

ANALYSIS OF DIGITAL IMAGES USING MORPHOLOGICAL OPERATIONS

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ABSTRACT

The main aim of this study is to transform the digital images into different forms. Image processing techniques are used with wide varieties of applications. The requirement is different for different applications. This study is mainly focused on how to transform the image using mathematical morphology so that it can be suitable for the respective applications.

Mathematical morphology has been chosen to explain how images are used to illustrate mathematical set theoretic operations, such as union, intersection by means of morphological operations like dilation and erosion.

These techniques are implemented in MATLAB using image processing algorithms. MATLAB is an excellent tool to accomplish these tasks.

KEYWORDS

Image Analysis, Morphological Morphology, Dilation, Erosion, Opening and Closing Operation, hit-or-miss operation, thinning, thickens and gray-scale.

1. INTRODUCTION

The field of digital image processing refers to processing digital images by means of a digital computer. In image processing operations both the input and the output are images.

2. MATHEMATICAL MORPHOLOGY

2.1 Basic morphological concepts

Mathematical morphology, which started to develop in the late 1960s, stands as a relatively separate part of image analysis. Mathematical morphology uses the concept of mathematical set theory for extracting meaning from the image.

A morphological transformation is given by the relation of the image (point set X) with another small point set B called a Structuring element. B is expressed with respect to a local origin O (called the representative point).

Morphological technique is a powerful tool for extracting features from an image.

2.1 Binary dilation and erosion

The set of black and white pixels constitute a description of a binary image. Assume that only black pixels are considered, and the others are treated as a background. The primary morphological operations are dilation and erosion, and from these two, more complex morphological operations such as opening, closing, and shape decomposition can be constituted.

2.2 Dilation

The dilation operation thickens the image. The extent of how much it should be thicken is based on the structuring element. The structuring element is a part of the image.

The morphological transformation dilation (+) combines two sets using vector addition. The dilation operation can be done by performing vector addition of the pair of elements for both the sets X and B .

Example:

$$\begin{aligned} X &= \{(1,0), (1,2), (1,2), (2,2), (0,3), (0,4)\} \\ B &= \{(0,0), (1,0)\} \\ X(+)B &= \{(1,0), (1,2), (1,2), (2,2), (0,3), (0,4), \\ &\quad (2,0), (2,2), (2,2), (3,2), (1,3), (1,4)\} \end{aligned}$$

The input image as shown below in Fig. (1)

input image 1



Fig(1): Input Image

The dilated image is as shown in Fig(2)

Dilated image



Fig(2):Dilated Image

2.3 Erosion

The erosion operation performs either shrinking or thinning of the object. The extent of this operation is decided by the structuring element.

Erosion (-) combines two sets using vector subtraction of set elements is the dual operator of dilation. Neither erosion nor dilation is an invertible transformation.

Example:

$$X=\{(1,0),(1,2),(1,2),(2,2),(0,3),(0,4)\}$$

$$B=\{(0,0),(1,0)\}$$

$$X(-)B = \{(0,3),(1,3),(2,3)\}$$

The result of Erosion operation with a disk of radius 2 is shown in Fig(3).

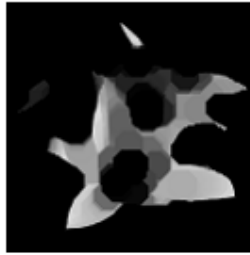
The result of Erosion with a disk of radius 8 is shown in Fig (4).

erosion with d disk of radius 2



Fig(3):Erosion with a disk of radius 2

erosion with a disk of radius 8



Fig(4):Erosion with a disk of radius 2

MATLAB Implementation

```
% Morphological operations dilation, erosion
I=imread('d:\matlab704\work\leter1.bmp');
figure,imshow(I);title('input image 1');
B=[0 1 0; 1 1 1; 0 1 0];
A2=imdilate(I,B);
figure,imshow(A2);
title('Dilated image');
A=imread('d:\matlab704\work\leter1.bmp');
figure,imshow(A);title('input image');
se=strel('disk',8);
A2=imerode(A,se);
figure,imshow(A2);
title('erosion with a disk of radius 8');
se=strel('disk',5);
A3=imerode(A,se);
figure,imshow(A3);title('erosion with a disk of radius 5');
se=strel('disk',2);
A4=imerode(A,se);
figure,imshow(A4);title('erosion with d disk of radius 2');
```

2.4 Opening and closing

We can't get back the original image by performing erosion followed by dilation and vice versa. Instead, the result is a simplified and less detailed version of the original image.

