, y)$ . Then, a vertical projection ( $P_y$ ) of the function  $f$  at point  $y$  is a summary of all pixel intensities in the  $y^{th}$  column of the input image. Similarly, a horizontal projection ( $P_x$ ) at

a point  $x$  of that function is a summary of all intensities in the  $x^{th}$  rows of that image.

Mathematically ;

$$P_x(x) = \sum_{j=1}^h f(x, j) \quad ; \quad P_y(y) = \sum_{i=1}^w f(i, y)$$

Where  $h$  and  $w$  are dimensions of the image.

### Example 5

Projection method used for detect object in image. To explain projection process, the following example is presented.

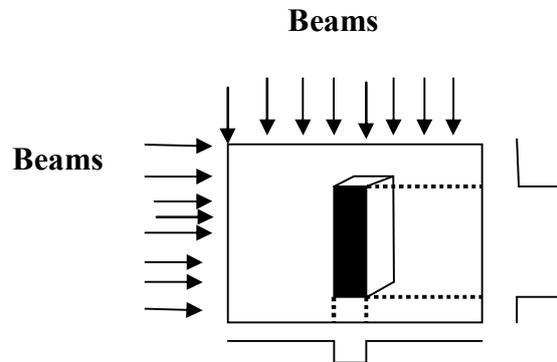


Figure 3.7: image of object and profile results from horizontal and vertical projection.

In this example Figure (3.7) shows binary image with object , suppose that beam pass from left to right through object (horizontal projection), also beam pass from up to down through object that means (vertical projection), the horizontal projection yields a profile of the object, which resulted from count the pixels, and the profile is plotted in the left of the image. As same the profile of the vertical projection is plotted in Figure (3.7).

From these two profiles the object can be reconstructed as shown in Figure 3.8

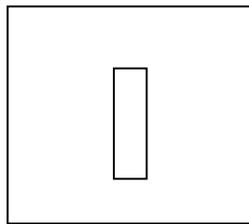


Figure 3.8: reconstructed image

# ***Chapter 4***

## ***Proposal algorithm***

### ***4.1 Introduction***

This chapter proposes an algorithm that will be used to extract object in the image.

The proposal algorithm has been made as a combination of methods, the used methods in the algorithm are, segmentation method, scale-space method, median filter method, and projection method. These methods are used to specify features of object and then reconstruct the object, according to the location, size, and number of objects in the image.

### ***4.2 Methods of the proposal algorithm***

Before mention the steps of our algorithm, this section will give a general view to understand the algorithm.

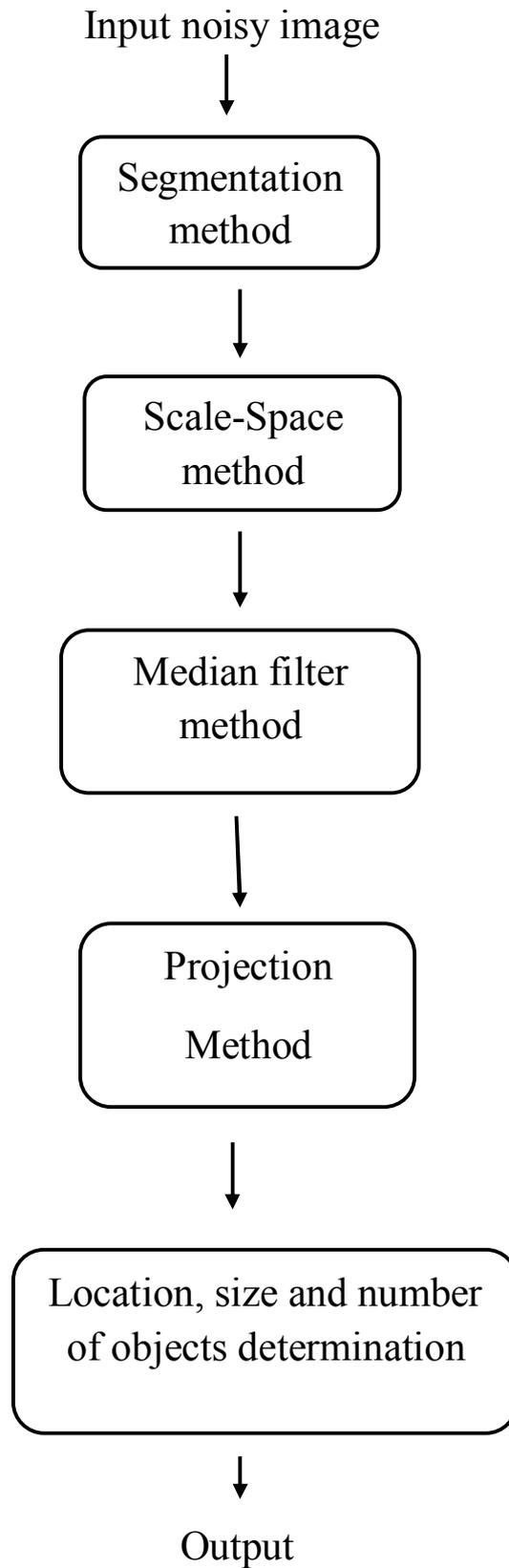
The first stage in the algorithm is the segmentation method which is proposed to extract the object from the background. Herein, the histogram-based thresholding method is applied to

segment the image into background and foreground. The histogram will be presented as a density curve. This curve might be oversmoothed or undersmoothed, then optimum bandwidth (smoothing parameter) will be obtained and applied to the curve. The Scale-Space method is used to get optimum bandwidth, this bandwidth will be used to find optimum smoothing curve, and then obtained optimum threshold value, which use to plot thresholded image.

The isolated pixels (Salt-and-Pepper noise), may be appeared in the thresholded image, then median filter method is suggested to remove this kind of noise.

Now, the binary image is obtained, to identify location, size and number of the objects in image the projection method will be applied.

The following diagram explains the stages of the suggested algorithm.



