



Mathematical Morphology Operations in MATLAB - An Overview

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Abstract— The image enhancement problem in digital images can be approached from various methodologies. Morphology is a broad set of image processing operations that process images based on shapes. Mathematical morphology is a theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology and random functions. Morphological operations supplies powerful tools for low-level image analysis and nonlinear branch in image processing. In morphological operators transforms the original image into another image through the interaction with the other image of certain shape and size which is known as the structure element. It directly related to the shape of objects in the image, majorly applied on gray scale and binary images. In this paper, the various kind of mathematical morphology operations on binary images are discussed with MATLAB software. Because when we process the image, MATLAB is the easiest tool to represent and process the image.

Keywords— Image processing, Morphological operations, Erosion, Dilation, Opening closing.

I. INTRODUCTION

Mathematical morphology is a foundation of morphological image processing. This consists of a set of operators that transform images according to the characterizations. Mathematical operators were developed for binary images and it was latterly extended to gray scale functions and images (7). These operations tend to simplify image data preserving their essential shape characteristics and eliminating irrelevances. As the identification of objects, object features and assembly defects correlate directly with shape; it becomes apparent that the natural processing approaches to deal with the machine vision recognition process.

Morphological operations are affecting the form, structure or shape of an object (4). Applied on binary images they are used in pre or post processing such as filtering, thinning and pruning. And also it's for getting a representation or description of the shape of objects and regions like boundaries and skeletons of the images.

A. Gray scale Image

A gray scale digital image value of each pixel carries intensity information (12). Gray scale images have many shades of gray in between; it is also called monochromatic, denoting the presence of only one (mono) color (chrome). Gray scale image are often the result of measuring the intensity of light at each pixel in a single band of electromagnetic spectrum and in such cases they are monochromatic proper when only a given frequency is captured.

B. Binary Image

In a binary image, each pixel assumes one of only two discrete values such as 1 or 0. A binary image is stored as logical array. `BW=im2bw (I, level)` this function converts the gray scale image I to a binary image. If the input image is not a gray scale image, `im2bw` converts the input image to gray scale, and then converts this gray scale image to binary by threshold (12).

The rest of the paper is structures as follows. Section 1 gives some basic information's about images and morphological operations. Section 2 embraces the various existing algorithms and some logical operations on images. It is followed by section 3 which includes the mathematical morphology operations. The next section 4 contains the discussions and applications about the morphological

operations. Finally Section 5 brings to a close with conclusion of the processed mechanism.

II. LITERATURE REVIEW

In 2015, Poonam Kumari and Sanjeev Kumar Gupta (8) has present an overview of Morphological Image Processing and edge detection using gradient based on different operators in MATLAB and developed its GUI (Graphical User Interface). The authors describe the basic technological aspects of Digital Image Processing with reference to Morphological techniques used in image processing. They also discussed the basic theory of morphological image processing and edge detection techniques to provide the importance of morphological operations in now a day. The objective of this paper is to study the boundary extraction and edge detection by using some morphological operations dilation, erosion, opening and closing, hit or miss etc.

In 2013, Amalorpavam.G et al. (2) discussed a study to transform the digital images into different forms. The authors developed this study is fully focused on the image transformation using mathematical morphology operations. They also provided some morphological operations which are performed on MATLAB image processing software.

In 2008, Rodrigo Frigato and Erivaldo Silva (9) has come out with an implementation of the extraction process which is depends on mathematical morphology processing. The authors integrate the remote sensing data and morphological techniques in same. The proposed method in this paper was related to pre-process which is applied on the original images. Finally they concluded that there results indicated better performance compared with existing methods.

2.1 Logical operations on images

A. Logical AND operation

The AND operation takes two binary representations of equal length and performs the logical AND operation on each pair of corresponding bits (5). If the first bit and second bit is 1, the result in each position is 1; otherwise the result is 0.

B. Logical OR operation

An OR takes two bit patterns of equal length and performs the logical inclusive OR operation on each pair of corresponding bits (13). The result in each position is 1 if the first bit or the second bit or both bits are 1, otherwise the result is 0. Perform the addition operation of the two bits in image (0,1) that is $0+1=1$, however $1+1=1$.

C. Logical NOT operation

Negation is an operation on one logical value, typically the value of a preposition that produces a value of true, when its operand is false and a value of false when its operation is true (11).

