MODULE 9 – Morphology

A. PURPOSE

1. Students are able to understand the concept of Morphology
2. Students can know some Morphology techniques
3. Students can create several morphology techniques using Python on Google Colab

B. TOOLS AND MATERIALS

1. PC/LAPTOP
2. Github
3. *Google Colaborator*

C. THEORY REVIEW

C.1 Definition of Operation Morphology

Morphological operation is an image processing technique that is based on the shape of the segment or region in the image . Operation morphology is usually applied to the image of the binary primary and a grayscale images. Based on the binary value, it can be distinguished which part of the object and which part is not an object or a background. Although often used in image binary, operating morphology is often also used the grayscale images. Some operations morphology that can be done is Dilation, Erosion , Closing and Opening.

Stages of operation morphology done by pass a Structuring Element on an image. The structural element has a function like a mask in the filtering process. With morphological operations, some of the applications that can be done are as follows :

- Establish spatial filters
- Obtain the skeleton (frame) object
- Determine the location of objects in the image
- Obtaining the shape of the object structure

Figure 1 below explain about the effect of the operation morphology in separating some of the objects.

Figure 1. Image before and after morphological surgery

(Source : Kadir , Abdul et al , 2013)

Morphological operations involve two arrays, namely an array which is the original image, and also an array which is the mask / structuring element . Figure 2 explains how the application of morphological operations worksin images. With the centroid on the mask used.
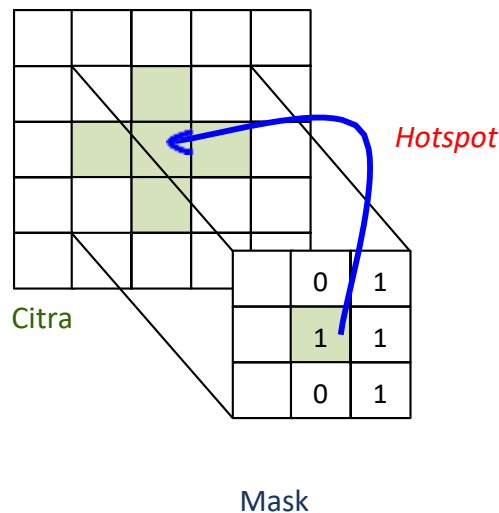

Figure 2. Application Operations morphology that involves Array Image and Mask

(Source : Kadir , Abdul et al , 2013)

C.2 Dilation Operations

Dilation operation which is one of the form of operation morphology that has the goal to increase the size of the segment object to add a layer around the object. Dilation operation can be done in 2 ways :

1. Modify all dot neigbors background with a point limit, or set each neigbors point to be an object point.
2. Modify all point at around the point boundary into an object point, or all neighboring point to become an object point.

Dilation operation is also used to obtain a wider image formulated as follows: (Gonzales & Woods, 2002):

$$A \oplus B = \left\{ z \mid \left[(\check{B})_z \cap A \right] \subseteq A \right\}$$

Where as,

   a) $\check{B} = \{w \mid w = -b, \text{ for } b \in B\}$

   b) $(B)_z = \{c \mid c = a + z, \text{ for } a \in A\}$

   c) z=(z1, z2)

The following is an example of a dilation operation applied to matrix A with a matrix mask B , which is shown in Figure 3.