*Figure 4.1: Diagram of the proposal algorithm*

### ***4.3 Algorithm***

The aim of the algorithm is to detect a geometrical object, which has a square shape in the image. The algorithm can be summarized in the following steps:

- 1- Plot the histogram (Density curve) of the image, to find the threshold, due to noise or different colours in the image. The density curve will be unsmoothed. Then to smooth the curve, the optimum bandwidth (smoothing parameter) should be obtained.
- 2- Use Scale-Space method to find optimum bandwidth, which use to obtain optimum threshold, see SubSection (3.3.1).
- 3- Segment the image into background and foreground by using optimum obtained threshold, then plot binary image, which may be containing some Salt-and-Pepper noise
- 4- Apply median filter to remove unwanted pixels (Salt-and-Pepper noise) may appear in the obtained binary image.

- 5- Use projection method, to obtain the horizontal and vertical profiles, from the binary image.
- 6- Determine the location, size and number of objects, by using the change points in the horizontal and the vertical profiles.
- 7- Use the obtained points in the previous step to reconstruct the object.

The algorithm will be explained and evaluated by using simulated data in the next chapter, if it yields good results then the algorithm will be implemented to real data.

# ***Chapter 5***

## ***Applications***

### ***5.1 Introduction***

As mentioned before, this chapter presents two kinds of applications. The first kind is application to synthetic data, which has been used to evaluate the proposed algorithm. If the algorithm to simulated data works well, then it will be applied to real data.

Next section introduce model, which can be used to create a simulated data and shown the three parameters (number, size and location of objects).

### ***5.2 Simulated Data***

This section describes an image consists of a square shape as an object. The object is defined by three parameters, which are number, location and size.

Suppose that the location of the square object is define by  $(x, y)$ , which are location coordinates. The size of the object is

determining by  $L_1$  and  $L_2$ ,  $L_1$  is the length(height), and  $L_2$  indicates width of the object, while number of the objects has been termed by  $N$ .

Mathematically;

$$N \sim \text{pois}(\lambda_0) \quad \text{"N=number of objects"}$$

$$X \sim \text{pois}(\lambda_1)$$

$$Y \sim \text{pois}(\lambda_2)$$

Where;  $X$  and  $Y$  are location coordinates

$$L_1 \sim \text{pois}(\lambda_3)$$

$$L_2 \sim \text{pois}(\lambda_4)$$

Where;  $L_1$ =length,  $L_2$ =width

Assume that,  $A$  is a matrix of zeros of size  $n \times m$

Where;

$$n \sim \text{pois}(\lambda_5)$$

$$m \sim \text{pois}(\lambda_6)$$

Note that,  $\lambda_0, \lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6$  are supposed to be chosen with restriction . where  $0 < \lambda < \infty$

Then the elements from the row  $X$  till  $(X + L_1)$  , and from the column  $y$  till  $(y + L_2)$  , are setting to be ones.

The matrix  $A$  will give binary image with black object and white background. This matrix will be contaminated by adding Gaussian noise, the resulted matrix is termed as  $f$ ,

where; 
$$f_{ij} = a_{ij} + e_{ij}$$

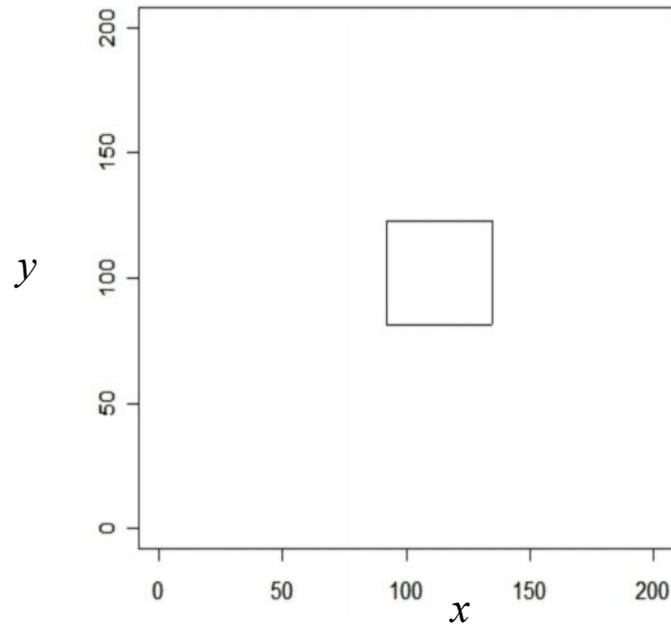
$$i=1, 2, \dots, m \text{ and } j=1, 2, \dots, n$$

Where  $e$  is distributed random normal with mean  $M$  and variance  $\sigma^2$ .

### ***5.3 Application to simulated data.***

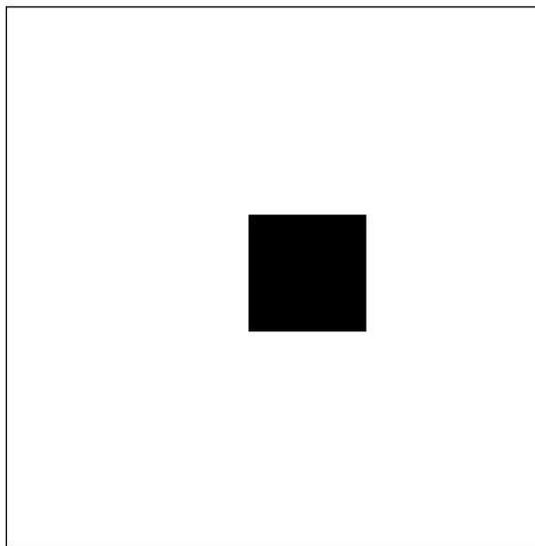
In this section, the image has been simulated with one geometrical object (square shape), the resolution is (40000) pixels, with dimensions 200 by 200, and displays in Figure (5.1). That is,  $n=200$  and  $m=200$ .

- $N$  indicates to number of objects in the image, where this parameter generated from Poisson distribution in this application  $N=1$ .
- Location coordinates  $(x, y)$  are generated from Poisson distribution with  $\lambda_1$  and  $\lambda_2$  equal to 100, ( $\lambda_1=100$  and  $\lambda_2=100$ ).
- Size of object defined by height (length) and width of the object  $(L_1, L_2)$  respectively, which are followed Poisson distribution, with  $\lambda_3=50$ ,  $\lambda_4=50$ .



