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# AN APPLICATION OF MORPHOLOGICAL IMAGE PROCESSING TO FORENSICS

**Showkat Ahmad Dar**

Department of Computer Science & Engineering,  
Just Awantipora J&k-India

**Sajjad Ahmad Lone**

Department of Computer Science & Engineering,  
Just Awantipora J&k-India

## ABSTRACT

*Morphological Image Processing is an important tool in the Digital Image processing, since that science can rigorously quantify many aspects of the geometrical structure of the way that agrees with the human intuition and perception. Morphologic image processing technology is based on geometry. It emphasizes on studying geometry structure of image. We can find relationship between each part of image. When processing image with morphological theory. Accordingly we can comprehend the structural character of image in the morphological approach an image is analyzed in terms of some predetermined geometric shape known as structuring element. Morphological processing is capable of removing noise and clutter as well as the ability to edit an image based on the size and shape of the objects of interest. Morphological Image Processing is used in the place of a Linear Image Processing, because it sometimes distorts the underlying geometric form of an image, but in Morphological image processing, the information of the image is not lost. In the Morphological Image Processing the original image can be reconstructed by using Dilation, Erosion, Opening and Closing operations for a finite no of times. The major objective of this paper is to reconstruct the class of such finite length Morphological Image Processing tool in a suitable mathematical structure using Java language. The Morphological Image Processing is implemented and successfully tested in forensics*

**Keywords:** BI: Binary Image, GTI: Gray tone Image, CI: Color Image

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## 1. INTRODUCTION

The Morphological image processing is generally based on the analysis of a two valued image in terms of certain predetermined geometric shape known as structuring element. The term morphology refers to the branch of biology that deals with the form and structure of animals and plants.

A very well suited approach for extracting significant features from images that are useful in the representation and description of region shapes is morphological (shape-based) processing. Morphological processing refers to certain operations where an object is Hit or Fit with structuring elements and thereby reduced to a more revealing shape. These structuring elements are shape primitives which are developed to represent some aspect of the information or the noise. By applying these structuring elements to the data using different algebraic combinations, one performs morphological transformations on the data.

The Morphological Image Processing operations are applied for binary images in Forensics as fingerprint Enhancement and reduction of noise in finger print images.

## 2. DIGITAL IMAGE PROCESSING

Digital image processing involves the manipulation and interpretation of digital images with the aid of a computer and it is an extremely broad subject and it often involves procedures, which can be mathematically complex.

The central idea behind is quite simple. The digital image is fed in to the computer one pixel at a time. The computer is programmed to insert the data in to an equation or series of equations, and then store the results that may display or further processed. Digital image processing used to solve a variety of problems. Although often unrelated, these problems commonly require methods capable of enhancing pictorial information for human interpretation and analysis.

Employment of fingerprints as evidence of crime has been one of the most important utilities in forensics, since the date 19th century. Where there are no witness to a certain crime, finger prints can be very useful in determining the offenders.

The impressions left on the surface are called latent fingerprints, and caused by the ridges on the skin. In most cases, they are incomplete and degraded. The individual features that uniquely identify a fingerprint are called minutiae. Thus, the basic ridge pattern together with the minutiae and their location on the finger print pattern uniquely identify a fingerprint. The Morphological Image Processing will enhance the degraded noisy and / or incomplete latent fingerprints.

Image enhancement and restoration procedures are used to process degraded images of unrecoverable objects or experimental results too expensive to duplicate. In physics and related fields, computer techniques routinely enhance images of experiments in areas such as high-energy plasmas and electron microscopy. Similarly successful applications of image processing concepts can be found In astronomy, biology, nuclear medicine, law enforcement, and defense.

## 3. IMAGE DATA BASICS

An image refers to a 2-D light intensity function, based on this 2-D array of numbers the images are categorized in to three forms,

- Binary Image (BI)

- Grey Tone Image (GTI)
- Color Image (CI)

### 3.1. Binary Image

The image data of Binary Image is Black and White. Each pixel is either '0' or '1'. A digital Image is called Binary Image if the grey levels range from 0 and 1.

