INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Department of Electronics & Electrical Communication Engineering

Vision & Intelligent Systems

Experiment 6

Morphological Operations

Submitted by:
Bbiswabasu Roy (19EC39007)
Jothi Prakash (19EC39023)

Contents

Objective

Applying Erosion, Dilation, Opening and Closing morphological operations on the input images.

Theory

Morphological Operations

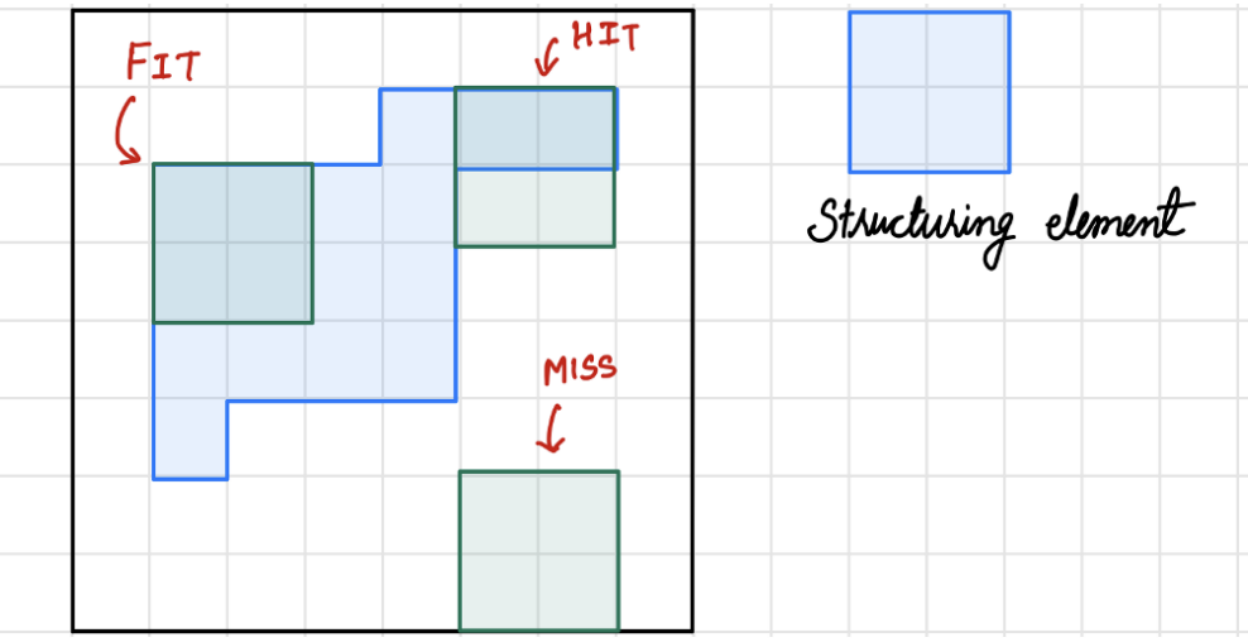
Morphology is a comprehensive set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors.

Image after segmentation

Image after segmentation and morphological processing

Structuring Element

It is a matrix or a small-sized template that is used to traverse an image. The structuring element is positioned at all possible locations in the image, and it is compared with the connected pixels. It can be of any shape.