A = { (2,2), (2,3), (2,4), (3,2), (3,3), (3,4), (4,3) }

B = { (-1, 0), (0,0), (1,0) }

Therefore,

A Dilasi B = { (2,2) + (-1, 0) , (2,2) + (0, 0) + (2,2) + (1, 0),

(2,3) + (-1, 0) , (2,3) + (0, 0) + (2,3) + (1, 0),

(2,4) + (-1, 0) , (2,4) + (0, 0) + (2,4) + (1, 0),

(3,2) + (-1, 0) , (3,2) + (0, 0) + (3,2) + (1, 0),

(3,3) + (-1, 0) , (3,3) + (0, 0) + (3,3) + (1, 0),

(3,4) + (-1, 0) , (3,4) + (0, 0) + (3,4) + (1, 0),

(4,3) + (-1, 0) , (4,3) + (0, 0) + (4,3) + (1, 0) }

= { (1,2), (2,2), (3,2),   (1,3), (2,3), (3,3),

(1,4), (2,4), (3,3),   (2,2), (3,2), (4,2),

(2,3), (3,3), (4,3),   (2,4), (3,4), (4,4),

(3,3), (4,3), (5,3) }

= { (1,2), (1,3), (1,4), (2,2), (2,3), (2,4),

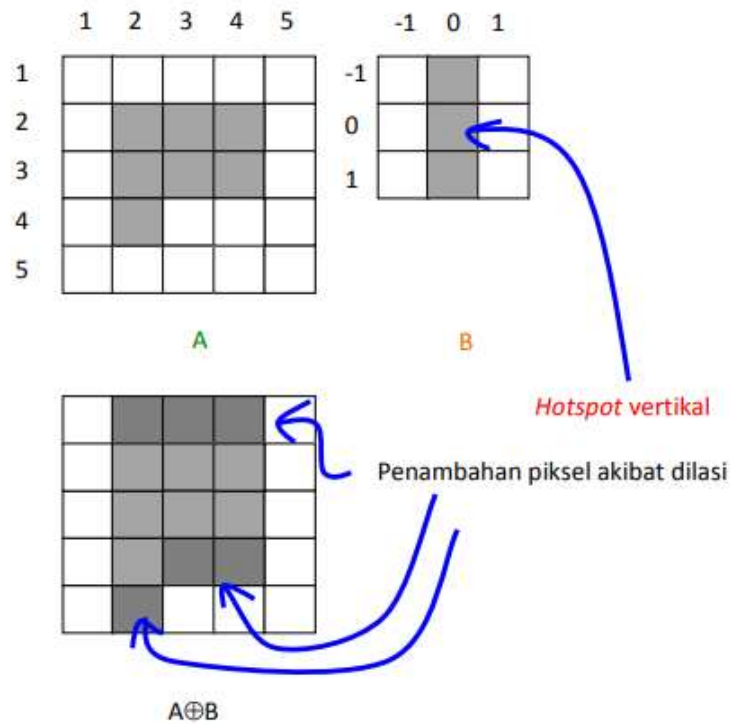(3,2), (3,3), (3,4), (4,2), (4,3), (4,4), (5,3) }

Figure 3. Dilation effect with vertical hotspot

(Source : Kadir , Abdul et al , 2013)

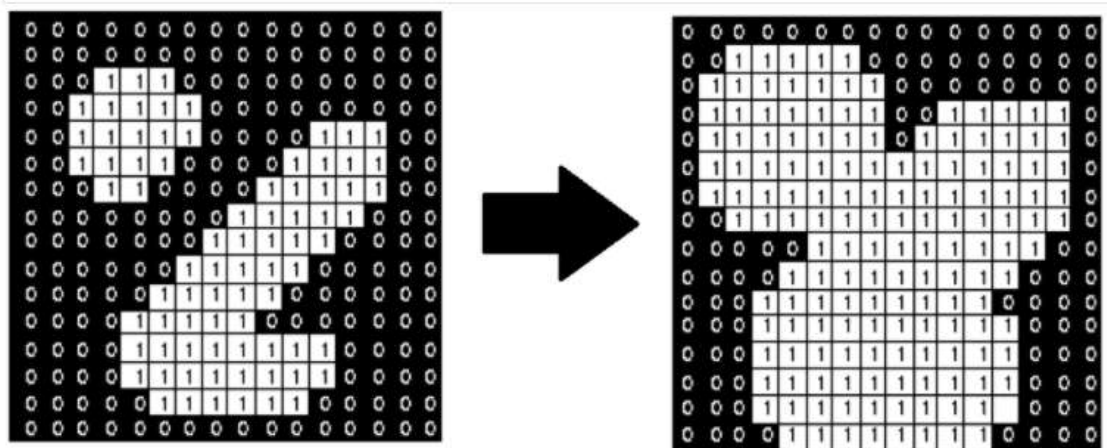Examples of operation dilation others can be seen in Figure 4.

Figure 4. Examples of Effects of Dilation Operations
(Source : https://devtrik.com/opencv/operasi-morfologi-pada-pengolahan-citra/)

C.3 Erosion Operations

Operation erosion is one of the form of operation morphology which operates as opposites with dilation operation. This operation will make an object in an image become smaller or thinner. This operation can be performed in two ways as follows :

1. Modify all boundary point and become background point
2. Modify all outer foreground point and become background point.

