CSE464 - Digital Image Processing - HW1

Fatih Kaan Salgır - 171044009

Exercise 1

To obtain A, B can be multiplied with transformation matrix C.

$C \cdot B = A$ where C is $\begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ 0 & 0 & 1 \end{bmatrix}$

Coordinates that are need to be registered by transformation matrix are;

	B(x,y)	A(x,y)
1	1,2	2,2
2	2,1	-1,4
3	3,1	-4,-4

Multiplication of each point in image B, gives the point in image A.

$C \cdot B_1 = A_1$
$C \cdot B_2 = A_2$
$C \cdot B_3 = A_3$

For B_1;

$$\begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \\ 1 \end{bmatrix}$$

$c_{11} + 2c_{12} + c_{13} = 2$
$c_{21} + 2c_{22} + c_{23} = 2$

For B_2;

$$\begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} -1 \\ 4 \\ 1 \end{bmatrix}$$

$2c_{11} + 2c_{12} + c_{13} = -1$
$2c_{21} + c_{22} + c_{23} = 4$

For B_3;

$$\begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 3 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} -4 \\ 4 \\ 1 \end{bmatrix}$$

$3c_{11} + 2c_{12} + c_{13} = -4$
$3c_{21} + c_{22} + c_{23} = 4$

Using first equations (c_{1i}) obtained by the matrix multiplication;

$c_{11} + 2c_{12} + c_{13} = 2$
$2c_{11} + c_{12} + c_{13} = -1$
$3c_{11} + c_{12} + c_{13} = -4$

$c_{11} = -3$
$c_{12} = 0$
$c_{13} = 5$

Using second equations (c_{2i}) obtained by the matrix multiplication;

$c_{21} + 2c_{22} + c_{23} = 2$
$2c_{21} + c_{22} + c_{23} = 4$
$3c_{21} + c_{22} + c_{23} = 4$

$c_{21} = 0$
$c_{22} = -2$
$c_{23} = 6$

The transformation matrix C is;

$$C = \begin{bmatrix} -3 & 0 & 5 \\ 0 & -2 & c_{23} \\ 0 & 0 & 1 \end{bmatrix}$$

Excercise 2

Morphological opening is used to remove artifacts while preserving the main object.

It is experimented with Z_4 and Z_8 structuring elements. While Z_4 left a single artifact, Z_8 successfully removed all the artifacts. However, on the edge areas of the image such as hands and legs, Z_4 was better compared to Z_8 in terms of preserving the main object.
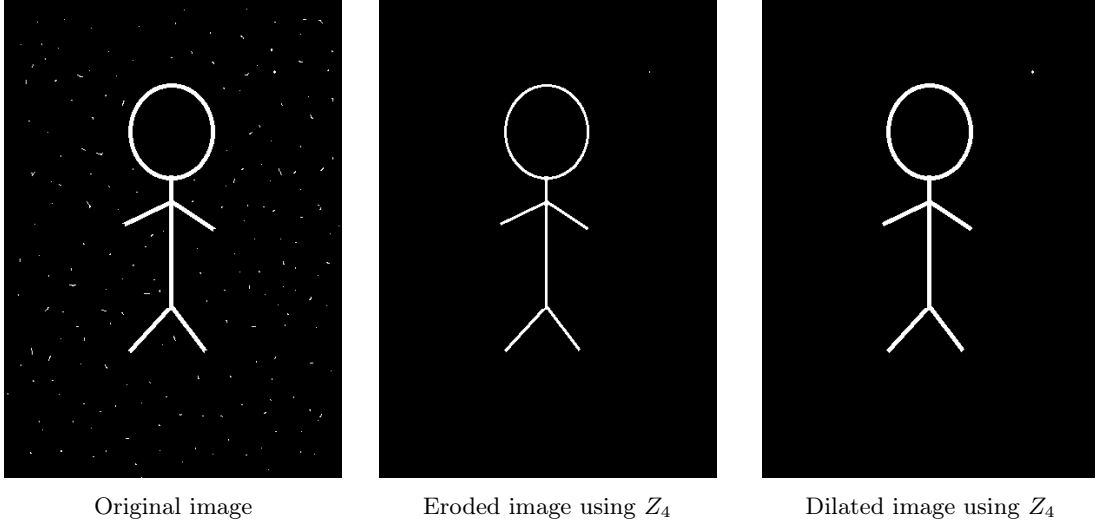

| Original image | Eroded image using Z_4 | Dilated image using Z_4 |

Figure 1: Morphological opening with Z_4 structuring elemnet

| Original image | Eroded image using Z_8 | Dilated image using Z_8 |
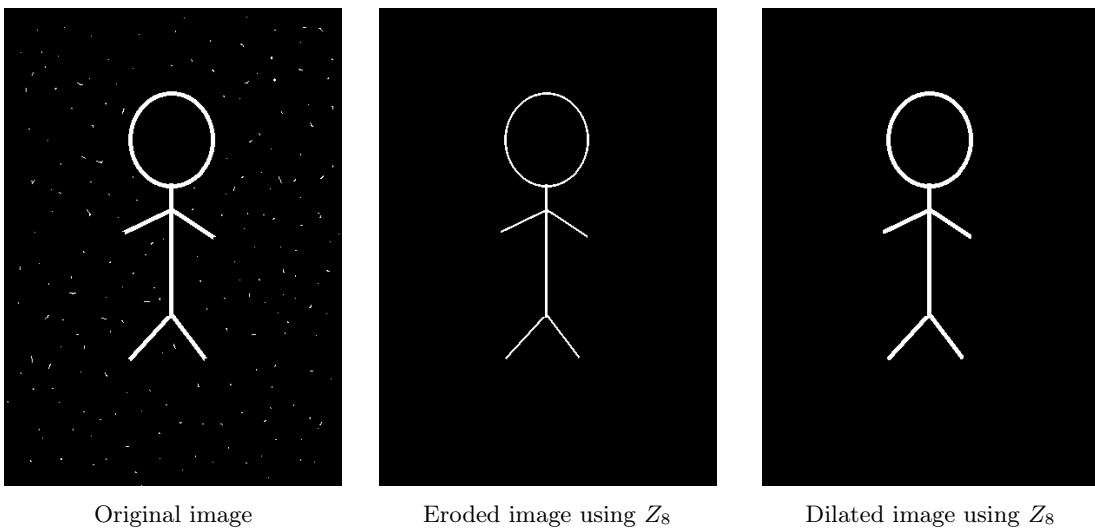
Figure 2: Morphological opening with Z_8 structuring elemnet

