EXPERIMENT 5

Morphological Operations

- *Write C++/Image-J modular functions to perform the following operations on the given test image, ricegrains_mono.bmp. All functions must support binary images.*

    1. *Make separate functions for erosion, dilation, opening, and closing of binary images*

        a. ***ErodeBinary, DilateBinary***
        Input: Binary image, structuring element
        Output: Eroded/dilated image

        b. ***OpenBinary, CloseBinary***
        Input: Binary image, structuring element
        Output: Opened/closed image

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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 my 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 other 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 is 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 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.

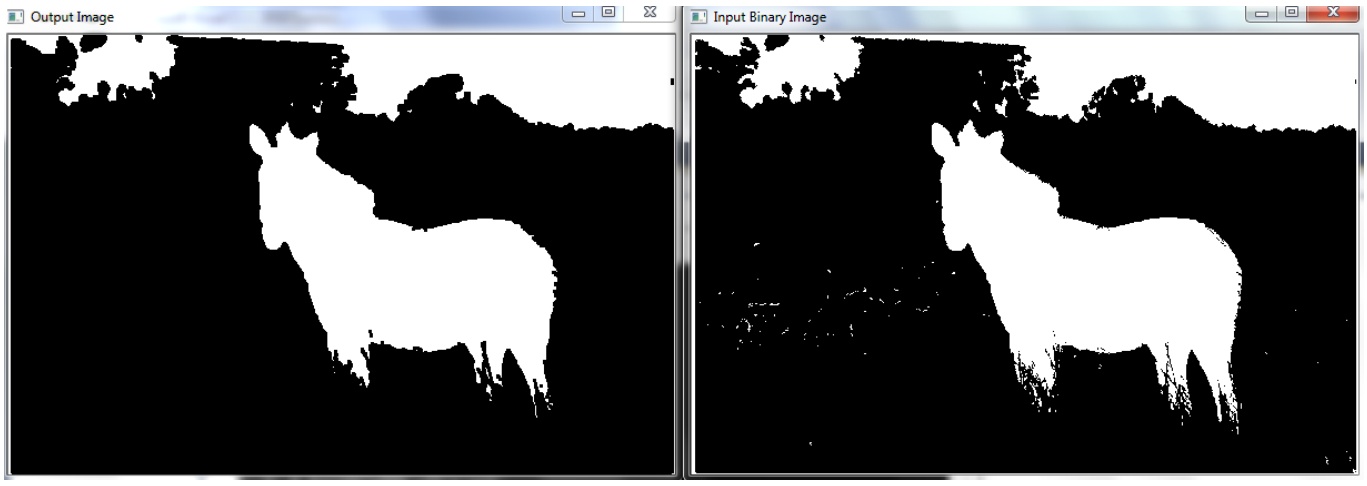
$$A \bullet B = (A \oplus B) \ominus B$$

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.