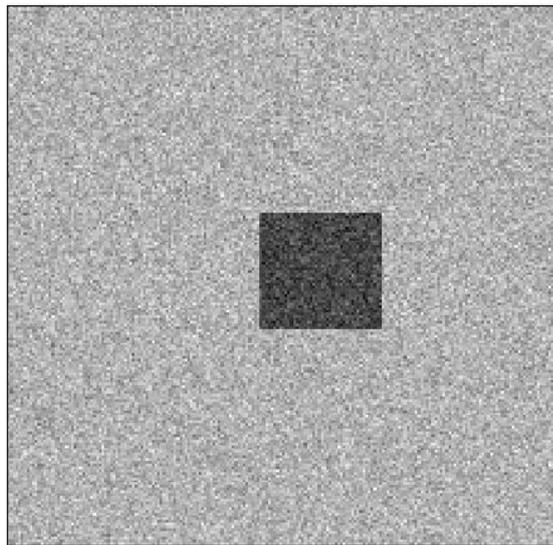
**Figure 5.1:** Simulated data

The simulated data, in Figure 5.1, is displayed as binary image in Figure 5.2. The foreground represents the object (square shape) while the rest of image is background with intensities equal to 1 and 0 respectively.



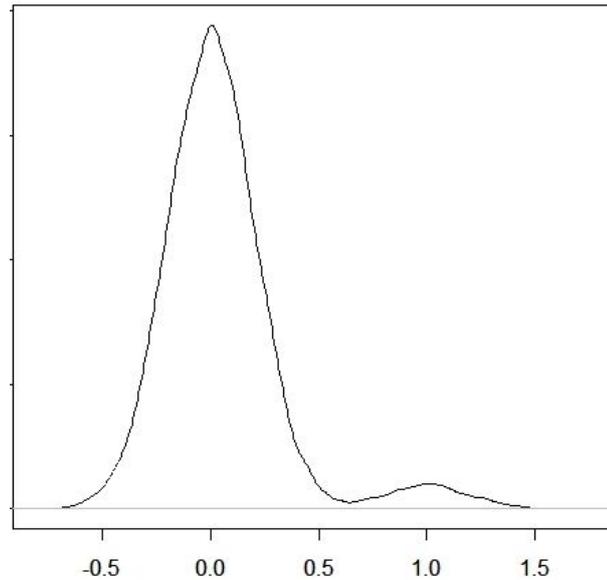
**Figure5.2:** Binary image of simulated data

The binary image is contaminated by adding Gaussian noise with mean equal to zero and standard deviation equal to 0.2, the noisy image is shown in Figure 5.3.



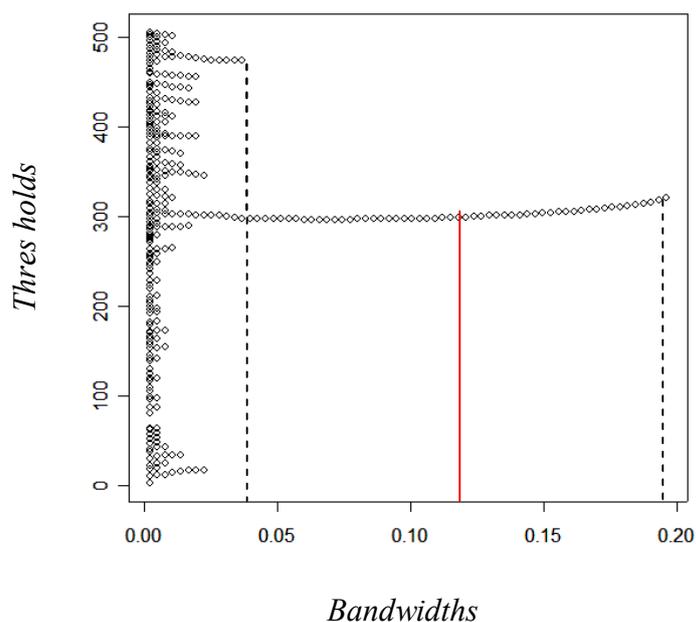
**Figure5.3:** Noisy image of simulated data

According to proposed algorithm, the image will be segmented into foreground and background. Then, thresholding approach is applied, to obtain the value of threshold, the noisy image density curve is plotted. Some of unimportant minima are appears, as in Figure (5.4). This leads to detect some misleading thresholds (local thresholds).



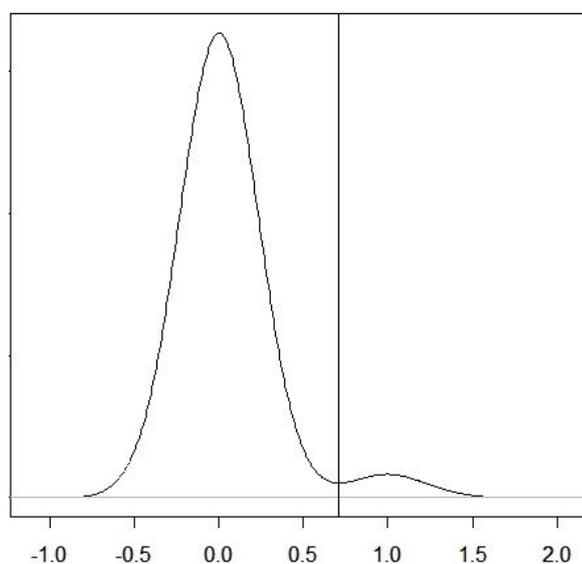
**Figure5.4:** Density curve of noisy image

To remove un-wanted minima, the algorithm suggests to smooth the curve of noisy image. This step is done by looking for optimum bandwidth (smoothing parameter), which is used to plot optimum density curve. To do so Scale-Space method must be applied. Figure (5.5) displays the diagram of the Scale-Space, it shows one tail that lasting longest the other. This means that the data has one threshold, and the optimum bandwidth is corresponding to median of the values of the longest tail in the Scale-Space diagram.



