

IMAGE RESTORATION BASED ON MORPHOLOGICAL OPERATIONS

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ABSTRACT

Image processing including noise suppression, feature extraction, edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression etc uses mathematical morphology which is a method of nonlinear filters.

It is modulated from traditional morphology to order morphology, soft mathematical morphology and fuzzy soft mathematical morphology. This paper is covers 6 morphological operations which are implemented in the matlab program, including erosion, dilation, opening, closing, boundary extraction and region filling.

KEYWORDS

Image Restoration, Structure Elements (SE), and Morphological operations.

1. INTRODUCTION

Image restoration provides a means to reconstruct damaged regions of an image. Image components for representation and description of region shape, such as boundaries, skeletons, and the convex hull are extracted by Morphological image processing [1]. It can be used for filtering, thinning and pruning. It is constructed with operations on sets of pixels. More sophisticated mathematical development are been required to Morphological processing for gray scale images [2,3].

Dilation and erosion are the main morphological operations [4]. The objects are expanded in dilation operation, thus small holes probably are filled and disjoint objects are connected. The objects are diminished in erosion operation with etching away (eroding) their boundaries. An application with the ability to select the proper structuring element and how erode or dilate the objects is proposed. These operations can be customized for an application by the proper selection of the structuring element, which determines exactly how the objects will be dilated or eroded [5].

The state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image in the morphological dilation and erosion operations [6]. The operation as dilation or erosion can be defined by the rule used to process the pixels. In this paper will mainly concentrate on 4 morphological operations and 2 basic morphological algorithms which are implemented in the program, including erosion,

dilation, opening, closing, boundary extraction and region filling, Users can arbitrarily choose one of the morphological operations through the six radio buttons, Change dynamically the SE size through moving the slider and there are 3 types of SE which are implemented in the program, including diamond, square and octagon. The pop-up menu change se type dynamically.

The rest of this paper organize in three sections, The next section introduces morphological operations and its steps, section three explains Some basic morphological algorithms and section four shows the results of each operation and 2 basic algorithms.

2. Morphological Operations

2.1 The operation of dilation

The process of the structuring element B on the image A and moving it across the image in a way like convolution is defined as dilation operation. The two main inputs for the dilation operator [7] are the image which is to be dilated and a set of coordinate points known as a structuring element which define also as a kernel. The exact effect of the dilation on the input image is determined by this structuring element [8]. The following steps are the mathematical definition of dilation for binary images:

1. Suppose that X is the set of Euclidean coordinates corresponding to the input binary image, and that K is the set of coordinates for the structuring element.
2. Let K_x denote the translation of K so that its origin is at x .
3. Then the dilation of X by K is simply the set of all points x such that the intersection of K_x with X is non-empty.

It dilation is defined as set operation. A is dilated by B , written as $A \oplus B$, is defined as (1):

$$A \oplus B = \{z | (\hat{B})_z \cap A \neq \phi\} \quad (1)$$

Among them, ϕ is for the empty set, B is for the structure element, and \hat{B} is for the reflection of collection B .

An example is shown in Figure (2.1), Note that with a dilation operation, all the 'black' pixels in the original image will be retained, any boundaries will be expanded, and small holes will be filled.

The some Characteristics of Binary dilation operator are:

- It is translation invariant.
- It is increasing, that is, if $A \subseteq C$ then $A \oplus B \subseteq C \oplus B$.

- It is commutative.
- It is associative, i.e. $(A \oplus B) \oplus C = A \oplus (B \oplus C)$.
- It is distributive over set union