**Ex:** A Binary Image shown below is,

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \end{pmatrix}$$

(A 4\* 5 Binary Image)

## 4. READING THE TAG IMAGE FILE FORMAT

Image processing involves processing or altering an existing image in a desired manner. The first step is obtaining an image, while this may sound obvious; it is not a simple matter, since usable image data is not readily available.

The programmer needs a simple method of obtaining image data in a standard, usable format, called image file format. The image file format determines the image data storage and also gives additional storage information with the pixel values.

The image file consists of a Header Segment and a Data-Segment. The Header will contain, at the very least, the width and the height of the image. Since it is impossible to display or process any image without knowledge of its dimensions.

The Headers of most file formats begin with a signature or magic number. A short sequence of bytes designed to identify the file as an image with the specific format.

## 5. FITTING AND HITTING

The Structuring Element is positioned at all positions or possible locations in the Binary Image and it is compared with the corresponding neighborhood of pixels.

The morphological operation resembles a 'Binary' correction. where the operation is logical than arithmetic in nature.

**Ex.:** Suppose we have two 3 \* 3 structuring elements

$$S1 = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 1 & 0 \\ 1 & 1 & 1 \end{pmatrix}$$

$$S2 = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

In a given image A, B, C is the three positions where the S1 and S2 Structuring Elements should be positioned. Figure 1 shows the binary Image used to test Fitting and Hitting of Structuring Elements S1 and S2

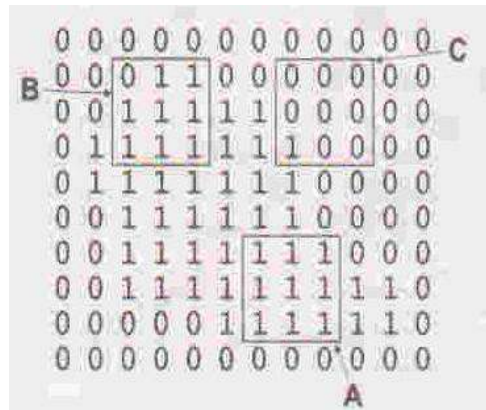


Figure 1

### FIT

The structuring element is said to FIT the image if, for each of its pixels that is set to '1', the corresponding image pixel is also '1'.

For the above example, Both S1 and S2 fit the image at 'A' (Remember that structuring element pixels set to '0' are ignored when testing for a fit). S2 fits the image at 'B' and neither S1 nor S2 fits at 'C'.

### HIT

A structuring element is said to HIT and Image if, for any of its pixels that is set to '1', the corresponding Image pixel is also '1'. (Here also we ignore Image pixels for which the corresponding structuring element pixel is '0'.)

For the above example, S1 and S2 HIT the Image in neighborhood 'A'. The same holds true at 'B'. But at neighborhood 'C', only S1 HITS the Image.

In this concept HITS corresponds to Union and where as the FITS corresponds to Intersection.

Furthermore it is possible to replace the set operation Intersection and Union by the Boolean operators 'AND' and 'OR'.

## 6. DILATION



### Dilation - Grow Image Regions

Dilation causes objects to dilate or grow in size. The amount and the way that they grow depend upon the choice of the structuring element [3]. Dilation makes an object larger by adding pixels around its edges.

The Dilation of an Image 'A' by a structuring element 'B' is written as  $A \oplus B$ . To compute the Dilation, we Position 'B' such that its origin is at pixel co-ordinates (x, y) and apply the rule.

$$g(x, y) = \begin{cases} 1 & \text{if 'B' hits 'A'} \\ 0 & \text{Otherwise} \end{cases}$$

Repeat for all pixel co-ordinates. Dilation creates new image showing all the location of a structuring element origin at which that structuring element HITS the Input Image. In this it adds a layer of pixel to an object, there by enlarging it. Pixels are added to both the inner and outer boundaries of regions, so Dilation will shrink the holes enclosed by a single region and make the gaps between different regions smaller. Dilation will also tend to fill in any small intrusions into a region's boundaries.

The results of Dilation are influenced not just by the size of the structuring element but by its shape also.

Dilation is a Morphological operation; it can be performed on both Binary and Grey Tone Images. It helps in extracting the outer boundaries of the given images.