**Figure 5.5:** Scale-Space diagram for data

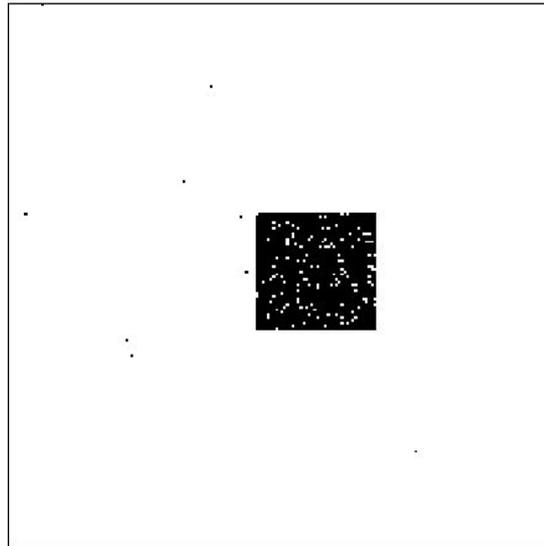
The optimum bandwidth is found to be  $= 0.12$ , (at vertical solid line in diagram), this value is used to smooth noisy image curve as in Figure (5.6), then the optimum value of threshold equal to  $T= 0.7$ , is obtained.



$$T=0.7$$

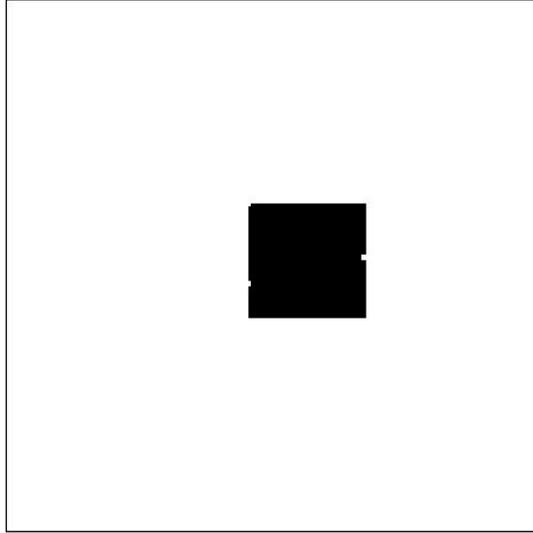
**Figure 5.6;** Optimum smoothing density curve

The optimum threshold is used to segment the noisy image, but some isolated pixels (Salt & Pepper noise) are appears, Figure 5.7, displays the image with isolated pixels.



**Figure 5.7:** Binary image with Salt and Pepper noise

The median filter is proposed to remove this noise. Where median filter method is used as a third stage in proposal algorithm, and the result is displayed in Figure 5.8.



**Figure 5.8:** Filtered image

The next step in proposal algorithm is a projection method (step 5 in section 4.3). This method is used to detect the main parameters to define the object. In this method, the values in each column are summed, and saved in vector  $Sc$  (vertical projection). The result of the vertical projection is plotted in Figure 5.9.

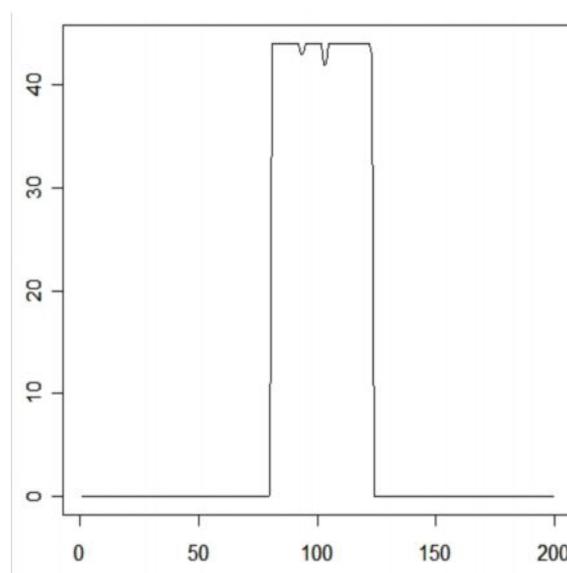


The positions of non-zero values in vector  $S_c$  are taken out in a new vector ( $P_c$ ), and they are;

$P_c = ( 92 \ 93 \ 94 \ 95 \ 96 \ 97 \ 98 \ 99 \ 100 \ 101 \ 102 \ 103 \ 104$   
 $105 \ 106 \ 107 \ 108 \ 109 \ 110 \ 111 \ 112 \ 113 \ 114 \ 115 \ 116$   
 $117 \ 118 \ 119 \ 120 \ 121 \ 122 \ 123 \ 124 \ 125 \ 126 \ 127 \ 128$   
 $129 \ 130 \ 131 \ 132 \ 133 \ 134 \ 135 )$

This vector has continuous values, which means the image contains one object, the first value 92, and the last value 135, in the vector  $P_c$  are determined the edges of the object horizontally. While the difference between those values gives the horizontal size of the object.

The same procedure is conducted on rows (Horizontal projection), and the results are plotted in Figure (5.10). This Figure confirms that the number of object in image is one.