Erosion operations have the effect of reducing the structure of the image. This operation is formulated as follows (Gonzalez & Woods, 2002).

$$A \ominus B = \{z | (B)_z \subseteq A\}$$

Figure 5 is a form of erosion operation on an image with a vertical linear mask. Figure 6 is an example of a change from the original image during an erosion operation. While figure 7 is an example of changing the original image on dilation with a circular structuring element image 11.
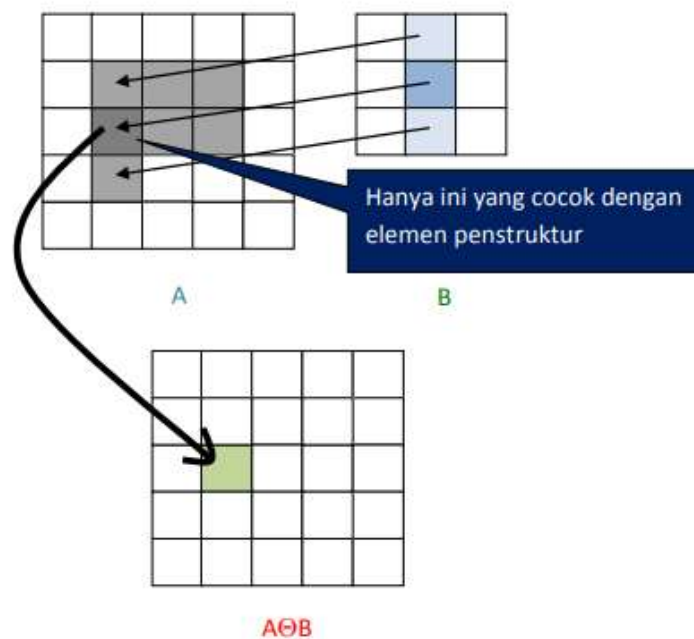

Figure 5 Examples of Erosion Operations
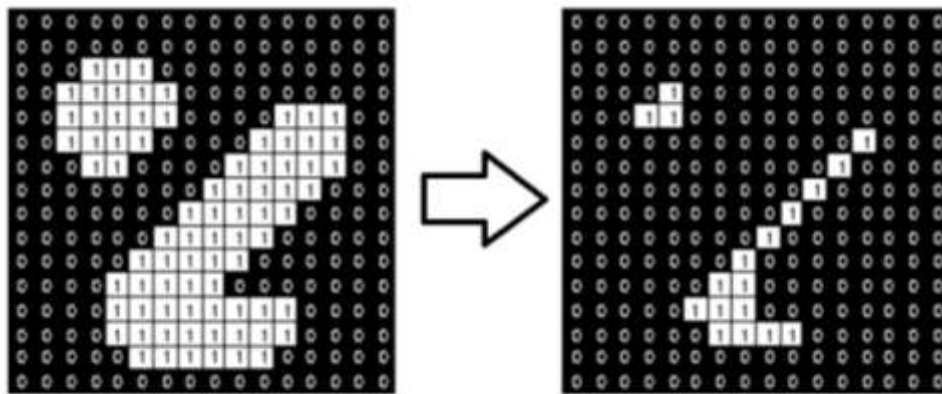(Source : Kadir , Abdul et al , 2013)

Figure 6. Application of Erosion Operations to Images
(Source : https://devtrik.com/opencv/operasi-morfologi-pada-pengolahan-citra/)

Figure 7. Application Operations Erosion in Citra with Mask Circle 11

C.4 *Structuring Element* (SE)

In morphological operations, the SE that can be used is very diverse, as shown in Figure 8. Based on the various SE forms the most commonly used are Cross, Rectangle, Line, and Circle SE .
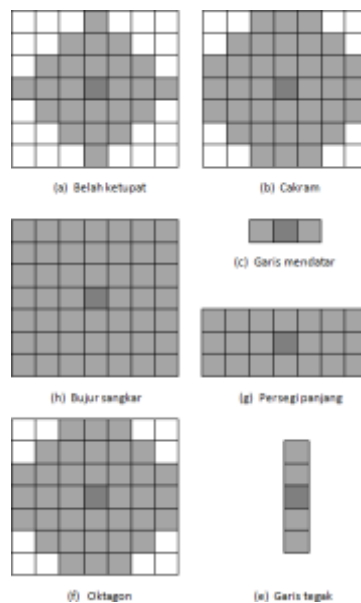

Figure 8. Various SE Shapes
(Source : Kadir , Abdul et al , 2013)

C.5 Opening Operation

Operation opening is a combination between the operations of erosion and dilation are performed in sequence , the image of the original eroded first and then dilate the result. This operation has the objective to cut off parts of the object are only connected with one or two pieces of point A , removing smaller objects without changing the area of the object. Opening is also idempotent, that is if repeated, do not have a sustainable impact.

