Exercise 1: Morphology
Part A

-1 = background, 1 = object pixel

Original

-1	-1	1	1	1	1	1	-1	-1	1
-1	1	1	1	-1	1	1	1	-1	1
1	1	1	-1	1	-1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	-1	1	-1	-1	1	1	1	-1	1
1	-1	1	-1	-1	1	-1	-1	1	1
1	1	1	1	1	1	-1	1	1	1
-1	-1	1	1	1	-1	1	1	1	1
1	1	1	1	-1	1	1	1	-1	-1
1	1	1	1	1	1	1	1	-1	-1

Erosion - First Element

-1	1	-1
1	O	1

First Element

-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	1	-1	-1	-1	1	-1	-1	-1
-1	1	-1	-1	-1	-1	-1	1	-1	-1
-1	1	1	-1	1	-1	1	1	1	-1
-1	-1	-1	-1	-1	-1	1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	1	-1	-1	-1	-1	-1	1	-1
-1	-1	-1	1	-1	-1	-1	1	1	-1
-1	-1	1	-1	-1	-1	1	-1	-1	-1
-1	1	1	1	-1	1	1	-1	-1	-1

Opening(Erosion -> Dilation) - First Element

-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	1	1	1	-1	1	1	1	-1	-1
1	1	1	-1	-1	-1	1	1	1	-1
1	1	1	1	1	1	1	1	1	1
-1	1	1	-1	1	1	1	1	1	-1
-1	-1	-1	-1	-1	-1	1	-1	-1	-1
-1	1	1	1	-1	-1	-1	1	1	1
-1	-1	1	1	1	-1	1	1	1	1
-1	1	1	1	-1	1	1	1	1	-1
1	1	1	1	1	1	1	1	-1	-1

Dilation - Second Element

O	1
1	1

Second Element

1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	-1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	-1	-1
1	1	1	1	1	1	1	1	-1	-1

Closing (dilation->erosion) - Second Element

1	1	1	1	1	1	1	1	1	-1
1	1	1	1	1	1	1	1	1	-1
1	1	1	1	1	1	1	1	1	-1
1	1	-1	-1	1	1	1	1	1	-1
1	1	-1	-1	1	1	1	1	1	-1
1	1	1	1	1	1	1	1	1	-1
1	1	1	1	1	1	1	1	1	-1
1	1	1	1	1	1	1	-1	-1	-1
1	1	1	1	1	1	1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

Part B

Before Erosion

1	1	1	1	-1	-1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	-1	-1	1	1	1

After Erosion

-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	1	1	1	-1	-1	1	1	-1
-1	1	1	1	-1	-1	1	1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1

Mask

-1	1	-1
1	O	1
-1	1	-1

Exercise 2: Hausdorff Distance
Part A

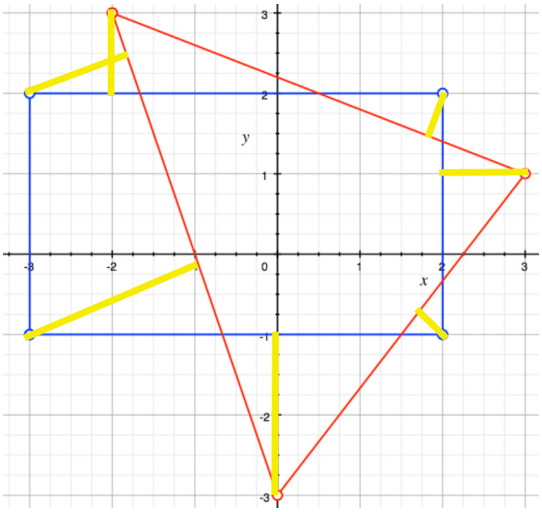
A(-2,3), B(3,1), and C(0,-3)
D(-3,2), E(2,2), F(2,-1), and G(-3, -1)
S1={A, B, C} and S2={D, E, F, G}

h(S1, S2) = max_s1(min_s2 (d(s1, s2)))
min (d(A, s2)): sqrt(1^2 + 1^2) = sqrt(2)
min (d(B, s2)): sqrt(1^2 + 1^2) = sqrt(2)
min(d(C, s2)): sqrt(2^2 + 2^2) = sqrt(8)
h(S1, S2) = max_s1(min(…)) = sqrt(8) ~ 2.8

h(S2, S1) = max_s2(min_s1 (d(s1, s2)))
min (d(D, s1)): sqrt(2)
min (d(E, s1)): sqrt(2)
min(d(F, s1)): sqrt(1^2 + 2^2) = sqrt(5)
min(d(G, s1)): sqrt(3^2 + 2^2) = sqrt(13)
h(S2, S1) = max_s2(min(…)) = sqrt(13) ~ 3.6

H(S1,S2) = max(h(S1,S2), h(S2,S1)) = **sqrt(13) ~ 3.6**

Part B



h(S1, S2) = max_s1(min_s2 (d(s1, s2)))
= max_s1(min (d(A, s2_polygon)), min (d(B, s2_polygon)), min(d(C, s2_polygon)))
= d(C, S2_polygon) = 2

h(S2, S1) = max_s2(min_s1 (d(s1, s2)))
= max(min(d(D, s1_polygon)), min(d(E, s1_polygon)), min(d(F, s1_polygon)), min(d(G, s1_polygon)))
= **d(D, s1_polygon) = sqrt(2^2 + (3/4)^2) = sqrt(73)/4 ~ 2.13**

H(S1,S2) = max(h(S1,S2), h(S2,S1)) = **sqrt(73)/4 ~ 2.13**

Exercise 3: Edge Detection

(a) Define what an edge is in an image
In short, edges are pixels that have a significant local change in intensity in the image.

(b) Briefly describe three causes of edges (1 sentence each)
- Surface reflectance discontinuity
    - This refers to change in the fraction of light incident on the surface that is reflected to viewer; possibly caused by different material.
- Illumination discontinuity
    - This refers to discontinuity in illumination, such as shadow.
- Surface Color Discontinuity
    - This refers to color change, such as the change in color between a (black) text and the (white) background.

(c) Consider the image and edge map shown here: https://en.wikipedia.org/wiki/Canny_edge_detector#/media/File:%C3%84%C3%A4retuvastuse_n%C3%A4ide.png Describe for each cause from (b) where the Canny Edge Detector found an edge and where it did not. This is easiest done if you print out the image and edge map.

Most of the edges are caused by Surface Color Discontinuity. Specific parts of edges are caused by Illumination discontinuity, such as parts of the fingers, upper and lower part of the mouth, upper and lower part of the eye, close to ear area, area between cheek and clothes.