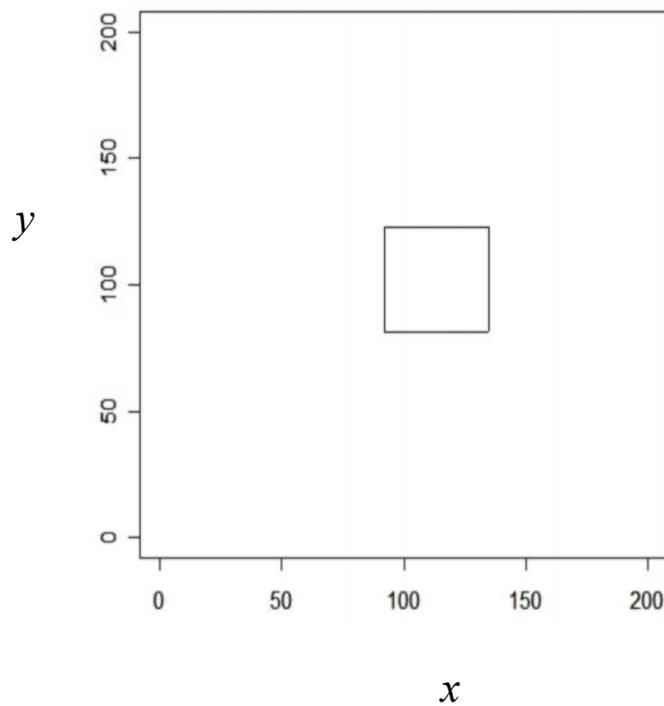
**Figure 5.10:** Horizontal Projection



Point in vector  $Pc$  corresponding to the first and the last points in  $Pr$ , and the last point in the  $Pc$  with the first and the last points in  $Pr$ . This step yields;

$$(92, 81), (92, 123), (135, 81), (135, 123)$$

These coordinates are used to reconstruct the object as in Figure(5.11).



**Figure 5.11:** Reconstructed dataset

The vertical size is calculated by subtract the last value in  $Pr$  from the first point in  $Pr$  that is

$$Pr_{43} - Pr_1 = 123 - 81 = 42$$

Also horizontal size

$$Pc_{44} - Pc_1 = 135 - 92 = 43$$

The algorithm yields good results, to detect the three parameters which are used to reconstruct the object.

These parameters are;

Location coordinates  $(x, y)$ , which are

$$(92, 81), (92, 123), (135, 81), (135, 123)$$

And the size of the object  $(L_1, L_2)$  equal to  $(42, 43)$ , and  $N$  that indicates to number of the objects in the image, and it equal to 1

## ***5.4 Application to real data***

In this example the algorithm will be applied to real data, which represents remotely sensed image. The image has been taken from Google Earth site ([www.googleEarth.com](http://www.googleEarth.com)), in the internet, this image is displayed in Figure 5.12. The image is for a farm in Tripoli-Libya, it consists of black square object.



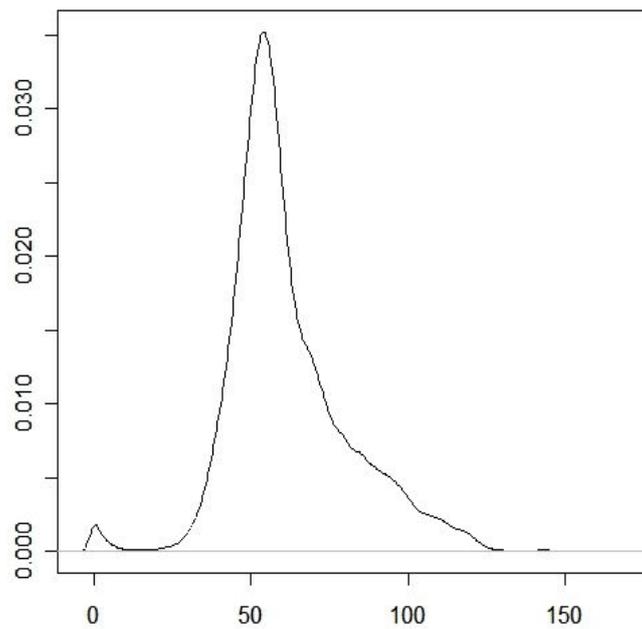
**Figure 5.12:** Image to farm in Tripoli

The image has been converted into Gray-level by using MATLAB software (version.7.6), and shown in Figure 5.13.



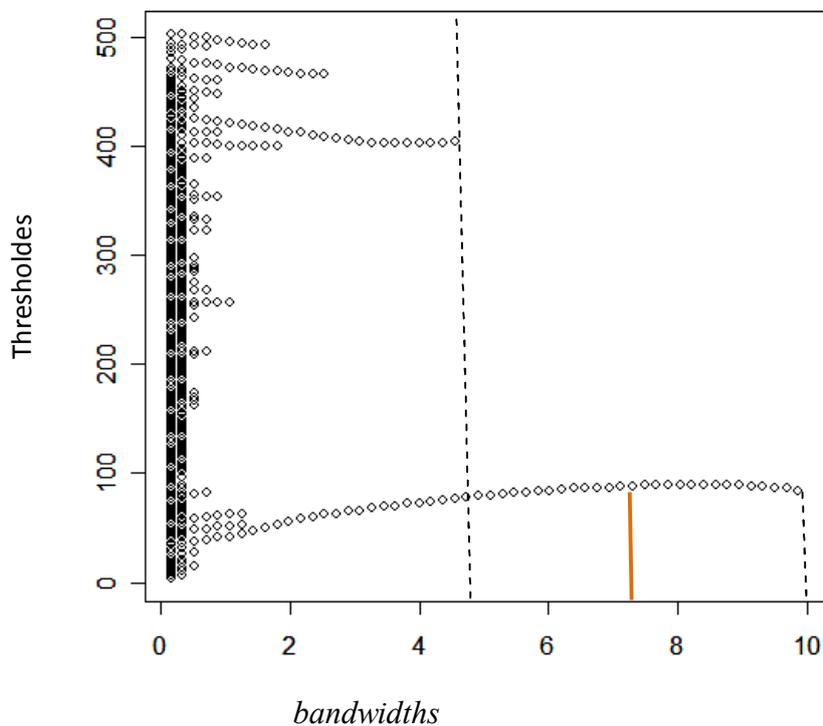
**Figure 5.13:** Gray-level image to the farm image

To segment the image, the density curve (histogram) of Gray-level image has been plotted as seen in Figure 5.14.