The opening operation uses the following equation :

$$A \text{ o } B = (A \ominus B) \oplus B$$

Opening operator can be used   as a low pass filter, the high pass filter , as well as bandpass filter if the structure elements used in the disc form (Shih, 2009). Figure 9 shows a form of opening operation begin with the erosion followed by the dilation process.
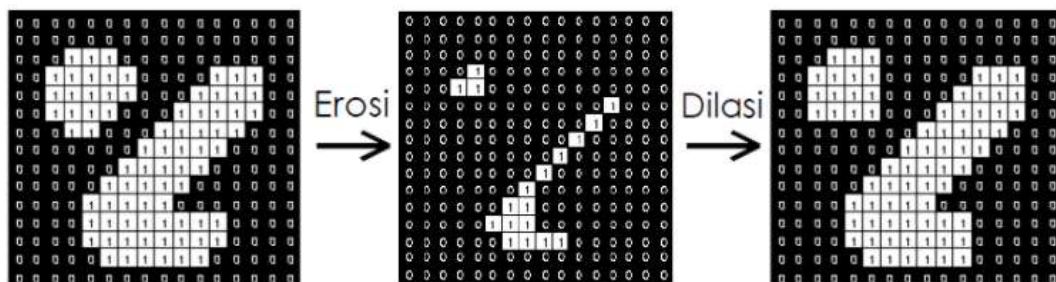

Figure 9. Operation Opening on Image
Source : https://devtrik.com/opencv/operasi-morfologi-pada-pengolahan-citra/)

C.6 Closing Operation

Closing operation is a combination between the dilation and erosion operation which are performed in sequence. Closing operation has an objective to close or eliminate the small holes that exist in the segment of the object, combine adjacent objects without changing the object itself.

The closing operation uses the following equation :

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

Figure 10 , 11 shows a form of application of the Closing operation that begins with the process of dilation up first, and proceed with the of erosion.
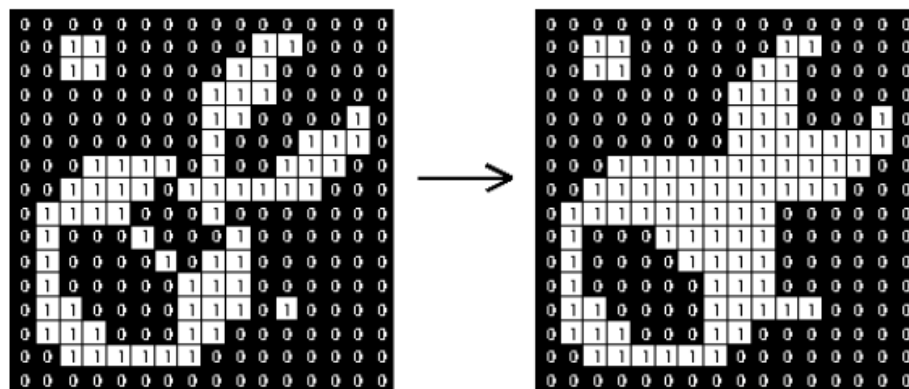
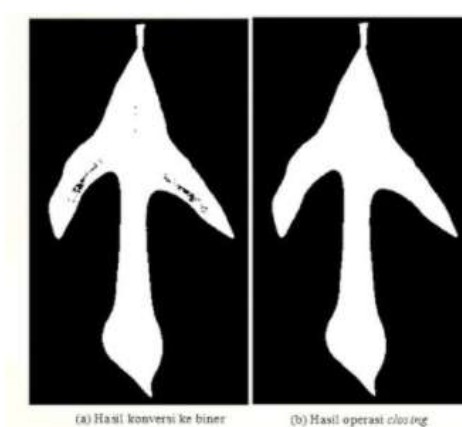Figure 10 . Operation Closing in Citra

(Source : https://devtrik.com/opencv/operasi-morfologi-pada-pengolahan-citra/)

(a) Hasil konversi ke biner   (b) Hasil operasi *closing*

Figure 11. Examples of Closing Operation in Image

(Source : Kadir , Abdul et al , 2013)

D. Practicum

1. Go to https://colab.research.google.com/. After making sure that Google Colab is connected to your Github , continue by selecting the repository that was used in the last week's lab , rename the file to "Week 9 .ipynb".