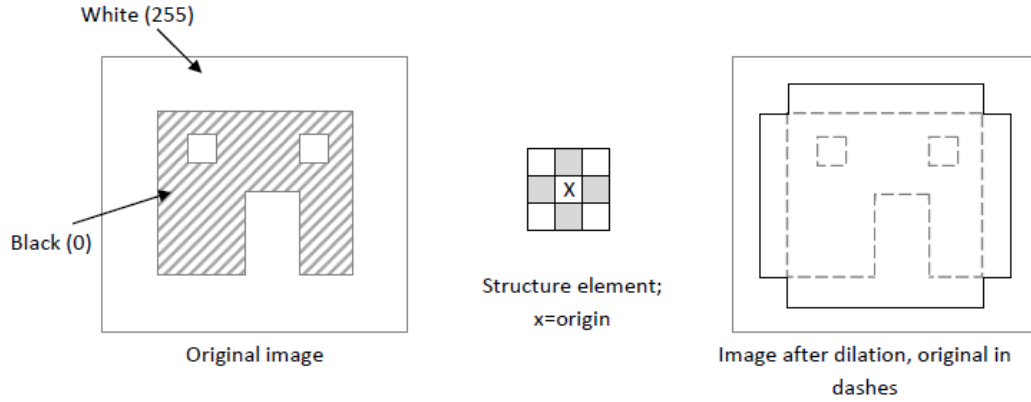


Figure (2.1) Representation of the dilation process

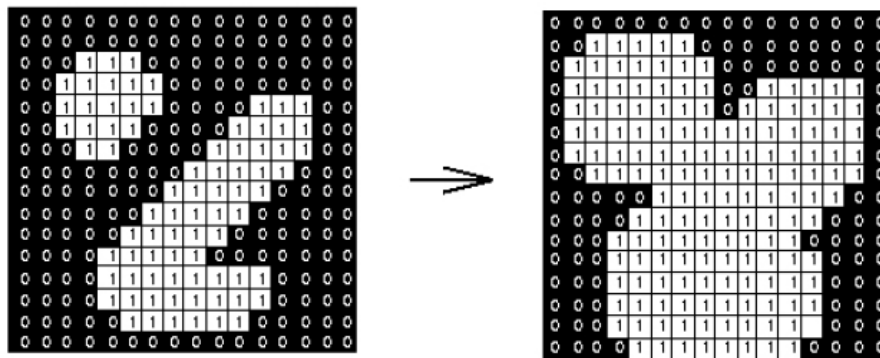


Figure (2.2) Effect of dilation using a 3x3 square structuring element on binary image

2.2 The operation of erosion

The erosion process is as same as dilation, but the pixels are converted to 'white', not 'black'. The two main inputs for the erosion operator [9] are the image which is to be eroded and a set of coordinate points known as a structuring element which define also as a kernel. The exact effect of the erosion on the input image is determined by this structuring element. The following steps are the mathematical definition of erosion for binary images:

1. Suppose that X is the set of Euclidean coordinates corresponding to the input binary image, and that K is the set of coordinates for the structuring element.
2. Let K_x denote the translation of K so that its origin is at x .

3. Then the erosion of X by K is simply the set of all points x such that Kx is a subset of X .

A is eroded by B , recorded as $A \ominus B$, and defined as (2)

$$A \ominus B = \{z | (B)_z \cap A^c \neq \phi\} \quad (2)$$

Among them, ϕ is for the empty set, B is for the structure element, and A^c is for the supplement of collection A .

In Figure (2.3), the only remaining pixels are those that coincide to the origin of the structuring element where the entire structuring element was contained in the existing object. Because the structuring element is 3 pixels wide, the 2-pixel-wide right leg of the image.