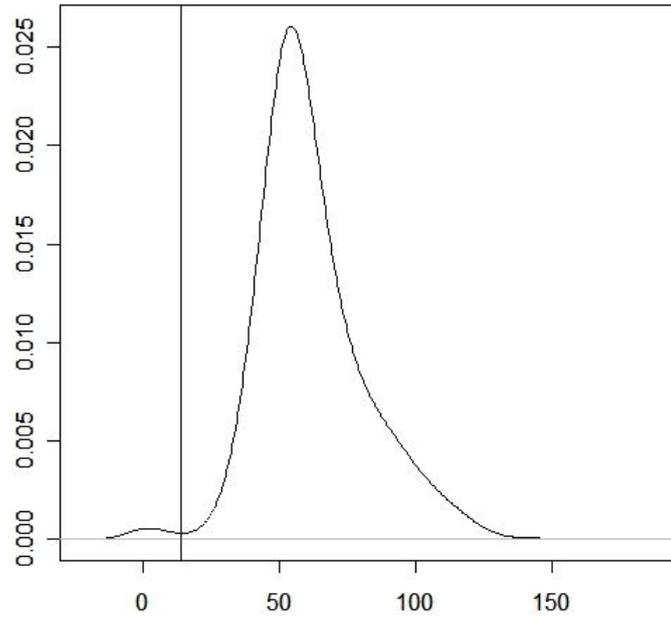
**Figure 5.14:** Density curve of noisy image

Looking at Figure 5.14 illustrated, there is a single threshold, but some local minima might lead to detect extra incorrect thresholds. To get optimum threshold the curve should be smoothed, then the optimum bandwidth is needed. To do so, the Scale-Space method is used. Figure 5.15, shows graphic form of Scale-Space method.



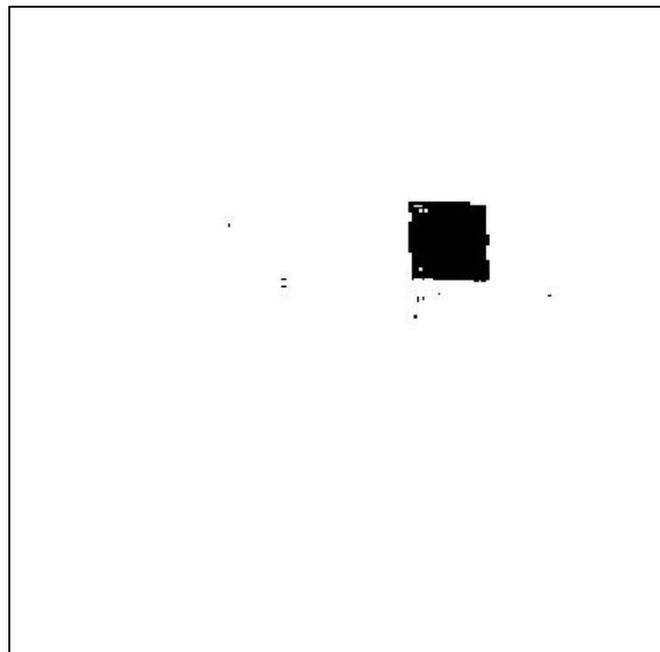
**Figure 5.15:** Scale-Space diagram for the real data.

The optimum bandwidth (smoothing parameter) equal to 7.30, which obtained by Scale-Space method, is used to plot optimum histogram as in Figure 5.16.



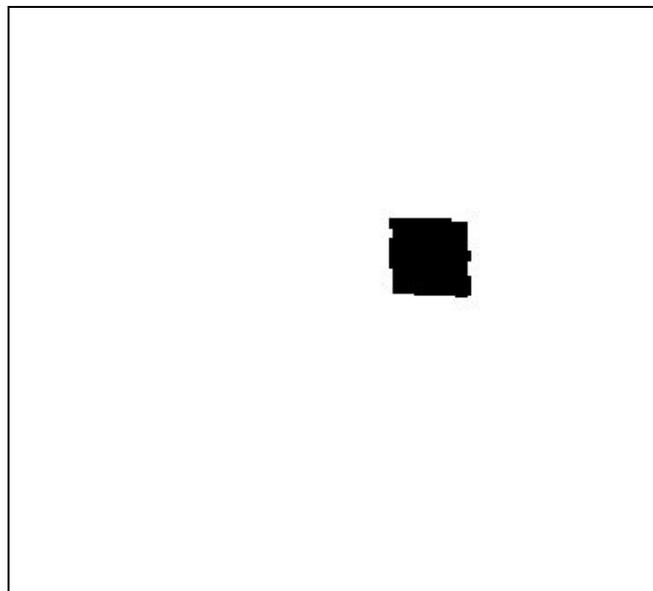
**Figure 5.16:** Smoothed density curve for the real data.

Then the optimum threshold is obtained from the optimum histogram and it found to be equal to 13.81, this is shown as vertical line in Figure 5.16.



**Figure 5.17:** Thresholded image

The optimum threshold is used to segment the image into object and background as seen in Figure 5.17. The thresholded image has had some isolated pixels as noise. The median filter has been suggested in the algorithm to remove these isolated points, and the resulted image is shown in Figure 5.18.