Then import the folder that exist on the drive you by the way as follows .

2. Import some libraries following that will be used during the test try practicum weeks to 6 below.

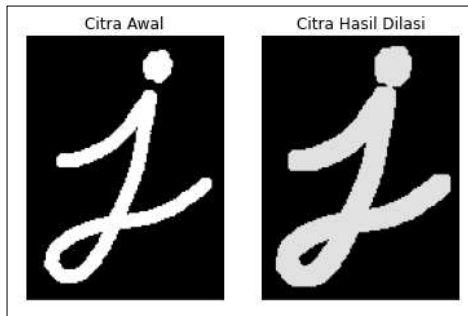3. Make the dilation operation and show the results on the image of the Structuring Element shaped 5 x 5 square **without** using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")
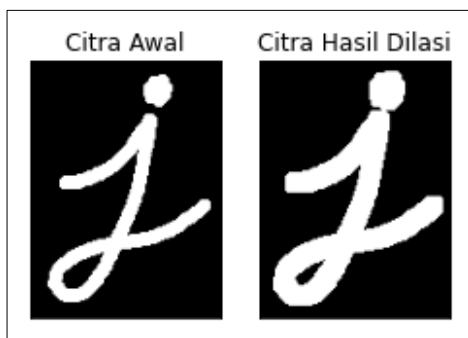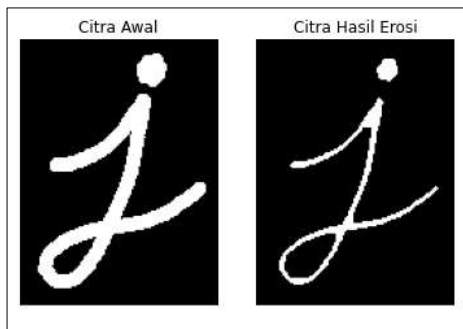

4. Make the erosion operation and show the results on the image of the Structuring Element shaped 5 x 5 square **without** using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")
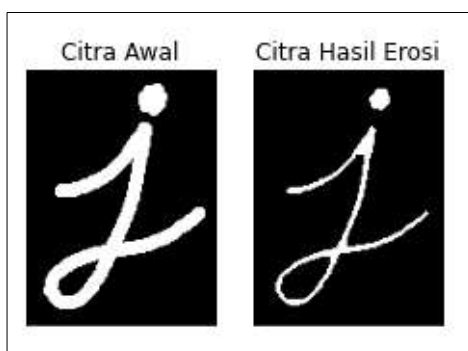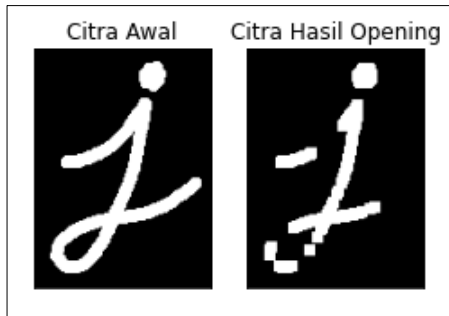

5. Make the dilation operation and show the results on the image of the Structuring Element shaped 5 x 5 square **using** the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")
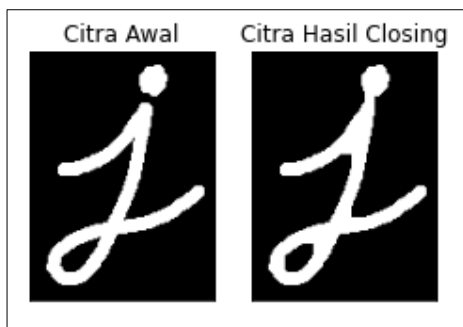
6. Make the erotion operation and show the results on the image of the Structuring Element shaped 5 x 5 square **using** the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")
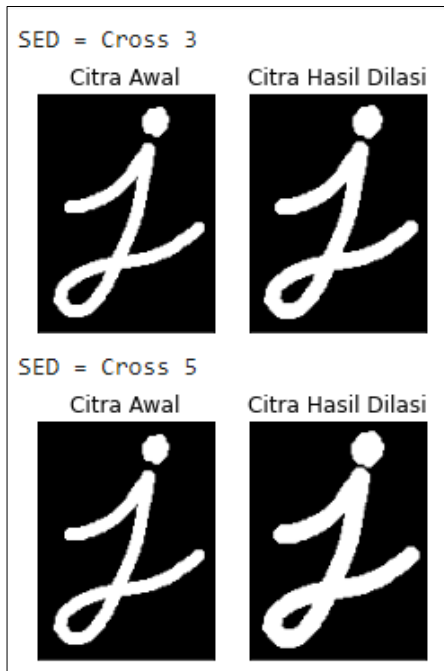