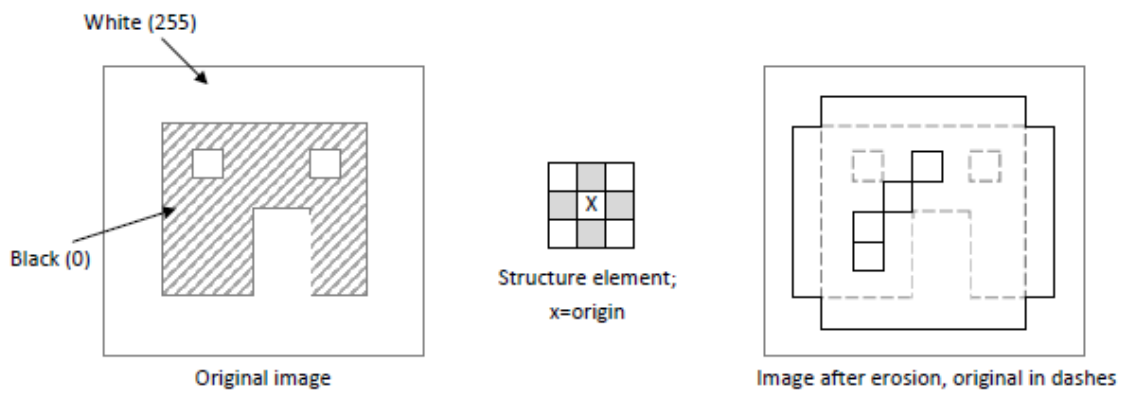


Figure (2.3) Representation of the erosion process

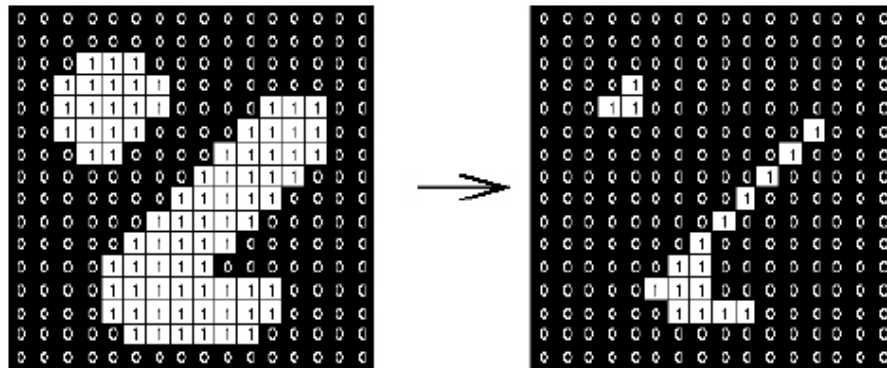


Figure (2.4) Effect of erosion using a 3x3 square structuring element on binary image

2.3 The operation of opening and closing

The combination of the two main operations, dilation and erosion, can produce more complex sequences. Opening and closing are the most useful of these for morphological filtering [10]. An opening operation is defined as erosion followed by a dilation using the same structuring element

for both operations. The basic two inputs for opening operator are an image to be opened, and a structuring element. Graylevel opening consists simply of graylevel erosion followed by graylevel dilation. See Figure (2.5) for the illustration of the opening process.

Using the structure element B to do the open operation on the set A , expressed as $A \circ B$, definite as

$$f \circ b = (f \ominus b) \oplus b \quad (3)$$

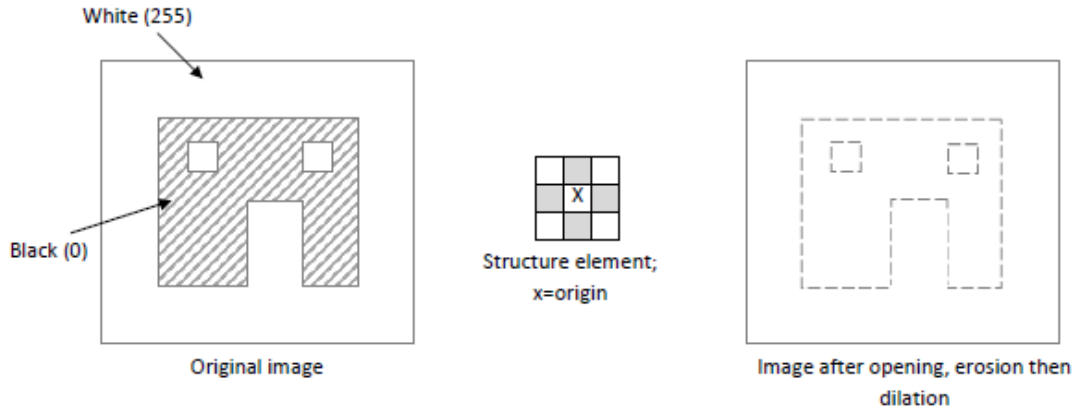


Figure (2.5) Representation of the opening process

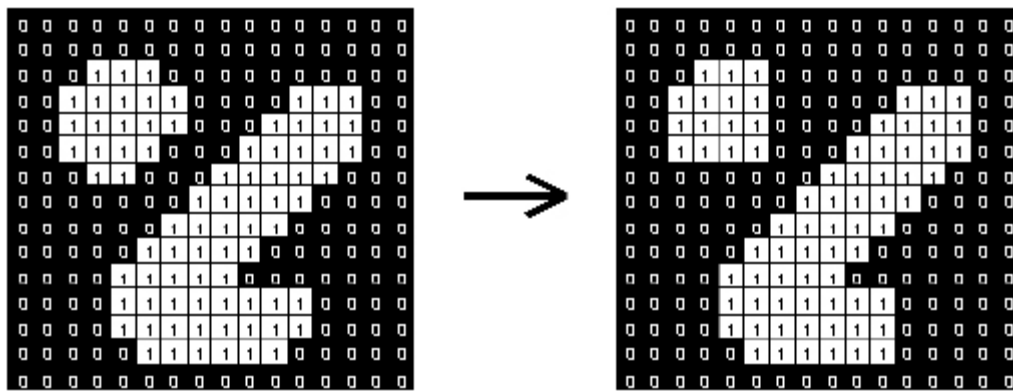


Figure (2.6) Effect of opening using a 3x3 square structuring element on binary image

Closing is opening performed in reverse. Simply it is defined as dilation then erosion using the same structuring element for both operations. The main inputs of the closing operator are an image to be closed and a structuring element. The process of a graylevel dilation followed by graylevel erosion is defined as Graylevel closing. Figure (2.7) shows the effects of filling in holes and closing gaps which define as closing operation.