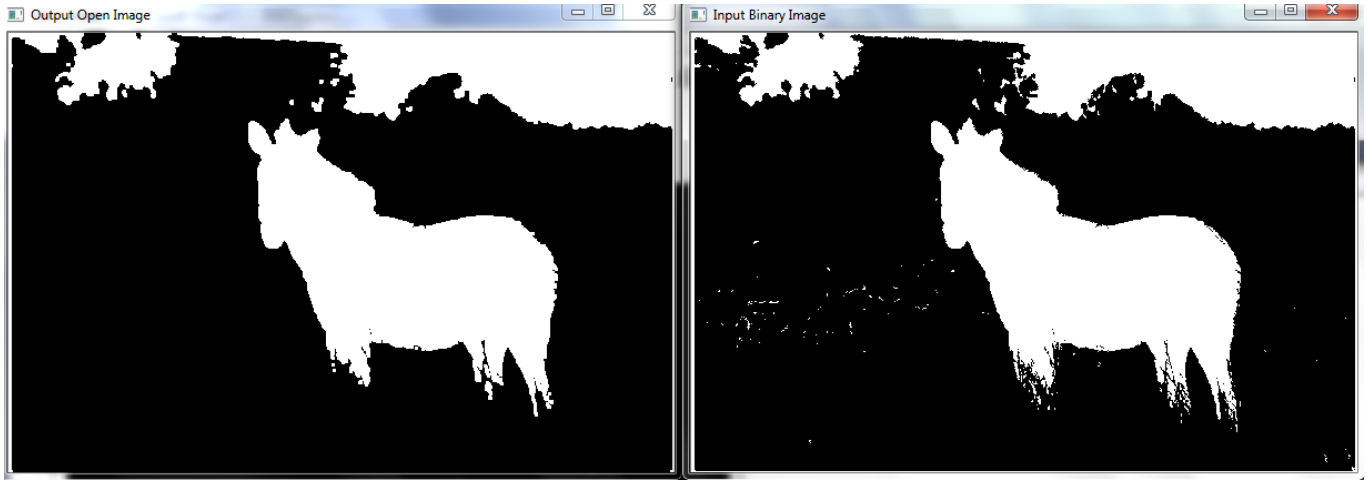
OUTPUT RESULTS

Erosion with 3X3 square with all 1

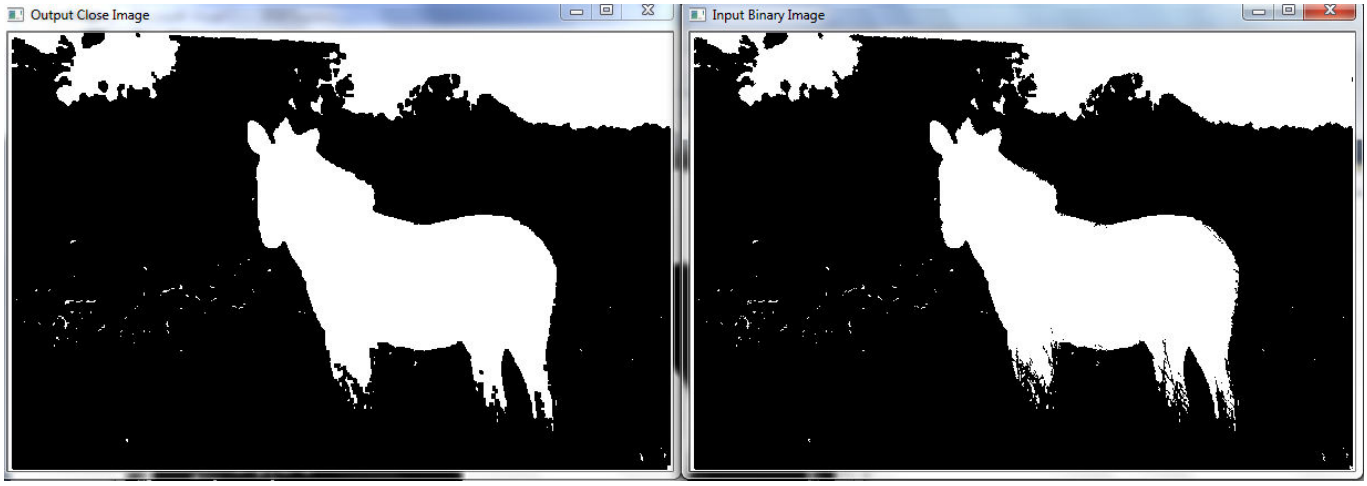


Dilation with 3X3 square with all 1

Opening with 3X3 square with all 1



Closing with 3X3 square with all 1



DISCUSSIONS

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

SOURCES

[1] Wikipedia page on Mathematical Morphology
https://en.wikipedia.org/wiki/Mathematical_morphology

[2] Tutorial on Morphological Image Processing
https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessinghtml/topic4.

[3] Opening
https://homepages.inf.ed.ac.uk/rbf/HIPR2/open.htm

[4] Closing
https://homepages.inf.ed.ac.uk/rbf/HIPR2/close.htm