Erosion followed by dilation creates an important morphological transformation called opening. The opening of an image X by the structuring element B is denoted by $X \ominus B$ and is defined as

$$X \ominus B = (X \ominus B) \oplus B$$

Dilation followed by erosion is called closing. The closing of an image X by the structuring element B is denoted by $X \oslash B$ and is defined as

$$X \oslash B = (X \oplus B) \ominus B$$

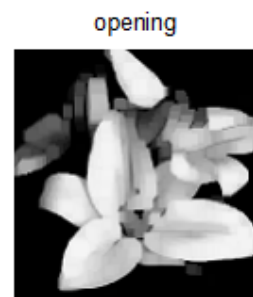
If an image X is unchanged by opening with the structuring element B , is called open with respect to B . Similarly, if an image X is unchanged by closing with B , it is called closed with respect to B .

The original image selected for opening as in Fig(5).



Fig(5): Input Image

The result of opening as shown in Fig(6).



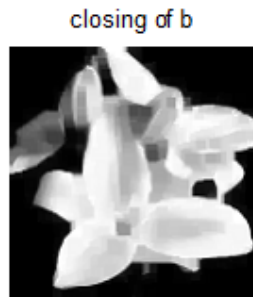
Fig(6): The resultant of opening

The result of closing as shown in Fig(7).



Fig(7): The result of closing

The result of closing of b as shown below in Fig(8).



Fig(8): The result of closing of b

2.5 Hit-or-miss transformation

The hit-or-miss transformation is the morphological operator for finding local patterns of pixels, where local means the size of the structuring element. It is a variant of Template matching that finds collections of pixels with certain shape properties (such as corners, or border points).

The hit-or-miss transformation operates as a binary matching between images X and the structuring element (B1, B2). It may be expressed using erosion and dilations as well.

$$X \ominus B = (X \ominus B1) \cap (X \ominus B2) \quad (X \ominus B)^c = (X \ominus B1) \cup (X \ominus B2)$$

MATLAB Implementation

```
% opening, closing hit or miss transformations
I=imread('d:\matlab704\work\flower.jpg');
figure,imshow(I);title('input image 1');
se=strel('square',5);
fo=imopen(I,se);
figure,imshow(fo),title('opening');
fc=imclose(I,se);
figure,imshow(fc),title('closing');
foc=imclose(I,se);
figure,imshow(foc),title('closing of b');
I=imread('d:\matlab704\work\judy2.bmp');
figure,imshow(I);title('input image 1');
B1=strel([0 0 0; 0 1 1; 0 1 0]);
B2=strel([1 1 1; 1 0 0; 1 0 0]);
g=bwhitmiss(I,B1,B2);
figure,imshow(g),title('hit or miss');
```

The input image is as shown below in Fig(9).

input image 1



Fig(9): The Input Image

The result of hit-or-Miss Transformation is as shown below in Fig(10).

hit or miss



Fig(10): The result of hit-or-Miss Transformation

2.6 Function bmorph

The function bmorph performs a number of operations by the combinations of dilation and erosion. Its calling syntax is

`g =bmorph(f, operation ,n)`

Here

f - Input image.

Operation - the required operation.

n – Number of times the operation has to be repeated.

2.7 Thinning

For thinning operation a portion of the object is subtracted by the set difference operations. It may be desirable for subsequent shape analysis to thin the ridges so that each is one pixel thick. Each application of bmorph's thinning operation removes one or two pixels from the thickness of binary image objects.

MATLAB Implementation

```
% Function bmorph thinning
%
I=imread('d:\matlab704\work\jackson.bmp');
figure,imshow(I);title('input image');
```

```
g1=bwmorph(I,'thin',1);  
figure,imshow(g1);title('thin with 1');  
g2=bwmorph(I,'thin',2);  
figure,imshow(g2);title('thin with 2');
```

input image 1



Fig(11): The Input Image

The result of Thin with 1 pixel is as shown in Fig(12).

thin with 1



Fig(12): The result of Thin with 1 pixel

The result of Thin with 2 pixel is as shown in Fig(13).

thin with 2



Fig(13): The result of Thin with 2 pixel

2.8 Thicken

When thinning, a part of the boundary of the object is subtracted from it by the set difference operation. When thickening; a part of the boundary of the background is added to the object. Thinning and thickening are dual transformations:

MATLAB Implementation

```
% Function bmorph thicken
%
I=imread('d:\matlab704\work\jackson.bmp');
figure,imshow(I);title('input image 1');
g1=bwmorph(I,'thicken',1);
figure,imshow(g1);title('thicken with 1');
g2=bwmorph(I,'thicken',2);
figure,imshow(g2);title('thicken with 2');
The result of Thicken of Fig(11) with 1 pixel is as shown in Fig(14) and the result of Thicken with
pixel 2 is as shown in Fig(15).
```



Fig(14): The result of Thicken with 1 pixel



Fig(15): The result of Thicken with 2 pixel

3. GRAY-SCALE MORPHOLOGY

Binary morphological operations acting on binary images are easily extendible to gray-scale images using the 'min' and 'max' operations. Erosion(respectively, dilation) of an image is the operation of assigning to each pixel the minimum(maximum) value found over a neighborhood of the corresponding pixel in the input image. The structuring element is richer than in the binary case, where it gave only the neighborhood. In the gray scale case, the structuring element is a function of two variables that specifies the desired local gray-level property. The value of the structuring element is added (subtracted) when the maximum (or minimum) is calculated in the neighborhood.