Like binary image, at opening operation, Use b to erode f plainly first, then on the results obtained, use b to do dilate operation. Also, using b to do closing operation on f , expressed as $f \bullet b$, definite as

$$f \bullet b = (f \oplus b) \ominus b \quad (4)$$

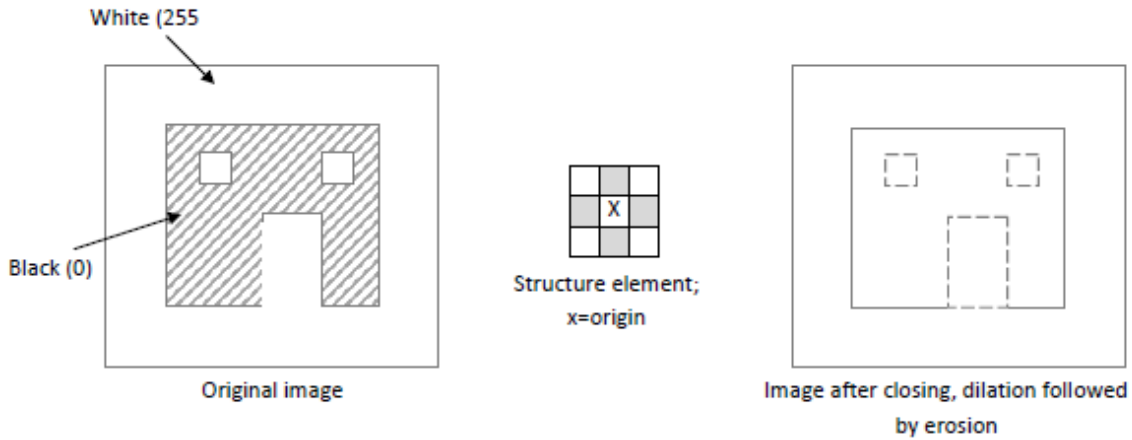


Figure (2.7) Representation of the closing process

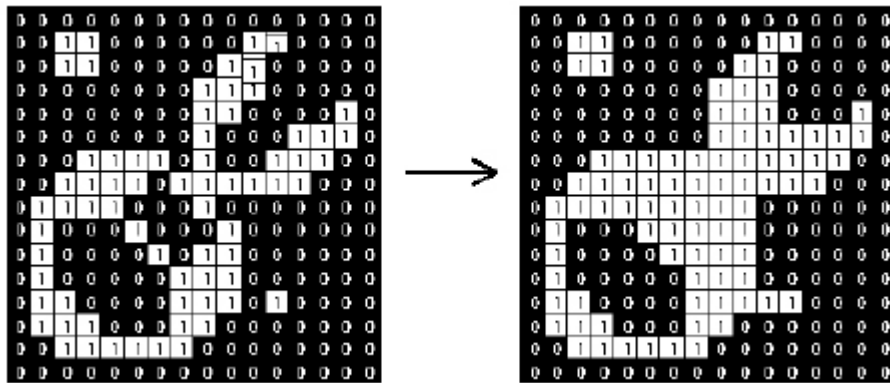


Figure (2.8) Effect of closing using a 3x3 square structuring element on binary image

3. Some Basic Morphological Algorithms

3.1 Boundary extraction

The boundary of a set A , denoted by $\beta(A)$, can be obtained by first eroding A by B and then performing the set differences between A and its erosion. That is,

$$\beta(A) = A - (A \ominus B) \quad (5)$$

Where B is a suitable structuring element.

'-' is the difference operation on sets (illustrated in Figure (3.1)).