III. MORPHOLOGICAL OPERATIONS IN IMAGE

A. Structuring Elements

An essential part of the dilation and erosion operations is the structuring elements used to probe the input image (13). A structuring element is a matrix consisting of only 0's and 1's that can have any arbitrary shape and size. The pixels with values of 1 define the neighbourhood.

B. Morphological operations

1. Dilation

Dilation is typically applied to binary image (1). The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels. Thus areas of foreground pixels grow in size while holes within those regions become smaller.

Effects on Dilation

- Expand and enlarge the objects in the image
- Fill gaps or bays of insufficient width
- Fill small holes of sufficiently small size
- Connect objects separated by a distance less than the size of the window



Fig.1. (a).Original image (b).Dilation by 3*3 (c).Dilation by 5*5

2. Erosion

The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels. Thus areas of foreground pixels shrink in size, and holes within those areas become larger (3).

Effects on Erosion

- Shrink object in the image
- Split the connected objects in the image
- Not filling the holes of the image

- Break the joins of the image



Fig.2.(a) Original image (b). Erosion b 3*3 (c). Erosion by 5*5

3. Opening

Dilation and Erosion are often used in combination to implement image processing operations. The normal morphological opening is erosion followed by dilation. The erosion “shrinks” an image according to the shape of the structuring element, removing objects that are smaller than the shape (3). Then the dilation step regrow’s the remaining objects by the same shape.

Effects on Opening

- Smooth contour
- Remove the protrusion



Fig.3. (a). Original image (b).Opening operation image

4. Closing

The normal morphological closing is a dilation followed by erosion. The dilation step “grows” the objects followed by the erosion which “shrinks” an image according to the shape of the structuring element, removing objects that are smaller than shape (6).

Effects on Closing

- Fuse narrow breaks
- Remove small holes and fill gaps

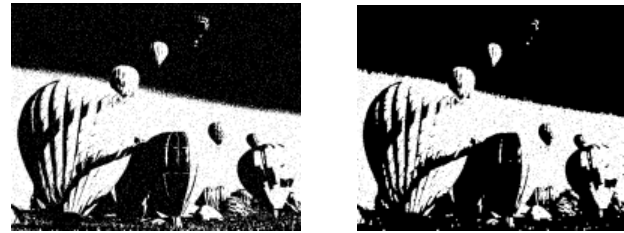


Fig.4. (a). Original Image (b). Closing image

5. Hit or Miss Transformation

In mathematical morphology, hit or miss transform is an operation that detects a given pattern in a binary image, using the morphological erosion operator and a pair of disjoint structuring elements (10). The result of the hit or miss transform is the set of positions, where the first structuring element fits in the foreground of the input image and the second structuring element misses it completely.

IV. APPLICATIONS IN MORPHOLOGICAL OPERATIONS

In this paper, the following applications are used as the morphological operations to enhance the image quality, such as the boundary extraction, thickening, thinning and regional filling.

A. Boundary Extraction

$$\beta(A) = A - A \odot B$$

$\beta(A)$ is the resultant picture of the boundary of A. The boundary extraction A minus the eroded picture, $A \odot B$. The resultant image after subtracting the eroded image from the original image has the boundary of the objects extracted. The thickness of the boundary depends on the size of the structuring element.

B. Thickening

The relation of A with B dilation resultant image is

$$A \odot \{B\} = ((... ((A \odot B^1) \odot B^2) ...) \odot B^n)$$

C. Thinning

$$A \otimes B = A - (A \odot B) = A \cap (A \odot B)^c$$

A is the original picture, B is the structural element and $A \odot B$ is the resultant picture of the erosion of A with B.

In this paper, a framework for image enhancement based on mathematical morphology has been presented. The various mathematical morphology operations are tested with MATLAB software to provide efficient image enhancement results.



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V. CONCLUSION

Some basic operations of morphological concepts are discussed in this paper with the help of MATLAB software. The morphological operations are having powerful set of tools for extracting features of interest in an image. A significant advantage in terms of implemented is the fact that dilation and erosion are primitive operations of morphology. And also the paper provides various applications to enhance the image like thinning, thickening and boundary extraction. When using the MATLAB tool it is the easiest one to enhance the image in image processing.

Future Work

In future, various image enhancement schemes like histogram equalization to improve the contrast and filtering in image noise is also considered. And some filtering with noise removal techniques are also implemented in future.

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