## 7. FOR BINARY IMAGE

Dilation operation is defined as follows,

$$D(A, B) = A \oplus B$$

Where,

A is the image

B is the structuring element of the order  $3 * 3$ .

Many structuring elements are requested for dilating the entire image.

## 8. EROSION



**Erosion - Shrink Image Regions**

Erosion causes objects to shrink. The amount of the way that they shrink depends upon the choice of the structuring element. Erosion makes an object smaller by removing or eroding away the pixels on its edges [3].

The Erosion of an image 'A' by a structuring element 'B' is denoted as  $A \ominus B$ . To compute the Erosion, we position 'B' such that its origin is at image pixel co-ordinate (x, y) and apply the rule.

$$G(x, y) = \begin{cases} 1 & \text{if 'B' Fits 'A',} \\ 0 & \text{otherwise} \end{cases}$$

Repeat for all x and y or pixel co-ordinates. Erosion creates new image that marks all the locations of a Structuring elements origin at which that Structuring Element fits the input image. The Erosion operation seems to strip away a layer of pixels from an object, shrinking it in the process. Pixels are eroded from both the inner and outer boundaries of regions. So, Erosion will enlarge the holes enclosed by a single region

as well as making the gap between different regions larger. Erosion will also tend to eliminate small extrusions on regions boundaries.

The result of erosion depends on Structuring element size with larger Structuring elements having a more pronounced effect & the result of Erosion with a large Structuring element is similar to the result obtained by iterated Erosion using a smaller structuring element of the same shape.

Erosion is the Morphological operation, it can be performed on Binary and Grey images. It helps in extracting the inner boundaries of a given image.

## 9. FOR BINARY IMAGES

Erosion operation is defined as follows,

$$E(A, B) = A \ominus B$$

Where,

A is the image

B is the structuring element of the order  $3 * 3$ .

Many structuring elements are required for eroding the entire image.

## 10. OPENING



**Opening** - structured removal of image region boundary pixels it is a powerful operator, obtained by combining Erosion and Dilation. “Opening separates the Objects”. As we know, Dilation expands an image and Erosion shrinks it [8]. Opening generally smoothes the contour of an image, breaks narrow Isthmuses and eliminates thin Protrusions [1].

The Opening of an image ‘A’ by a structuring element ‘B’ is denoted as  $A \circ B$  and is defined as an Erosion followed by a Dilation, and is

Written as [3],

$$A \circ B = (A \ominus B) \oplus B$$

Opening operation is obtained by doing Dilation on Eroded Image. It is to smoothen the curves of the image. Opening spaces objects that are too close together, detaches objects that are touching and should not be, and enlarges holes inside objects.

Opening involves one or more Erosions followed by one Dilation.

## 11. CLOSING



**Closing** - Structured Filling In of Image Region Boundary Pixels

It is a powerful operator, obtained by combining Erosion and Dilation. “Closing, join the Objects” [3]. Closing also tends to smooth sections of contours but, as opposed to Opening, it generally fuses narrow breaks and long thin Gulf’s, eliminates small holes and fills gaps in the contour [1].

The Closing of an image 'A' by a structuring element 'B' is denoted as  $A \bullet B$  and defined as Dilation followed by Erosion; and is written as [3].

$$A \bullet B = (A \oplus B) \ominus B$$

Closing is obtained by doing Erosion on Dilated image. Closing joins broken objects and fills in unwanted holes in objects.

Closing involves one or more Dilations followed by one Erosion.

## 12. EXPERIMENTAL RESULT

### 1. Finger Print Enhancement

Fingerprints are unique. The differences between fingerprints are due to the type and the position of the ridge characteristics. In most cases, acquired latent fingerprints are degraded, noisy and or incomplete. Thus to reduce the rejection rates during the matching stage, latent fingerprints have to be enhanced prior to matching. This can be enhanced using Morphological Image Processing.

The figure 2 is original image, to enhance the fingerprints we are subjecting to the Morphological Operations. When the image is Dilated, it leaves specific & clear ridges to visualize, can be seen in fig3. By Eroding the fig (3), the ridges are thickened for analysis. Can be seen in fig 2.

