

Image Processing Laboratory

Experiment 5: Morphological Operations

Report

Group-6



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1 Introduction

Morphological image processing is a collection of non-linear operations related to shape or morphology of features in image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images.

Binary images may contain numerous imperfections like distortion in binary regions produced by simple thresholding due to noise. Morphological image processing pursues the goals of removing these imperfections by accounting for the form and structure of the image. Morphological techniques explore an image with a small shape or template called a structuring element. The structuring element (SE) used in convolution with the image to compare with the pixels in neighbourhood. Some operations try to find whether the SE fits or matches exactly with the neighbourhood, while others test if it hits or partially matches to the neighbourhood.

Following are four basic operations in morphological techniques:

1. **Erosion:** The erosion of a binary image f by a structuring element s (denoted $f \ominus s$) produces a new binary image $g = f \ominus s$ with ones in all locations (x, y) of a structuring element's origin at which that structuring element s fits the input image f , i.e. $g(x, y) = 1$ if s fits f and 0 otherwise, repeating for all pixel coordinates (x, y) .

Mathematically,

$$A \ominus B = \{x \in Z^2 | (B)_x \subseteq A\}$$

2. **Dilation:** The dilation of an image f by a structuring element s (denoted $f \oplus s$) produces a new binary image $g = f \oplus s$ with ones in all locations (x, y) of a structuring element's origin at which that structuring element s hits the input image f , i.e. $g(x, y) = 1$ if s hits f and 0 otherwise, repeating for all pixel coordinates (x, y) . Dilation has the opposite effect to erosion; it adds a layer of pixels to both the inner and outer boundaries of regions. Mathematically,

$$A \oplus B = \{c \in Z^2 | c = a + b \text{ for some } a \in A, b \in B\}$$

3. **Opening:** The opening of A by B is obtained by the erosion of A by B, followed by dilation of the resulting image by B.

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

4. **Closing:** The closing of A by B is obtained by the dilation of A by B, followed by erosion of the resulting image by B.

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

2 Algorithm

Both Erosion and Dilation require the structuring element to move in a convolution like fashion and check for hit or fit. For opening and closing output of the first operation is fed to another operation.

Following are the codes for checking fit and hit:

FIT

HIT

Now, Erosion and Dilation are computed as following: **Erosion**

Dilation

Opening and Closing are calculated as following: Opening

Closing

3 Output Results

Following are the results for all the operations performed on the binary image shown together with it:

4 Analysis

- Morphological operations may act as a filter of shape. This shape is defined by the structuring element. Only those portions of the image that fit the structuring element are passed by the filter; smaller structures are blocked and excluded from the output image.
- The size and shape of the structuring elements are very important feature for morphological operations as they decide which part of the image will be filtered out in the output and which part will be included. It was observed that for certain SEs the output is a blank image. This way, it may damage object of interest along with elimination of noise.
- The effect of opening is similar to rounding off things. It smoothens the boundaries of the image by chopping off elements. It happens that because erosion first sharpens the image boundaries by chopping off noisy parts and then dilation smooths them. (*Refer Figure 1*)

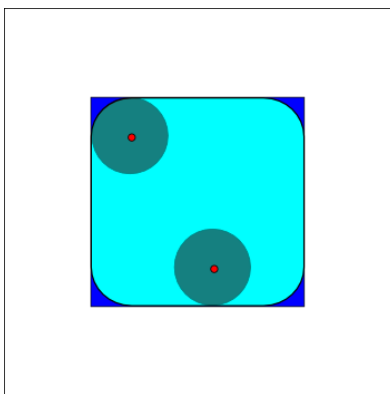


Figure 1: The erosion of the dark-blue square by a disk, resulting in the light-blue square [1]

- Closing uses dilation followed by erosion. Thus it first adds extra parts to the image and then sharpens them. In contrast to opening, here the smoothening process is done by adding elements. (*Refer Figure 1*)

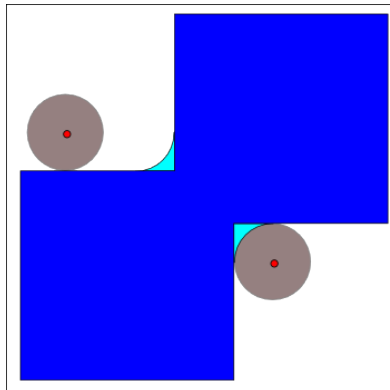


Figure 2: The dilation of the dark-blue square by a disk, resulting in the light-blue square with rounded corners [1]

5 Sources

- [1] Wikipedia page on Mathematical Morphology
https://en.wikipedia.org/wiki/Mathematical_morphology#Basic_operators
- [2] Tutorial on Morphological Image Processing
<https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/topic4.htm>