



Image Segmentation using Mathematical Morphology : A Study

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Abstract- Mathematical morphology deals with the mathematical theory of describing shapes using sets. It is a non-linear image processing method for the analysis and processing of geometrical structures. Mathematical morphology has been widely used for many applications of image processing and analysis. In image processing, it is used to investigate the interaction between an image and a certain chosen structuring element. Morphological techniques include erosion and dilation, opening and closing, outlining, and thinning and skeletonization. Mathematical morphology can be used for edge detection, image segmentation, noise elimination, feature extraction and other image processing problems. In this paper we are going to discuss document image segmentation using morphological operations.

Keywords: Morphology, Dilation, Erosion, Opening, Closing

1. INTRODUCTION

Image segmentation is the one of the most important operation in Computer Vision and Image Processing. Segmentation is the partition of a digital image into different regions according to some criterion. The main aim of segmentation is to locate objects of interest in the image. Fig. 1 shows the Digital Image Segmentation System [2].

Pre-processing for Image Enhancement

Input Image

Segmentation

Output segmented Image

Post-processing for Image enhancement

Fig: 1 Digital Image Segmentation System

Input image that is acquired from some problem domain by using some image acquisition system is submitted to the pre-processing phase for image

enhancement. After that segmentation of image is done in the segmentation phase. The actual segmentation is stopped when

object of interest is isolated. Today, several research groups are doing work in the field of document image analysis and developing and designing systems to automatically process and extract relevant information from documents such as magazines, maps, newspapers, engineering drawings, forms etc. Image Segmentation techniques are broadly classified following different categories.

- Histogram based techniques
- Region based techniques
- Edge based methods
- Morphology based technique
- Hybrid technique

In the following sections, morphological techniques for image segmentation have been discussed.

2. MORPHOLOGICAL TECHNIQUE:

Mathematical morphology is a powerful tool to extract information from images that concentrates on the geometrical structure with in the image. Most of the morphological operations like opening and closing are implemented using the two basic operations, erosion and dilation [3,4,5]. Mathematical morphology is used for image segmentation due to the following salient features [1].

1. Morphological operations provide for the systematic alteration of the geometric content of an image while maintaining the stability of the important geometric characteristics.
2. There exists a well developed morphological algebra that can be employed for representation and optimization.
3. It is possible to express digital algorithms in terms of a very small class of primitive morphological operations.
4. There exist rigorous representations theorems by means of which one can obtain the expression of morphological filters in terms of the primitive morphological operations.

2.1 Morphological Operations

Mathematical morphology provides a wide range of operators which are based on the concept of set theory. Some of the operations are described in this section.

2.1.1 Dilation and Erosion are the main functions which make the object smaller and larger. Dilation increases the area of an object by adding pixels around the boundaries and fills interior holes. Erosion makes an object smaller by removing or

eroding away the pixels on its edges. To carry out the dilation and erosion two pieces of data to be submitted: an image to be eroded or dilated, and the structuring element.

Let $A: z^2 \rightarrow z$ be a gray scale image and $B: z^2 \rightarrow z$, a structuring element, then dilation of A by B is denoted by $A \oplus B$ is given as [1]

Where $(x+s, y+t) \in D_A, (s, t) \in D_B$ and D represents the discrete domain of the images.

The erosion of A by B is denoted by $A \ominus B$ is given as

Where $(x+s, y+t) \in D_A, (s, t) \in D_B$.

2.1.2 Opening and Closing

Opening and closing help to separate and join objects. Opening operation detaches objects that are touching but should not be, and enlarges holes inside the objects. By repetitively applying erosion and dilation, image details which are smaller than the structuring elements can be eliminated without affecting its global geometric features. It smoothes contours by suppressing small islands. So, opening operation is simply an erosion operation followed by a dilation operation. Opening operation is defined as

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

Closing operation joins broken objects and fills in unwanted holes in objects. It smoothes the contours by filling in narrow gulfs and eliminates small holes. It involves one or more dilations followed by one erosion.

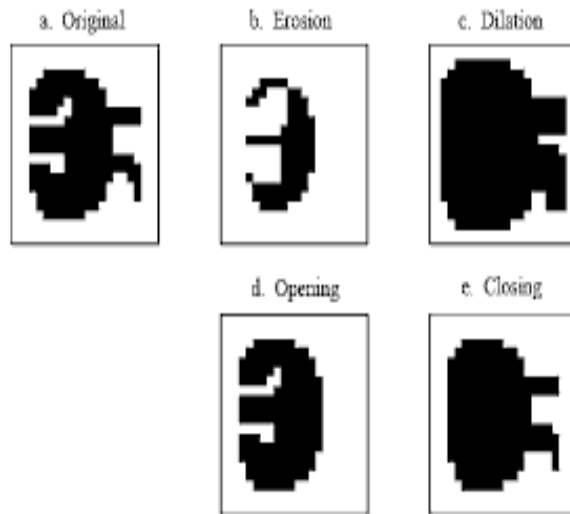
$$(A \bullet B) = (A \oplus B) \ominus B$$

2.2 Structuring Element

Structuring element is just a set of point coordinates that differs from the input image in the sense that it is much smaller than the input image coordinate set and second its coordinate origin is not in the corner. Structuring element is assumed to be of a particular shape. There are mainly two types of structuring elements [3,4].

- Flat Structuring Element (Take two parameters and used for two dimensional images)
- Non-Flat structuring Element (Take three parameters and used for three dimensional images)

Further Flat structuring elements are arbitrary, pair, diamond, disk, periodic line, rectangle, line, square, octagon. Non-Flat structuring elements are arbitrary and ball.



3. SOME BASIC MORPHOLOGICAL ALGORITHMS

3.1 Boundary Extraction

Boundary of any object A in image can be obtained by first eroding object by structuring element B and then performing the set difference between A and its erosion.

$$\text{Boundary (A)} = A - (A \ominus B)$$

Boundary of any object A in image can be obtained by first eroding object by structuring element B and then performing set difference between A and its erosion.

3.2 Region Filling

An algorithm for region filling can be developed based on set dilations, complementation and intersections.

$$(A \oplus B) \cap A^c \quad K=1, 2, 3, \dots$$

3.3 Thinning

Thinning is the data reduction process that erodes an object until it is one-pixel wide, producing a skeleton of the object. It will be easy to recognize

objects such as letters or silhouettes by looking at their bare bones. Thinning is done by eroding the image repetitively until it gets one pixel wide. AB can be defined

$$AB = A - (AB)$$

AB is the hit-or-miss transform between sets A and B.

3.4 Thickening

Thickening is the morphological dual of thinning and is defined as

$$A \oplus B = A(AB)$$

4. CONCLUSION

Mathematical Morphology is an important tool in the image processing . There are many morphological operators such as Erosions , Dilation, Thinning, Convex Hull, Skeletons using which features of objects in digital images can be extracted.

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