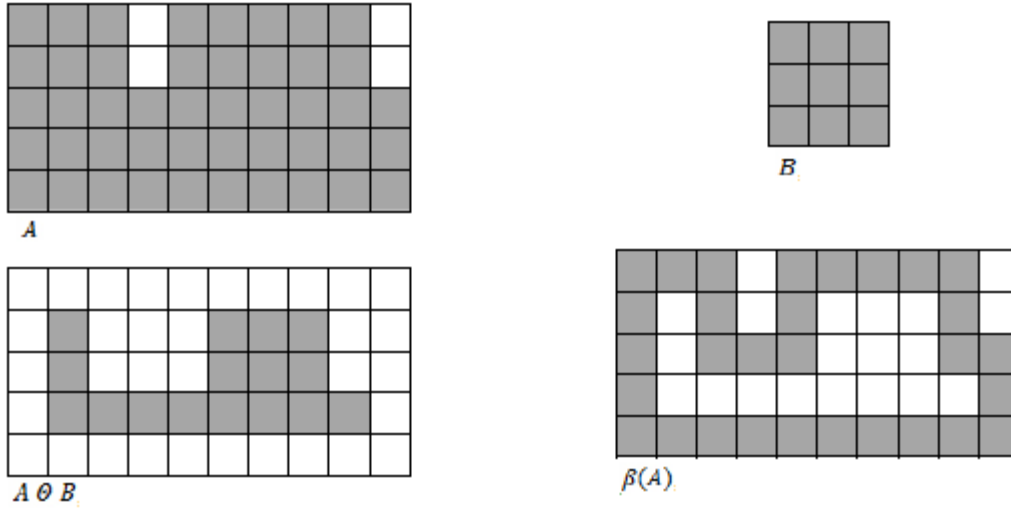


Figure (3.1) Representation of the boundary extraction algorithm

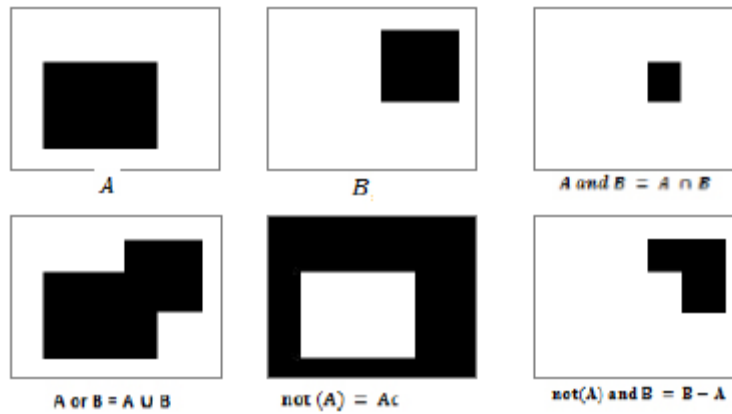


Figure (3.2) Representation of the main operations on sets

3.2 Region Filling

The algorithm for region filling based on set dilations, complementation, and intersections. The main idea is filling the entire region with 'black' starting from a point p inside the boundary. If we adopt the convention, first step all non-boundary (background) points are labeled 'white' and then we assign a value of 'black' to p to. Filling the region with 'black' by the following procedure:

$$X_k = (X_{k-1} \oplus B) \cap A^c \quad k = 1, 2, 3, \quad (6)$$

where

- $X_0 = p$,
- B is the symmetric structuring element
- \cap is the intersection operator (see Figure (3.3))
- A^c is the complement of set A (see Figure (3.3))

The algorithm terminates at iteration step k if $X_k = X_{k-1}$. The filled set and its boundary is contained by the set union of X_k and A .