The gray-scale dilation of f by structuring element b , denoted $f(+b)$, is defined as

$$(f(+b)(x,y) = \max\{f(x-x',y-y')+b(x',y') \mid D_b\}$$

Where D_b is the domain of b .

The gray-scale erosion of f by structuring element b , denoted $f(-)b$ is defined as

$$(f(-)b)(x,y) = \min\{f(x+x',y+y') - b(x',y') \mid (x',y') \in D_b\}$$

Opening and closing

The opening of image f by structuring element b , denoted $f \circ b$ is defined as

$$f \circ b = (f(-)b)(+)b$$

The closing of f by b , denoted $f \bullet b$ is dilated followed by erosion:

$$f \bullet b = (f(+)b)(-)b$$

MATLAB Implementation

```
% Gray - scale morphology
I=imread('d:\matlab704\work\butterfly.bmp');
figure,imshow(I);title('input image 1');
se=strel('square',3);
gd=imdilate(I,se);
figure,imshow(gd),title('dilated image');
ge=imerode(I,se);
figure,imshow(ge),title('eroded image');
morph_grad=imsubtract(gd,ge);
I=imread('d:\matlab704\work\bubbles.jpg');
figure,imshow(I);title('input image 2');
se=strel('disk',5);
fo=imopen(I,se);
figure,imshow(fo),title('image opened');
foc=imclose(fo,se);
figure,imshow(foc),title('closing of opening');
```

The result of dilation of input image (16) as shown in Fig (17) and the result of erosion is shown in Fig (18).

input image 1



Fig(16): The input image

dialted image



Fig(17): The result of gray scale dilation

eroded image



Fig(18): The result of gray scale erosion

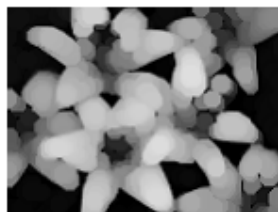
The result of opening of input image (19) as shown in Fig (20) and the result of closing is shown in Fig (21).

input image 2



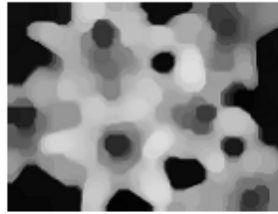
Fig(19): The input image

image opened



Fig(20): The result gray scale opening

closing of opening



Fig(21): The result of gray scale closing of opening

4. APPLICATION OF MORPHOLOGICAL OPERATIONS

1. One of the most common uses of morphological operation thinning is to reduce the threshold output of edge detectors, finds the boundary of a binary objects etc.

Edge is the line, which is found between two different boundaries where the boundaries varies in colour, texture or pattern.

Traditional methods of edge detection

1. Sobel Edge Detector
2. Canny Edge Detector
3. Prewitt Edge Detector
4. Laplacian of a Gaussian (LoG) Detector
5. Roberts Edge Detector

Edge Detector	Basic Properties
Sobel	Locates edges based on the Sobel approximation to the derivatives.
Prewitt	Locates edges based on Prewitt approximation to the derivatives.
Roberts	Finds edges using the Robert approximation to the derivatives.
Laplacian of a Gaussian(LoG)	Identifies edges based on zero crossings after filtering $f(x,y)$ with a Gaussian filter.
Canny	Finds edges by looking for local maxima of the gradient of $f(x,y)$. The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds to detect strong in weak edges, and includes the weak edges in the output only if they are connected to strong edges.

Result of Edge detections.

input image



Input Image

edge detection by prewitt



using prewitt

edge detection by sobel



using sobel

edge detection by canny



using canny

edge detection by roberts



using Laplacian

edge detection by roberts



using roberts

Result of Morphological Operations:



Dilated Image



Eroded Image



Thin with one



Thin with two

From this experiment we can say that mathematical morphology is the best method for edge detection.

5. CONCLUSION

Mathematical Morphology is a powerful tool for examining shapes in pictures. It is powerful tool because of its ability to transform the structure of object with simple forms that enhances their interpretations. It is also very useful tool for extracting features from the images.

Some of the areas in which the morphologically extracted image features can be used are analysis of components of the images in the field of medical imaging, satellite images (Remote Sensing Images), chemicals synthesis, industrial manufacturing of components, agriculture, artificial intelligence, neural networks etc.

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