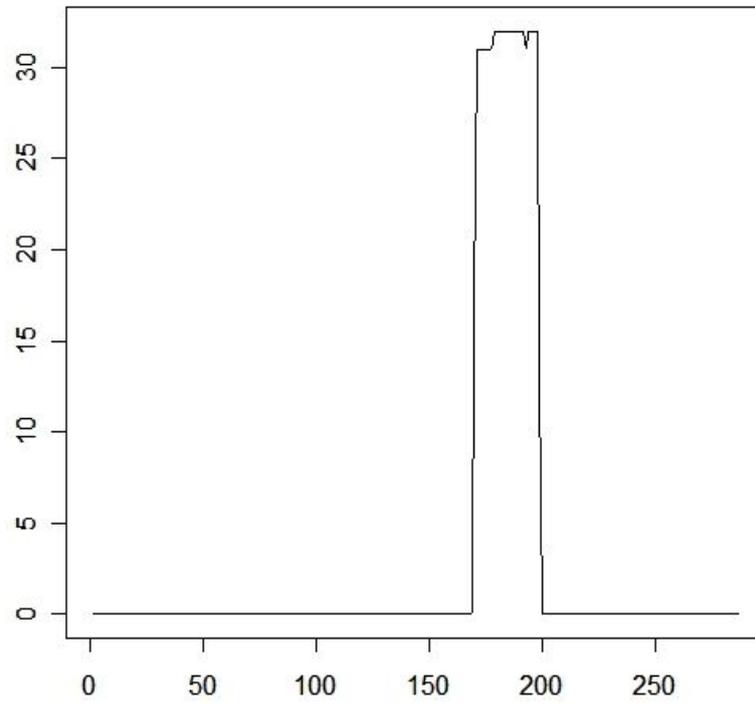


**Figure 5.18:** Filtered image

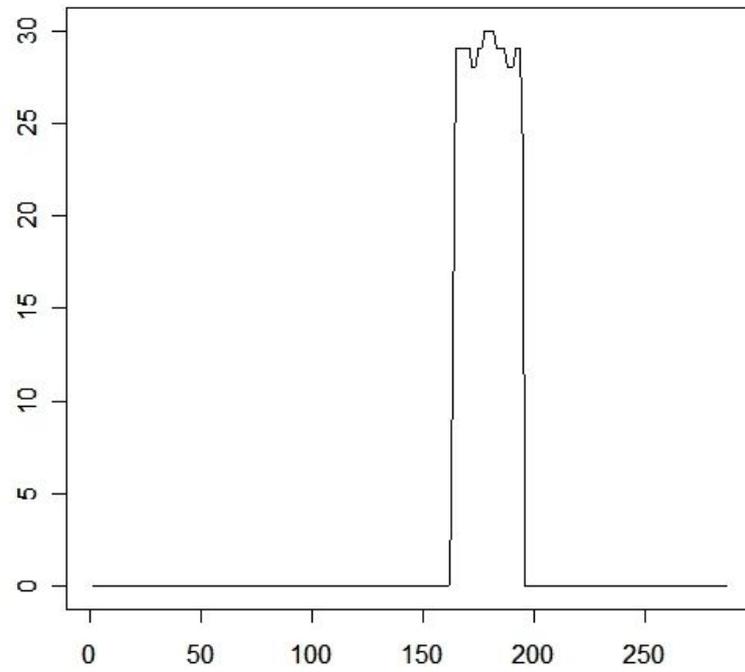
the last stage of the proposed algorithm is to detect the object in the image. The detection is based on identify location, size, and number of objects in the image.

The projection method is proposed to achieve this stage. Figure 5.19(a) and (b) show vertical and horizontal projection respectively.

(a)



(b)



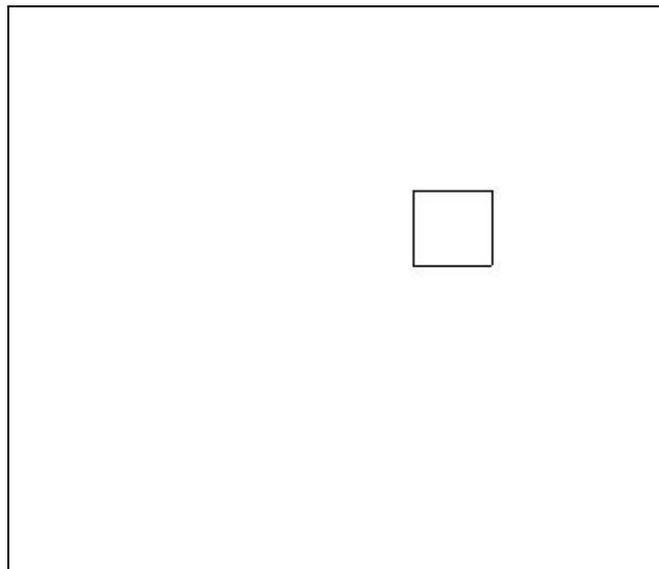
**Figure 5.19:** (a) Vertical projection (b) Horizontal projection





the four points, which identify the location and the size of the object.

The location of the object is represented by the points (170,163), (170,195), (199, 163), (199,195), which are used to reconstruct the object as in Figure 5.20.



**Figure 5.20:** Reconstructed square object in the image

The size of the object in the image can be obtained by using the first and the last points in  $pr$  and  $pc$ , as:

$$\text{Horizontal length} = 199-170=29.$$

And

$$\text{Vertical length} = 195-163=32.$$

Visually, the algorithm yields very good results, as it can be seen in Figure 5.20, respect to Figure 5.12.

# *Chapter 6*

## *Summery and Conclusions*

### *6.1 Summary*

This study presents an algorithm to identify the geometrical object in the images. To identify the object from the image, three main characteristics should be obtained; number, size, and location of that object. This algorithm contains of number of approaches; segmentation method which is used to extract the foreground from background by histogram-based thresholding technique, Scale-Space method is adopted to find the optimum bandwidth that is used to obtain optimum smoothing curve, and then obtained optimum threshold value, which use to segment thresholded image, median filter has been applied to remove the isolated pixels (Salt and Pepper noise) may be arise in the thresholded image, the previous methods used to get binary image, to detect the main characters of square object in the image, projection method was applied.

## ***6.2 Conclusions***

The proposed algorithm, in this project, has been evaluated by using a synthetic data and achieved good results. This achieved encouraged to apply the algorithm to real data, the presented in example with image has square shape of object in this thesis. In case of real data, algorithm yields well result. The algorithm provided good results and achieved the aims of this research when the image contain one object, but such good results were not be possible when the objects in image are overlapped.

## ***6.3 Future work***

- In this project, number of objects was supposed to be one, in future this character might be unknown and it simulated from discrete distribution.
- Also, if the image contains more than object, the algorithm should be modified to handle case of overlapping between the objects.
- The aim of this study was detected geometrical object according to its main characteristics; location, size and

number. This objective can be developed to identify non-geometric objects, such as; handwriting, fingerprint, and etc.

- Try to determine the true shape of the object.
- The image that was analyzed was converted to gray scale, in the future try to analysis the multi-color image.