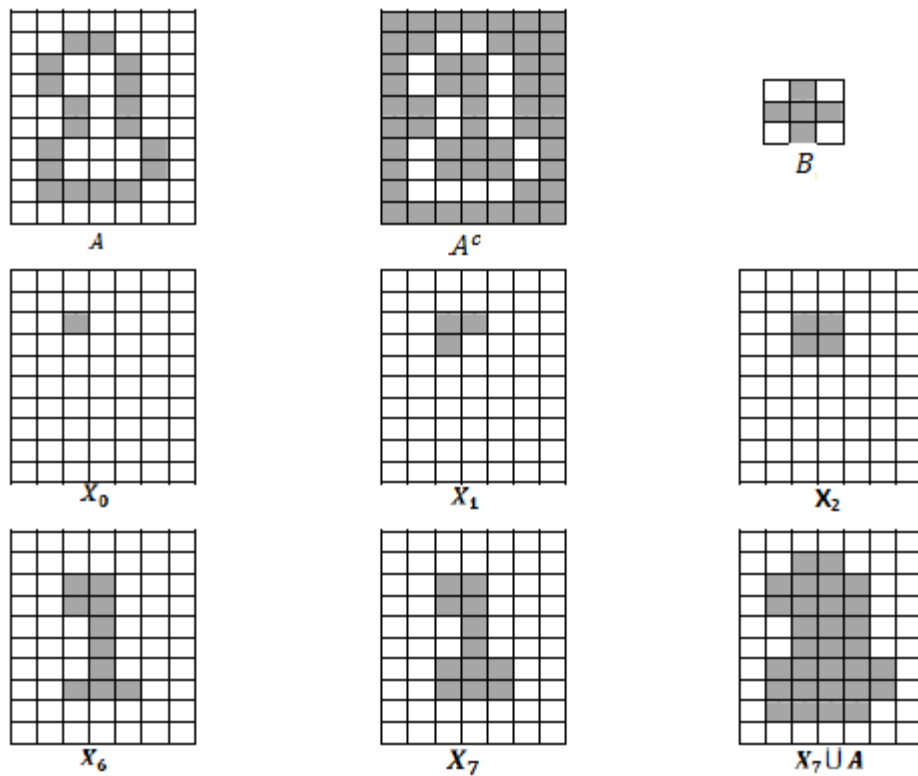


Figure (3.3) Representation of the region filling algorithm

4. SIMULATED RESULTS

At matlab program we applied the 4 morphological operations and 2 basic algorithms using six radio buttons, so users can determine any of the morphological operations needed, we added 3 types of SE (diamond, square and octagon) and a slider to modify dynamically the SE size. Dynamically change SE type through the pop-up menu, the experimental results for each operation and algorithms show in the following figure.