By performing Open operation to fig (2), the ridges that are broken can be joined to analyze the fingerprints clearly, can be seen in fig 3. And by performing Close operation to the fig (2), the ridges which are overlapped can be separated and can be analyzed clearly, can be seen in fig 5.

### 2. Original Binary Image



Figure 2

### 3. Dilated Image

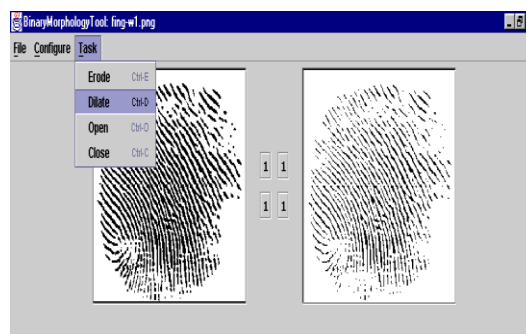


Figure 3



#### 4. Eroded Image

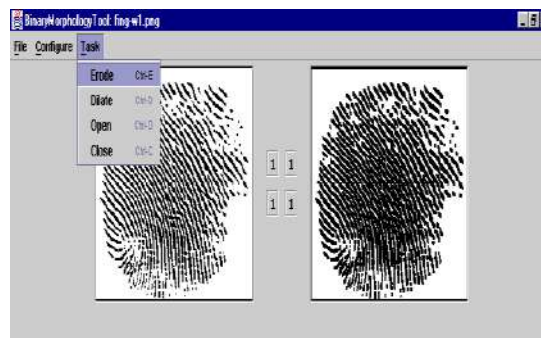


Figure 4

#### 5. Open Image

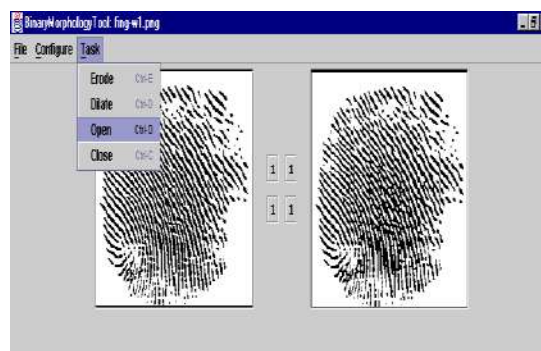


Figure 5

#### 6. Close Image

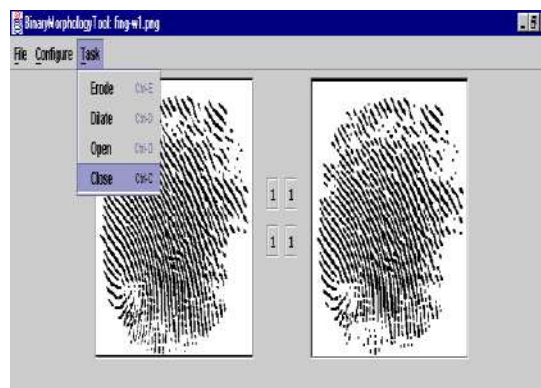


Figure 6

### 13. CONCLUSION

This report represents the practical operation of Morphological Image Processing and it successfully performed the Fundamental and Compound operations of Morphological Image processing on Binary images in, Forensics Fingerprint Enhancement and reduction of noise in finger print images.

## 14. IMPLEMENTATION

This concept has been implemented in java. The java platform provides a convenient representation for images that makes the implementation of image processing software relatively straight forward. The Binary image operations are implemented using Swings and have a GUI for performing Dilation, Erosion, Opening & Closing operations

## 15. FUTURE SCOPE

The Morphological Image Processing can be further applied to a wide spectrum of problems including:

- Medical image analysis: Tumor detection, measurement of size and shape of internal organs, Regurgitation, etc.
- Robotics: Recognition and interpretation of objects in a scene, motion control and execution through visual feedback
- Radar imaging: Target detection and identification.

And this is further extended to Color image concept and 24-bit True Color concept and a special feature such as Automatic selection of Structuring element for object classification through Morphology is still challenging to this technique and has been chosen to be the major direction of the future work.

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