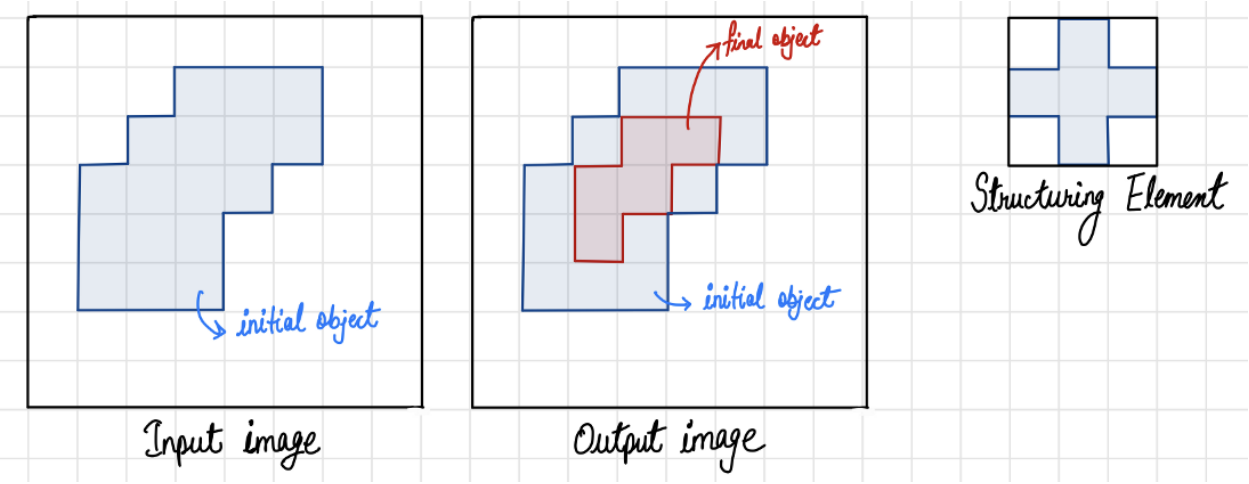


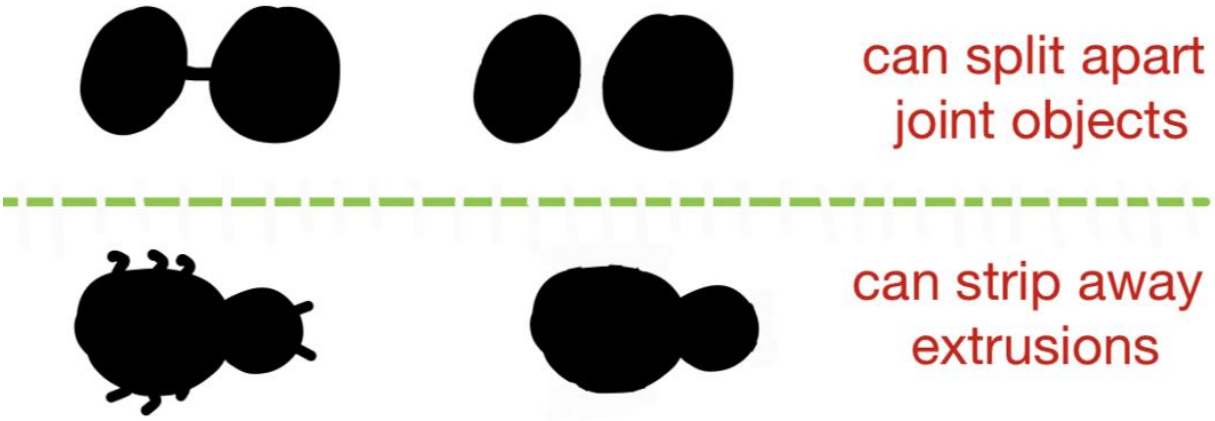
Erosion

Erosion shrinks the image pixels, or erosion removes pixels on object boundaries. First, we traverse the structuring element over the image object to perform an erosion operation. The output pixel values are calculated using the following equation.