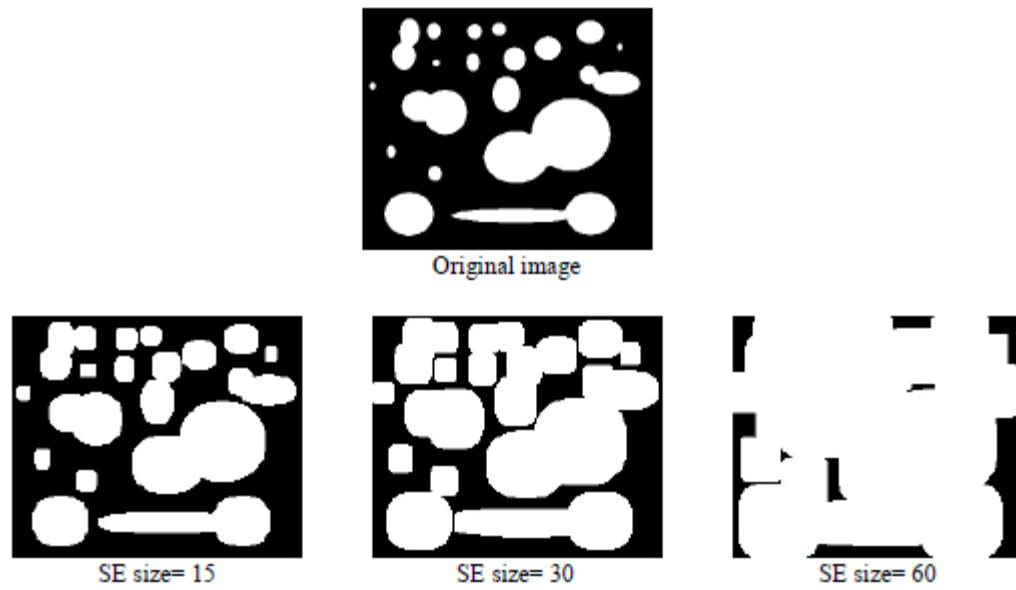


Figure (4.1) Effect of dilation on grayscale image with SE type = square

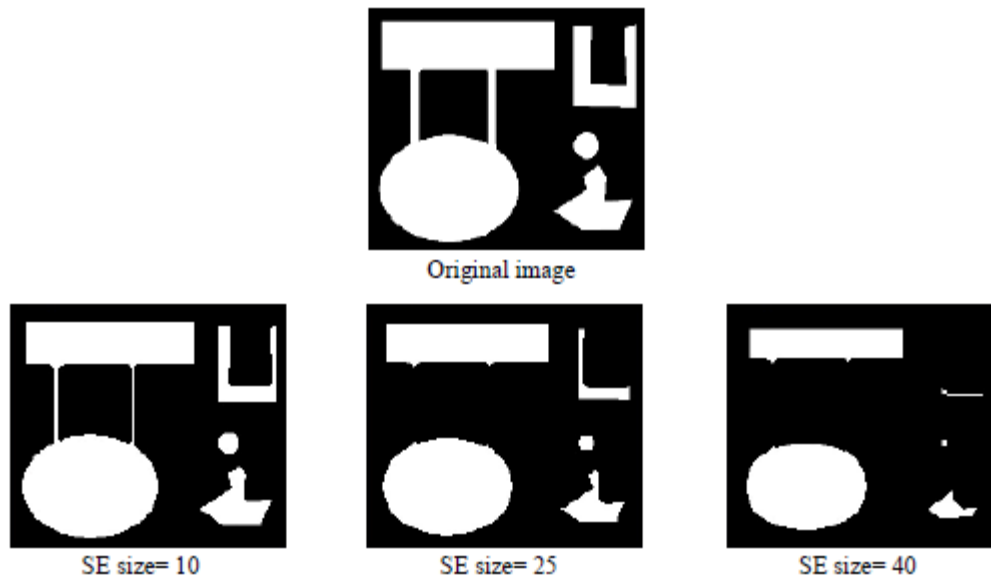


Figure (4.2) Effect of erosion on grayscale image with SE type = diamond

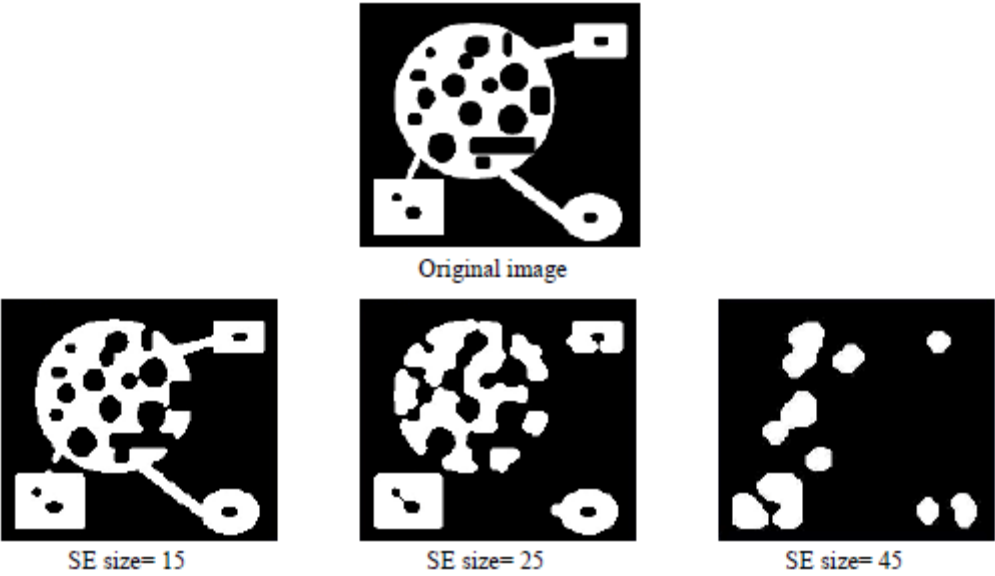


Figure (4.3) Effect of opening on grayscale image with SE type = octagon

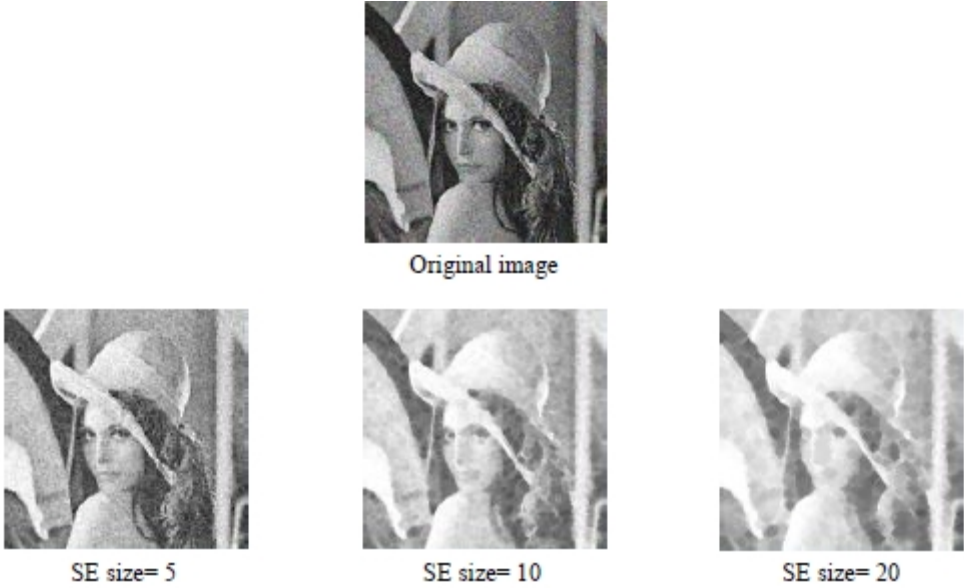


Figure (4.4) Effect of closing on grayscale image with SE type = diamond

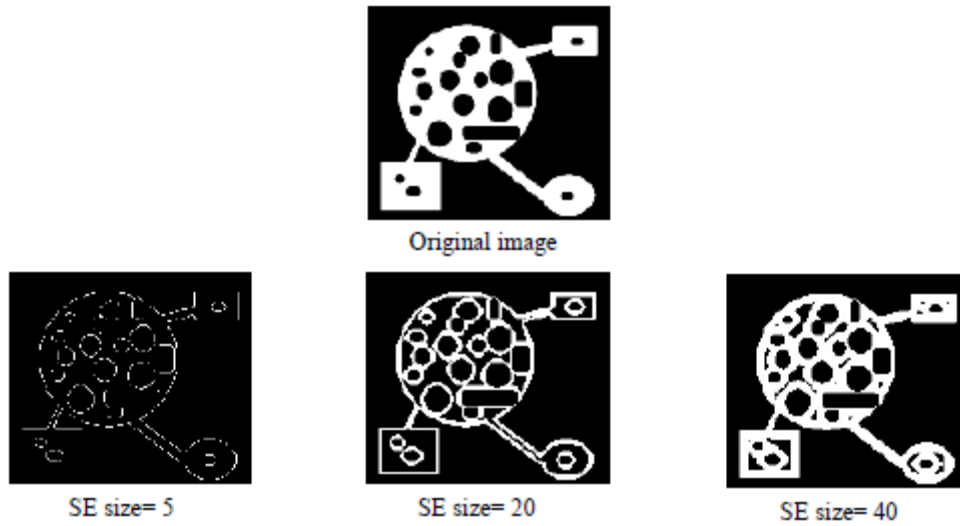


Figure (4.5) Apply boundary extraction algorithm on grayscale image with SE type = diamond



Figure (4.6) Apply boundary extraction algorithm on grayscale image with SE type = diamond



Figure (4.7) Apply region filling algorithm on grayscale image

5. IMAGE RESTORATION USING MORPHOLOGICAL OPERATIONS, A CASE STUDY

The general idea behind using Morphological operations in image restoration is to apply dilation & erosion with the same factor.

