International Journal of Recent Trends in Engineering & Research
ISSN(ONLINE) : 2455-1457 IMPACT FACTOR : 3.344

A Review On Role Of Mathematical Morphology In Digital Image Processing

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A B S T R A C T-The geometric structures of images and signals can be systematically analyzed by using mathematical morphology. Mathematical morphology provides very useful tools and techniques for analysis of digital images. Image Operations like reduction, enlargement, rotation, color corrections, quantization or image differencing are geometric transformations. The basic assumption in image morphology is that image contains geometric structures that can be handled by set operators. Mathematical morphology can be used in many areas like noise elimination, feature extraction, edge detection and image segmentation. In this paper role of mathematical morphology in digital image processing will be described.
Keywords: Mathematical Morphology, Dilation, Erosion, Structuring Element, Image Processing, Noise

I. INTRODUCTION

Morphologic image processing technology is based on geometry. Mathematical morphology developed from mathematical set theory and it was earlier introduced by Matheron for geometrical analysis and later extended to image analysis by J.Serra. It emphasizes on studying geometry structure of image by finding the relationship between each part of image[1]. In the morphological approach, an image is analyzed in terms of some predetermined geometric shape known as structuring element. Small matrix used to analyze an image under study for properties of interest. The structuring element is sometimes called the kernel. The Kernel is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one.

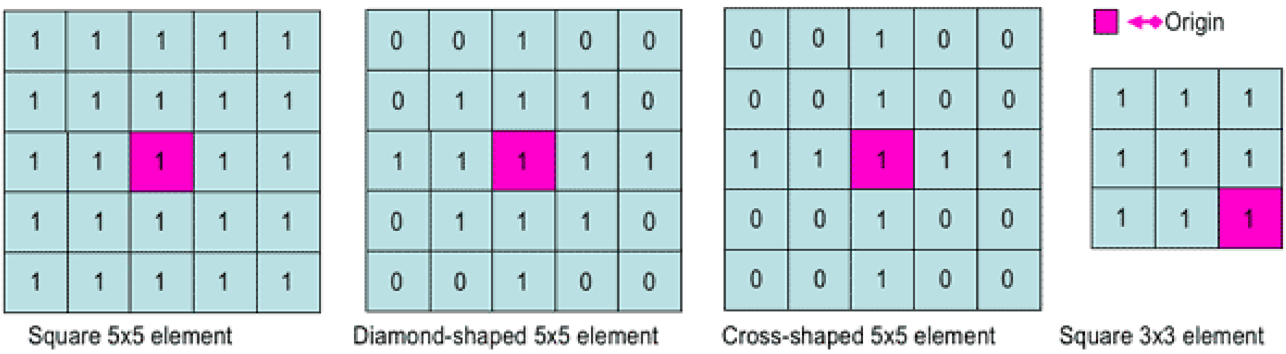

Figure 1 Examples of structuring elements

Morphological processing has a capability of removing noise and enhancing an image. The image can also be modified based on the size and shape of the objects of interest. The morphological processing refers to branch of non linear image processing which can be used in place of a linear image processing, because it sometimes distort the given geometric form of an image, the information in Morphological image Processing remain preserved[2]. This technology is having a significant role in many fields of image processing.

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.

II. MORPHOLOGICAL TRANSFORMATION OPERATION

Image morphology is the name of a specific methodology used for analyzing the geometric structure inherent within an image[3]. The theoretical base of mathematical morphology is set theory. In digital images, the points which belong to set are called foreground and which belongs to complement set are called background.

