

Transformation 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. The word morphology commonly denotes a branch of biology that deals with the form and structure of animals and plants. We use the same word here in the context of mathematical morphology as a tool for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons, and the convex hull. We are interested also in morphology technique for pre-or-post processing, such as morphological filtering, thinning, and pruning. 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. We can define image processing as a discipline in which both the input and output of a process are images.

2. Mathematical Morphology

Basic morphological concepts: Mathematical morphology, which started to develop in the late 1960s, stands as a relatively separate part of image analysis. It is based on the algebra of non-linear operators operating on object shape and in many aspects supersedes the linear algebraic system of convolution.

A morphological transformation ψ 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:

Dilation is an operation that “grows” or “thickens” objects in a binary image. The specific manner and extend of this thickening is controlled by a shape referred to as a structure element.

The morphological transformation dilation (+)

combines two sets using vector addition. The dilation is the point set of all possible vector additions of pair of elements, one from each of the sets X and B.

Example:

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

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

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

The input image is shown as below.

input image 1



FIGURE 1 INPUT IMAGE

The dilated image is as shown below.

Dilated image



FIGURE 2 DIALATED IMAGE

2.3. Erosion:

Erosion “shrinks” or “thins” objects in a binary image. As in dilation, the manner and extend of shrinking is controlled by a structure 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:

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

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

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

Erosion with a disk of radius 8, 5 & 2 are shown below of the image in Figure 1.

erosion with a disk of radius 8



erosion with d disk of radius 2



FIGURE 3 ERATED

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:

Erosion and dilation are not inverse transformations-if an image is eroded and then dilated, the original image not re-obtained. 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 $X \circ B$ and is defined as

$$X \circ B = (X (-) B) (+) B$$

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

$$X \bullet B = (X(+)B)(-)B$$

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

input image 1



The result of opening as shown below

opening



The result of closing as shown below

closing



The result of closing of (b) as shown below.

closing of b



FIGURE 4 RESULT OF OPENING AND CLOSING

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.

$$X(x) B = (X (-) B1) \cap (Xc (-) B2) = (X (-) B1) \setminus (X (+) B2)$$

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');
```

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

The input image is as shown below.



FIGURE 5 INPUT IMAGE

The result of hit-or-Miss Transformation is as shown below.

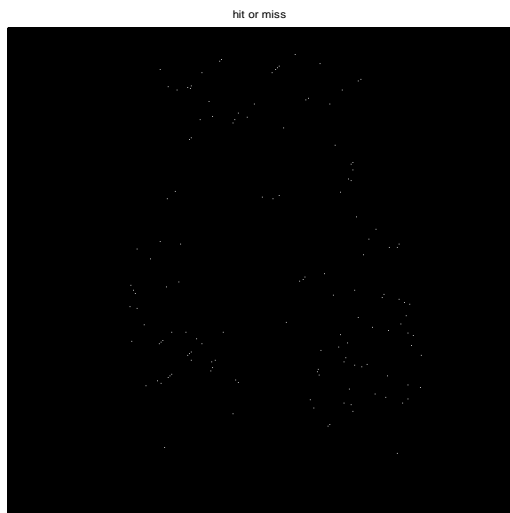


FIGURE 6 RESULT OF HIT-OR-MISS TRANSFORMATION

2.6. Function bmorph

IPT function bmorph implements a variety of useful operations based on combinations of dilations, erosions, and lookup table operations. Its calling syntax is

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

Where, f is an input binary image, operations is a string specifying the desired operation, and n is a positive integer specifying the number of times the operation is to be repeated. Input argument n is optional and can be omitted, in which case the operation is performed once. Table (1) describes the set of val-

id operations for bmorph.

2.7. Thinning

Thinning means reducing binary objects or shapes in an image to strokes that are a single pixel wide. 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');
```

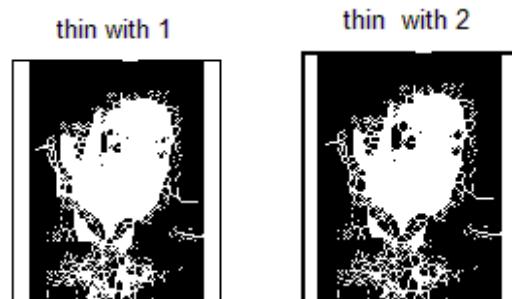


FIGURE 7.

Thicken

Thickens objects without joining disconnected 1s

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');
```

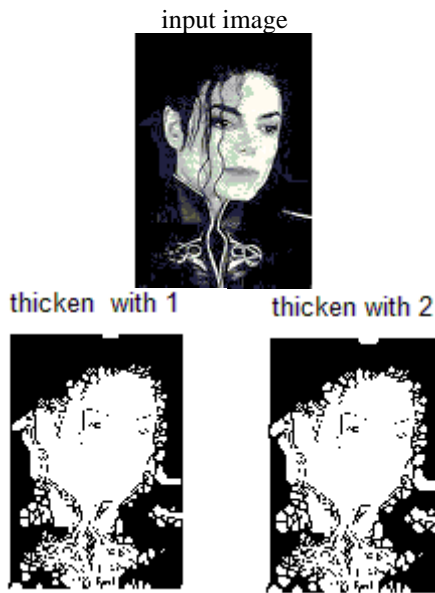


FIGURE 8.

2.8. Gray-Scale dilation and erosion

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.

2.9. Dilation and Erosion

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

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

Where Db is the domain of b .

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

$$(f(-b)(x,y) = \min\{f(x+x',y+y')-b(x',y') \quad Db\}$$

Opening and closing

The expressions for opening and closing gray-scale images have the same form as their binary counterparts. The opening of image f by structuring element b , denoted $f \circ b$ is defined as

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

This is simply the erosion of f by b , followed by the dilation of the result by b . Similarly, the closing of f by b , denoted $f \bullet b$ is dilated followed by ero-

sion:

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

3. Gray-Scale Morphology

The result of dilation as shown below:



The result of dilation as shown below.



The result of erosion is shown below.



The result of opening is shown below.

Morphological gradient



FIGURE 9 GRAY SCALE DILATED AND ERODED IMAGES

input image 2



The input image is as shown below.
The result of opening is shown below.

image opened



The result of closing is shown below.

closing of opening

**FIGURE 10 GRAY SCALE OPENING & CLOSING****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('dialted image');
ge=imerode(I,se);
figure,imshow(ge),title('eroded image');
morph_grad=imsubtract(gd,ge);
figure,imshow(morph_grad),title('Morphological
gradient');
```

```
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')
```

4. CONCLUSION

Mathematical Morphology is a powerful tool for examining shapes in visual pictures. It is powerful tool because of its ability to transform the structure of object with simple forms that enhances their interpretations.

The following techniques have been discussed:

- Dilation expands image and Erosion shrinks it.
- Opening smoothen the contour of an object breaks, narrow isthmuses, and eliminating their protrusion.
- Closing tends to smooth sections of contours but, as opposed to opening, it generally fuse narrow breaks and long thing gulfs, eliminates small holes and fills gaps in the contour.
- Hit-or-miss transform is a basic tool for shape detection.
- Other features such as boundary extraction, extraction of connected components, thinning, thickening, and pruning are very useful.

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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