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جامعة بنغازي  
كلية العلوم  
قسم الإحصاء

## خوارزمية لتحديد شكل هندسي في الصورة

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## الخلاصة

تعتبر الصور مصدر مهم للمعلومات في كثير من مجالات البحث العلمي، تنتج الصور بطرق مختلفة منها علي سبيل المثال الكاميرات و الرادارات والمجهر الالكتروني وغيرها من الأجهزة. يمكن تعريف الصورة الرقمية علي إنها دالة في بعدين هما  $(x, y)$  يشيران إلي إحداثيات الموقع وقيمه الدالة عند تلك النقطة تسمى كثافة الصورة عند تلك النقطة.

لتحديد الشكل الهندسي في الصورة نحتاج إلي وضع خوارزمية تحتوي علي مجموعة من الأساليب لانجاز ذلك الهدف وهذه الطرق هي:

طريقة الفصل ونحتاج إليها لفصل الواجهة (الشكل الهندسي) عن الخلفية، ثم طريقة فراغ المقياس لتنعيم منحنى كثافة الصورة ثم طريقة مرشح الوسيط لتخلص من النقاط المعزولة.

بعد تنفيذ المراحل الأولى من الخوارزمية و حصولنا علي الصورة الثنائية باللونين الأسود للجسم والأبيض للخلفية ، وتكون الصورة خالية من التشويش ، نكون قد توصلنا إلي مرحلة التعرف أو تمييز الشكل الموجود داخل الصورة. ثم اعتمادا علي طريقة الإسقاط ،فاننا سوف نحدد عدد و مواقع وحجم الأجسام.

عند تطبيق هذه الخوارزمية علي البيانات الاصطناعية، أعطت نتائج جيدة، بالتالي تم تطبيقها علي البيانات الحقيقية وحققت ما نهدف إليه في هذا البحث وهو التعرف علي شكل هندسي في صورة الرقمية.

## Appendix

### R-code for the proposed algorithm

```
z=matrix(0,200,200)
x=rpois(1,100)
y=rpois(1,100)
l1=rpois(1,50)
l2=rpois(1,50)
z[x:(x+l1),y:(y+l2)]=1
image(z,col=gray(64:0/64),axes=F);box()

#####add Gaussian noise to image#####

z1=z+rnorm(200*200,0,0.2)
image(z1,col=gray(64:0/64),axes=F);box()

#####Scale-Space Method #####

a= density((z1))
ha=a$bw
d=80
b= seq((ha*0.1),(ha*10),length=d)
```

```

ydn=0
u=matrix(0,d,510)
for(i in 1:length(b)){
a1=density((z1),b[i])
yd=a1$y
for(j in 1:(length(yd)-1)){
ydn[j]=yd[j+1]-yd[j] }
xt=0
for(k in 1:(length(yd)-2)){
if(ydn[k]<0 & ydn[k+1]>0){
xt[k]=a1$x[k+1]}else {
xt[k]=0} }
u[i,]=xt}
yu=NULL
for(i in 1:d){
yu=c(yu,which(u[i,]!=0))
}
xb= NULL
for(i in 1:d){
xb=c(xb,rep(b[i],length(which(u[i,]!=0)))) }
plot(xb,yu)

r=NULL
for( i in 1: d){
r = c(r,length(which(u[i,]!=0)))
}

```

```

rr=unique(r)
B=0
for(i in 1:length(r)){
B[i]=length(which(rr[i]==r))
}
BB=rr[which.max(B)]
q=which(r==BB)

```

##### Optimum Bandwidth (bwo) #####

```

bwo=median(b[q])
w=density(z1,bwo)
yz1=w$y
m=0
for(i in 1:(length(yz1)-1)){
m[i]=yz1[i+1]-yz1[i] }
d=NULL
for( i in 1:(length(m)-1)){
if(m[i]<0 && m[i+1]>0){
d=rbind(d,i)
}}
plot(w)
abline(v=w$x[d])
T=w$x[d]

```

#####Optimum Thresholdng #####

```

zt=matrix(0,nrow(z1),ncol(z1))
for(i in 1:nrow(z1)){
for(j in 1:ncol(z1)){
if(z1[i,j]>T){
zt[i,j]=1} else {
zt[i,j]=0}
}}
image(zt,col=gray(64:0/64),axes=F);box()

```

```

##### median filter procedure #####

```

```

## It use for remove salt and paper noise #####

```

```

neigh = function(x,i){
neigh = c(i-1,i+1,i-ncol(x),i+ncol(x),
i-ncol(x)-1,i+ncol(x)-1,i-ncol(x)+1,i+ncol(x)+1)
neigh = neigh[neigh>0]
neigh = neigh[neigh<=length(x)]
return(neigh)}

# Median smoothing filter - good for isolated outliers

medianfilter=function(x){
nc = ncol(x); nr = nrow(x)
output = matrix(0,nrow=nr ,ncol=nc)
for (i in 1:nc){
for (j in 1:nr){
neigh = x[i,j]

```

```
if(i>1)neigh = c(neigh,x[i-1,j])
```

```
if(i<nc)neigh = c(neigh,x[i+1,j])
```

```
if(j>1)neigh = c(neigh,x[i,j-1])
```

```
if(j<nr)neigh = c(neigh,x[i,j+1])
```

```
output[i,j] = median(neigh)
```

```
}}
```

```
return(output)
```

```
}
```

```
zm=medianfilter(zt)
```

```
##### binary image #####
```

```
image(zm,col=gray(64:0/64),axes=F);box()
```

```
##### projection method #####
```

```
dim(zm)
```

```
nr=nrow(zm)
```

```
nc=ncol(zm)
```

```
x11()
```

```
sc=0
```

```
for ( i in 1:nr){
```

```
sc[i]=sum(zm[i,])
```

```
}
```

```
plot(sc,type="l")
pc=which(sc!=0)
```

```
x11()
```

```
sr=0
for(i in 1:nc){
sr[i]=sum(zm[,i])
}
plot(sr,type="l")
pr=which(sr!=0)
```

```
##### reconstructed data #####
```

```
x1=c(pc[1],pc[1],pc[length(pc)],pc[length(pc)],pc[1])
x2=c(pr[1],pr[length(pr)],pr[length(pr)],pr[1],pr[1])
plot(x1,x2,type="l",xlim=c(0,200),ylim=c(0,200))
```