A. **Dilation**

Dilation causes objects to dilate or grow in size. The amount and the way that they grow depends upon the choice of the structuring element. Dilating without specifying the structural element makes no more sense than trying to lowpass filter an image without specifying the filter. Dilation of A by B is defined as

$$D(A,B) = A \oplus B = \bigcup_{\beta \in \mathrm{B}} (A+\beta)$$

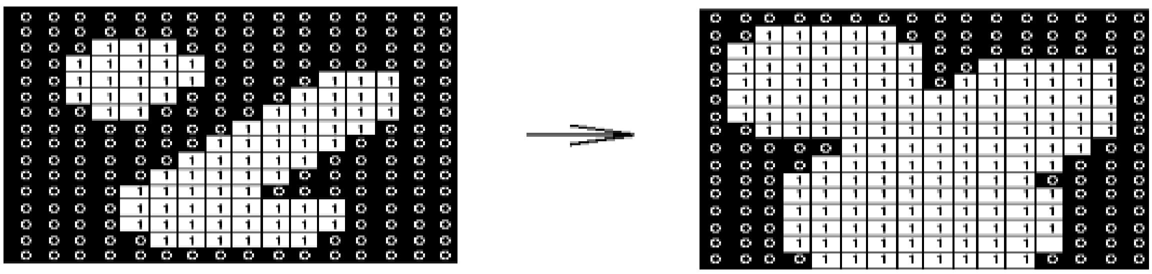

*Figure 2 Effect of dilation using a 3*3 square structuring element*

B. Erosion

Erosion work (at least conceptually) by translating the structuring element to various points in the input image, and examining the intersection between the translated kernel coordinates and the input image coordinates. The erosion of A by B is defined as

$$\mathrm{E(A,B)=A} \ominus \mathrm{B} = \bigcap_{\beta \in \mathrm{B}} (\mathrm{A} - \beta)$$

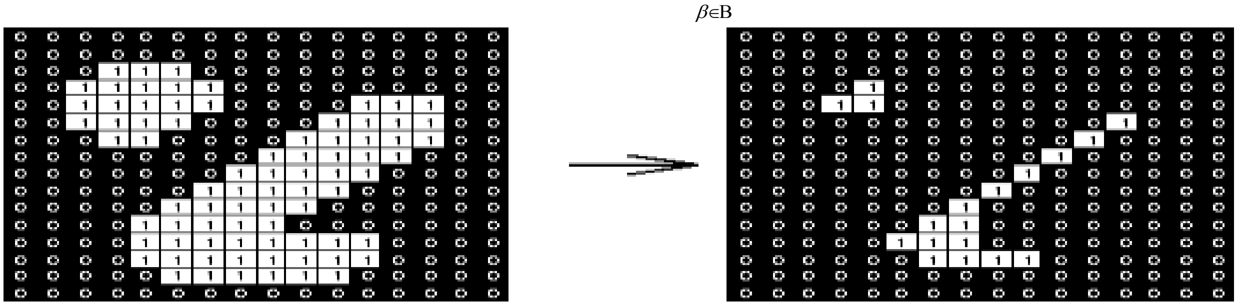

*Figure 3 Effect of Erosion using a 3*3 square structuring element*

C. Opening

Very simply, an opening is defined as erosion followed by a dilation using the same structuring element for both operations. The opening operator therefore requires two inputs: an image to be opened, and a structuring element.

$$O(A,B)=A\circ B=D(E(A,B),B)$$

The basic effect of an opening is somewhat like erosion in that it tends to remove some of the foreground (bright) pixels from the edges of regions of foreground pixels. However it is less destructive than erosion in general.

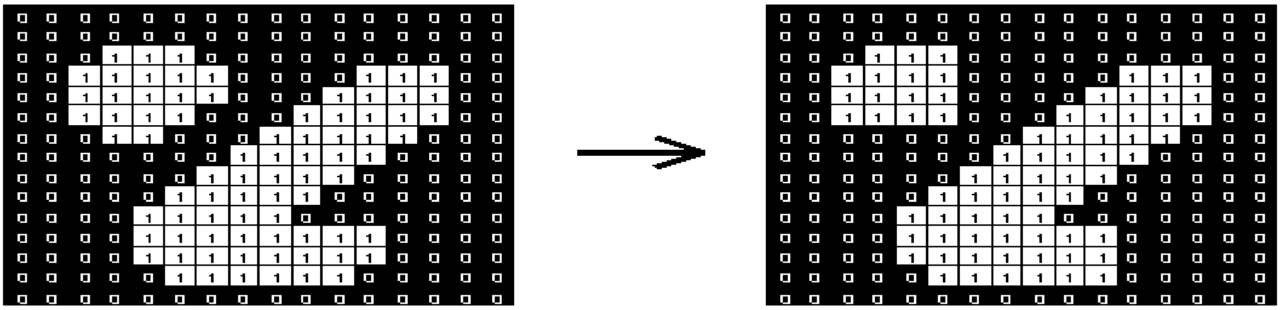

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Figure 4 Effect of Opening using a 3*3 square structuring element