Excercise 3

8×8 cross structuring element is used to erode the image. To make the curve intersections stand out, the image is dilated with 17×17 ellipse structuring element. Negation of the original image is summed with the intersection points, to separate curve segments. Lastly, connected component labeling can be applied in order to count number of curve segments. However, there are some errors near the edges of the image.
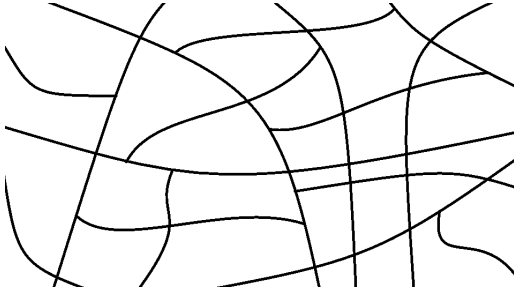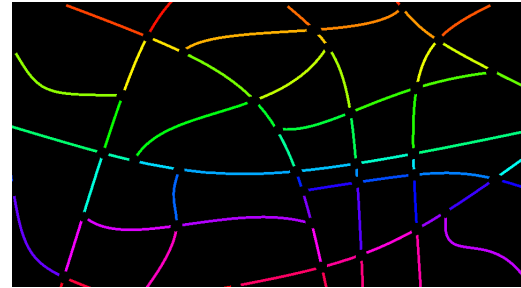

Original image
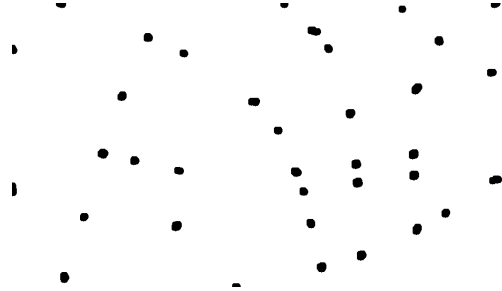
After applying erosion followed by dilation
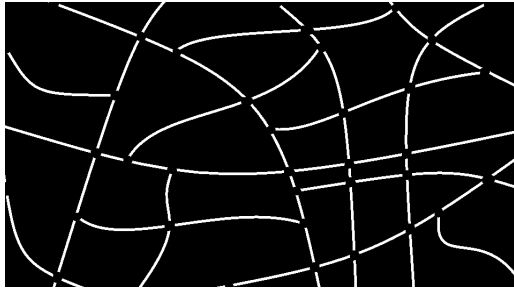
Seperated curve segments

Curve segments colored using CC labeling

Exercise 4

One of the teeth of the hair comb is used as a structuring element. The image is inverted (negated) and morphological opening is applied. This allows detecting the faultless teeth of the comb. Then the opened version of the images is arithmetically summed with the original version of the image in order to detect the faulty teeth. To make the missing teeth more distinguishable, the image is dilated by 4×4 structuring element. The last image demonstrates the missing teeth over the original one.
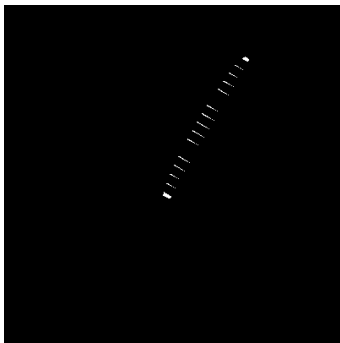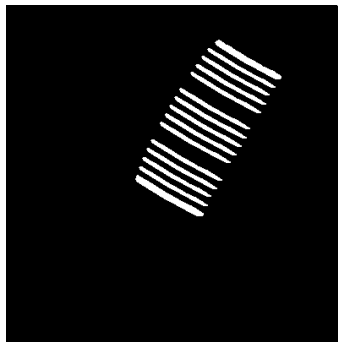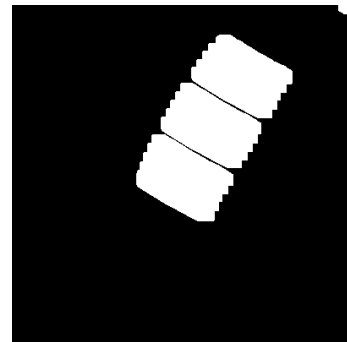

Original image

Negated image

Custom structuring element (73×43 px)
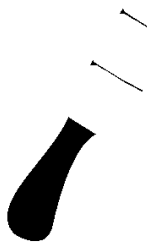

Eraded version of the negated image with custom SE

Dilation is applied (opened)

Dilation with SE $= 13 \times 13$

Summation with original image

Dilated with SE $= 4 \times 4$

Demonstration of final result