Pixel (output) = 1 {if FIT}

Pixel (output) = 0 {otherwise}



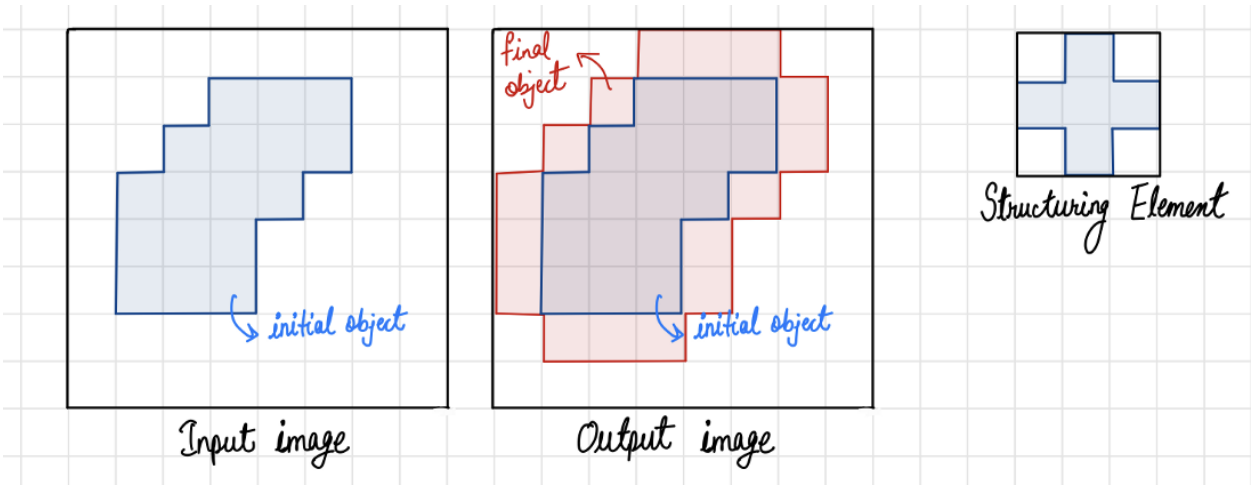


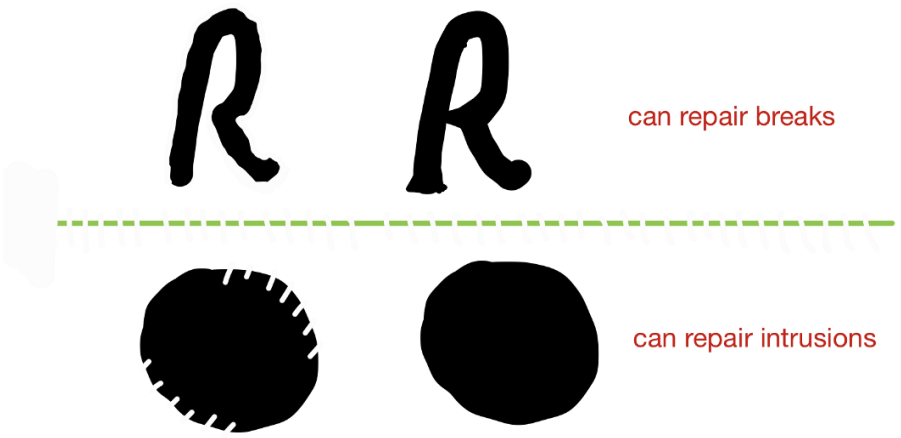
Dilation

Dilation expands the image pixels, or it adds pixels on object boundaries. First, we traverse the structuring element over the image object to perform an dilation operation. The output pixel values are calculated using the following equation.