D. Closing

Closing is defined as an dilation followed by erosion using the same structuring element for both operations. The closing operator therefore requires two inputs: an image to be closed, and a structuring element. Closing is similar in some ways to dilation in that it tends to enlarge the boundaries of foreground (bright) regions in an image (and shrink background color holes in such regions), but it is less destructive of the original boundary shape.

$$C(A,B)=A\bullet B=E(D(A,-B),-B)$$

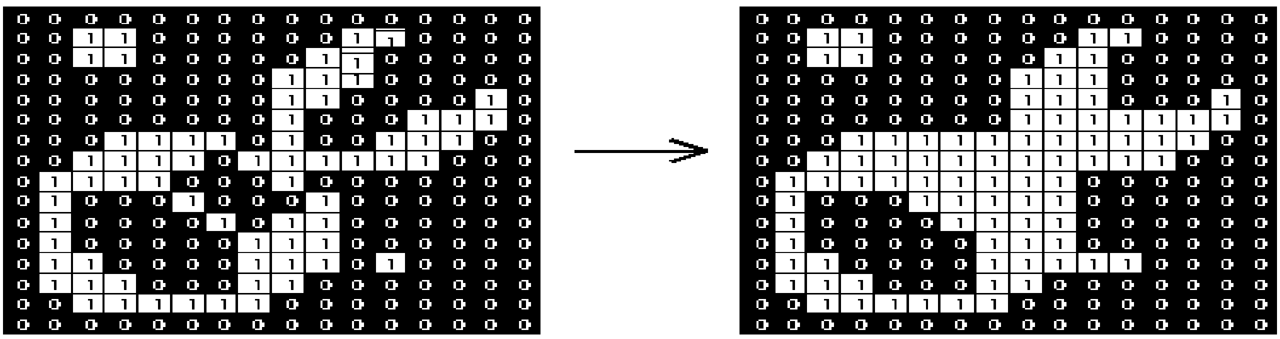

Figure 5 Effect of Closing using a 3*3 square structuring element

Some features of mathematical morphology are given below which makes it highly useful in image processing system.

a) The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels.
b) There exists a well-developed mathematical morphological algebra which can be employed for representation.
c) It is possible to express digital algorithms in terms of a very small class of primitive morphological operations which can be employed for representation and optimization.
d) There exist rigorous representations theorems by means of which one can obtain the expression of morphological filters in terms of the primitive morphological operations.

III. APPLICATIONS OF MATHEMATICAL MORPHOLOGY

A. Face detection using morphological image processing

The aim of this study is to detect and locate human faces in a color image. A wide spectrum of techniques has been used including color analysis, template matching, maximal rejection classification and model based detection[4]. This method uses rejection based classification. Various steps under this algorithm are[5].

a) The non-skin color regions are rejected using color segmentation.
b) A set of morphological operations are then applied to filter the clutter resulting from the previous step.
c) The remaining connected regions are then classified based on their geometry and the number of holes.
d) Finally, template matching is used to detect zero or more faces in each connected region.

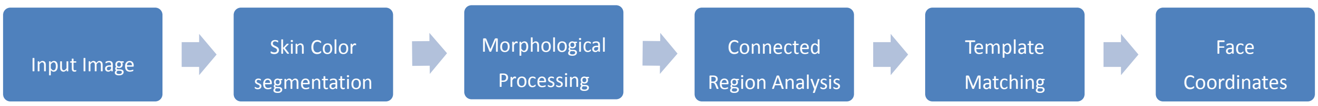

Figure 6 Block diagram of face detector

B. Text extraction for Image

Text in the image contains useful information which helps to acquire the overall idea behind the image. Character extraction from image is important in many applications[6]. Extraction of text information present in scene images finds diverse applications, such as automatic annotation, indexing, and structuring of images, document analysis, vehicle license plate extraction, technical paper analysis, and object oriented data compression. Mathematical morphology is used to perform the edge detection [7]. This algorithm is used to find out the connected component, in connected component set gray level value of each component is calculated, when components are found then labeling is done. After the selection process components whose variation is less than threshold value the text can be extracted. This method consists of four steps[8]:

a) Edge extraction
b) Text Candidate Region Formation
c) Labeling of Text candidate regions
d) Elimination of non text regions