7. Make the Opening operation and show the results on the image of the Structuring Element shaped 7 x 7 square **with** and **without** using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")
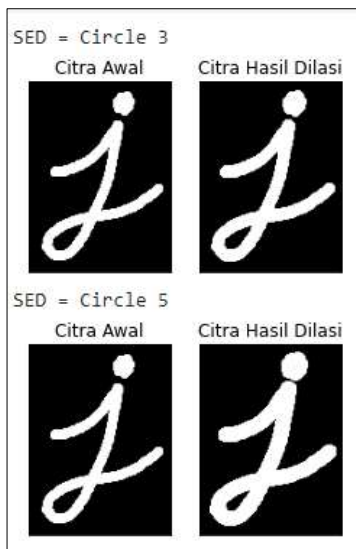

8. Make the Closing operation and show the results on the image of the Structuring Element shaped 7 x 7 square **with** and **without** using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")
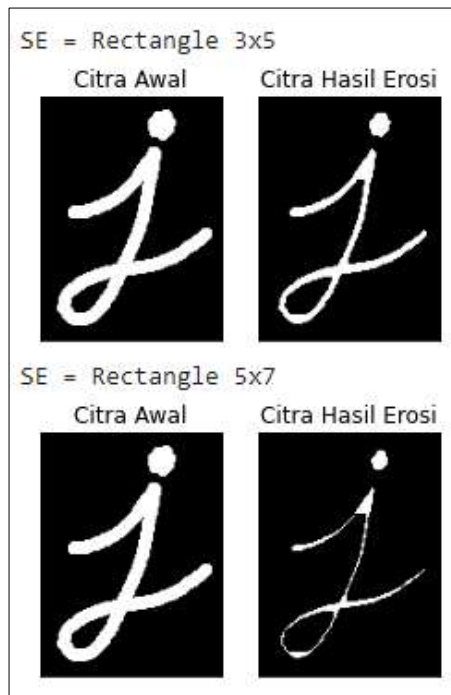
9. Make the Dilation operation and show the results on the image of the Structuring Element shaped 3x3 and 5x5 Cross using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")
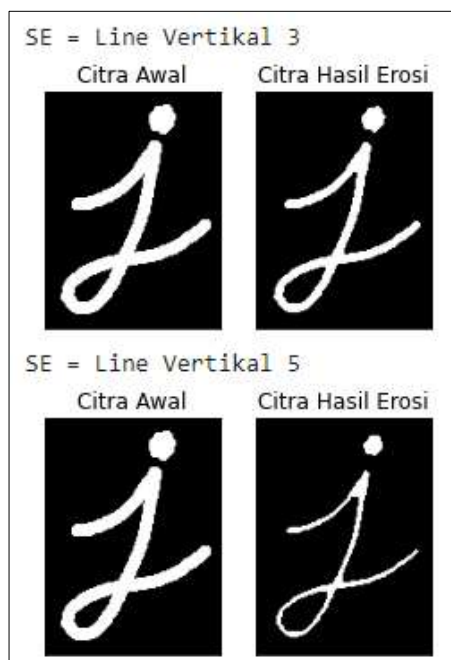

10. Make the Dilation operation and show the results on the image of the Structuring Element shaped 3x3 and 5x5 Circular using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")

11. Make the Erotion operation and show the results on the image of the Structuring Element shaped 3x3 and 5x5 Rectangle using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")

12. Make the Dilation operation and show the results on the image of the Structuring Element shaped 3 and 5 Line Vertical using the OpenCV morphology library, thus generating the results shows in the figure (Use image "j.png")

--- GOOD LUCK ---