Example:



(a)
Original Image

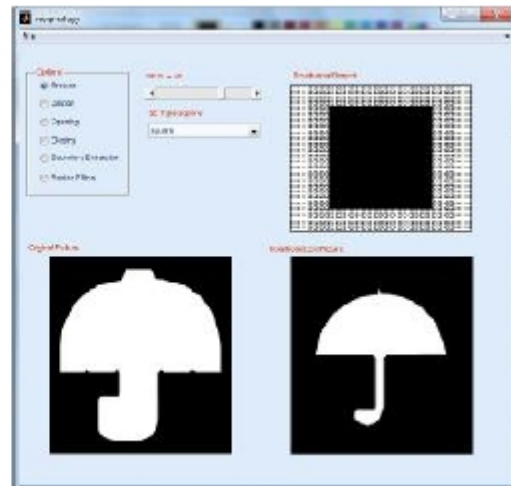
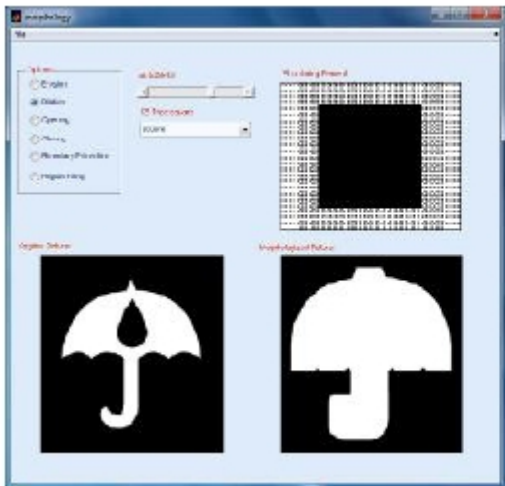


(b)
Apply dilation using square
SE size = 43 on image (a)



(c)
Apply erosion using square
SE size = 43 on image (b)

In matlab program:



The disadvantages of this method is if the objects near with the distance ($2 * SE_size$) then stuck together so in future work we will consider separating objects in the image.

6. CONCLUSION

Image processing techniques which deal with the shape (or morphology) of features in an image is described by Morphological image processing (or morphology). In this paper 4 morphological operations (dilation, erosion, opening and closing) and 2 basic algorithms (boundary extraction and region filling) are implemented in matlab program with user interface in which changing the parameters of SE such as its size or type are simple.

7. REFERENCES

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