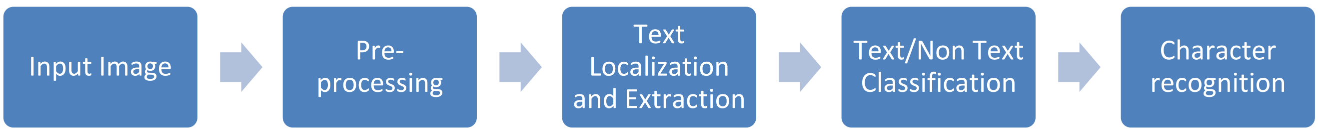

Figure 7 Block diagram for text extraction from image

C. Denoising Using Morphological Filters

Dilation removes the negative impulse and smoothes the positive impulse and Erosion removes the positive impulse and smoothes the negative impulse, opening removes the positive impulse and reserves negative impulse; closing removes the negative impulse and smoothes the positive impulse[9]. Opening and closing combined calculations is often applied when the morphological is used. The main goal of morphological de-noising is to extract the impulse signal and depress the noise in the bearing testing signals, so the differential filter of morphological closing and opening is used for this purpose[10]. So equation 1 is used as differential filter.

$$DIF(f) = f \bullet g - f \circ g$$

D. Image Compression

Image compression is the representation of an image in digital form with as few bits as possible while maintaining an acceptable level of image quality [11]. Mathematical morphological operations can used for purpose of image compression. The significance map is preprocessed using mathematical morphology operators to identify and create clusters of significant coefficients[12]. Application of mathematical morphology self organizing feature map based image compression system to broad classes of images resulted in a satisfactory PSNR to the compression ratio.

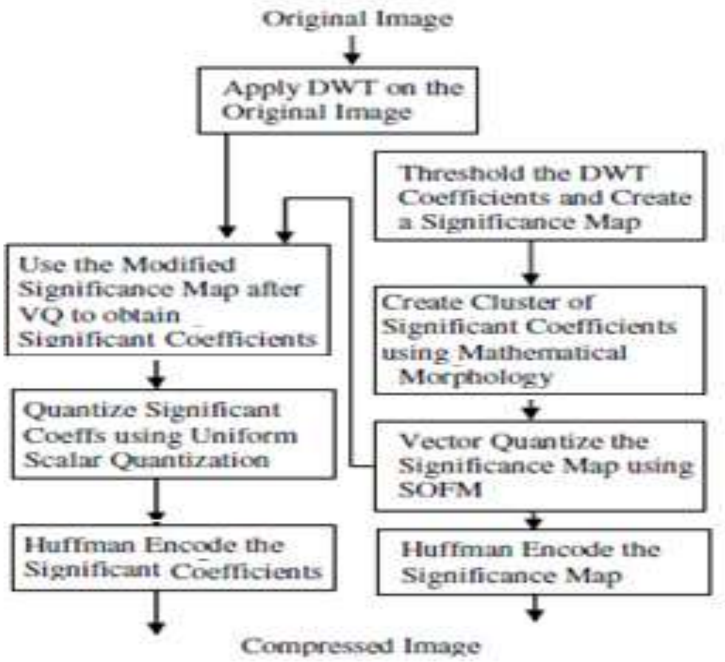

Figure 7 Block diagram of Compression System

IV. CONCLUSION

It has been concluded that mathematical morphology is having a many significant applications in digital image processing. There are many applications of mathematical morphology in image processing such as image enhancement, image restoration, noise detection, component analysis and text extraction from image, these applications are fulfilled with the help of mathematical operators such as dilation, erosion, opening and closing.

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