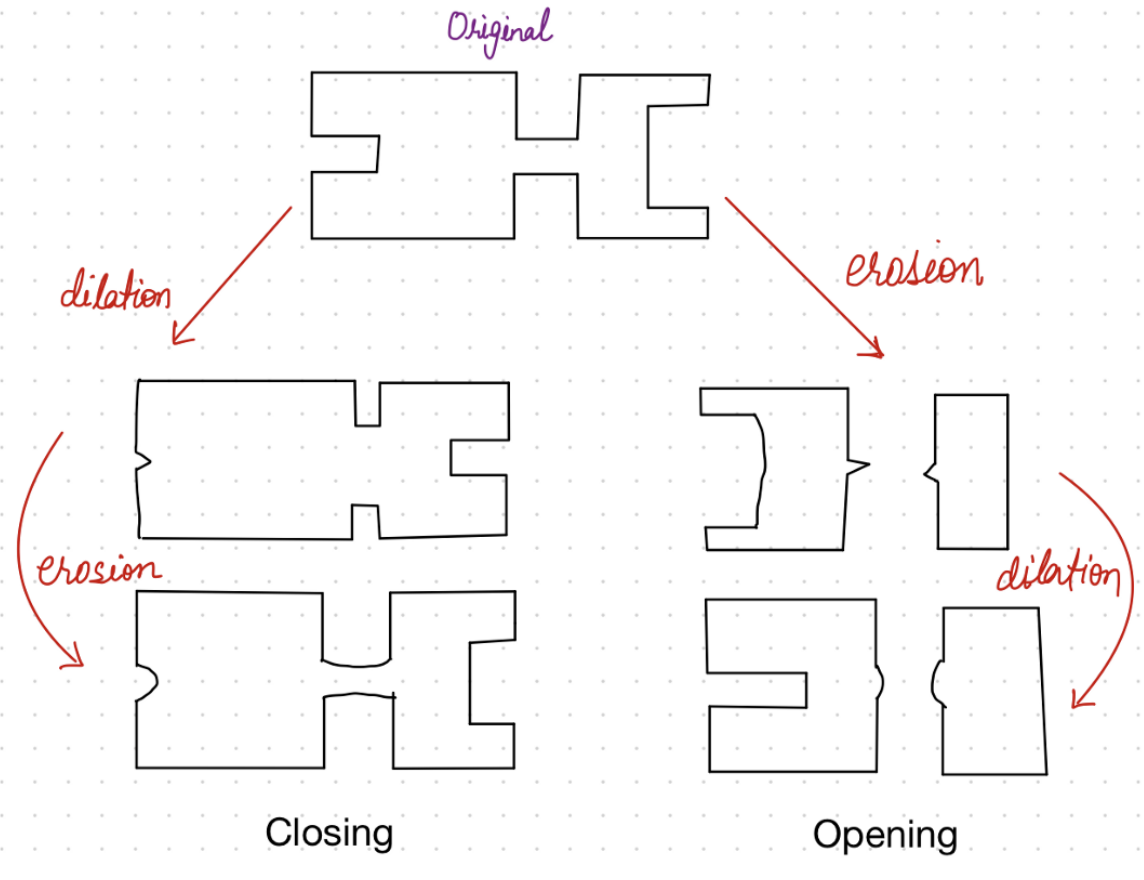
Pixel (output) = 1 {if HIT}

Pixel (output) = 0 {otherwise}





Compound Operations



Opening

Opening is the task of performing erosion on the original image with a defined kernel. Then using the same kernel to perform dilation on the transformed image.

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

It has various use cases

- Eliminates protrusions
- Breaks necks
- Smooths Contours

Closing

Closing is the task of performing dilation on the original image with a defined kernel. Then using the same kernel to perform erosion on the transformed images

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

It has various use cases

- Smooth Contour
- Fuse narrow breaks and long think gulfs
- Eliminates small holes
- Fill gaps in the contour

Algorithms

Following algorithm is used to implement dilation

- Take as input the kernel using which we will perform dilation on the image
- Iterate over all the pixels of the input image, then consider those pixels with white color.
- For every white pixel offset it by the position of the white pixel on the provided kernel.
- Store the results in a new image and then return the image.

Following algorithm is used to implement erosion

- Take as input the kernel using which we will perform the erosion on the image.
- Iterate over all the pixels of the input image.
- For every white pixel offset on the kernel, there must be a corresponding white pixel in the input image.
- If all are white then corresponding pixel in the new image is white otherwise it is black.
- Store the results and return the image

Following algorithm is used to implement Opening

- Take as input the kernel using which we will perform opening on the image.
- Initially perform erosion on the input image.
- On the same modified image, perform the dilation operation using the same kernel.
- Store the results and return the modified image

Following algorithm is used to implement Closing

- Take as input the kernel using which we will perform closing on the image.
- Initially perform dilation on the input image.
- On the same modified image, perform the erosion operation using the same kernel.
- Store the results and return the modified image

Kernels

1	1

Kernel 1

1	1	1
1	1	1
1	1	1

Kernel 2

0	1	0
1	1	1
0	1	0

Kernel 3

1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1

Kernel 9x9

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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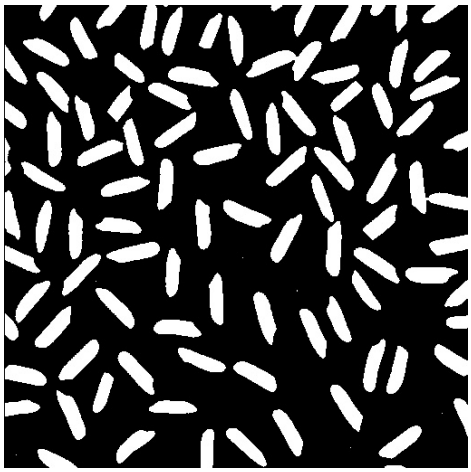
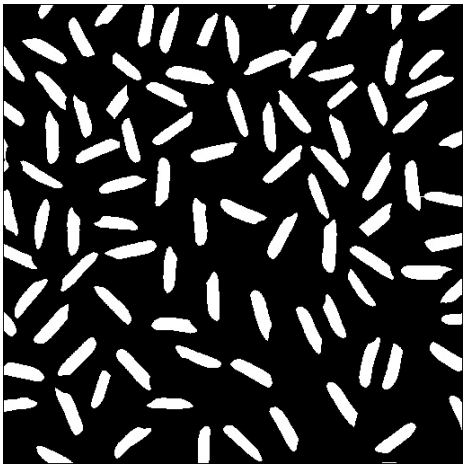
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Kernel 15x15

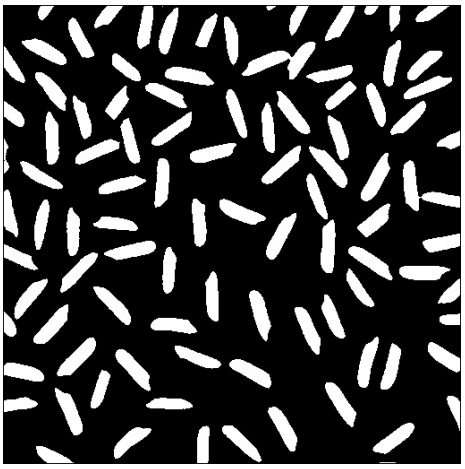
Erosion



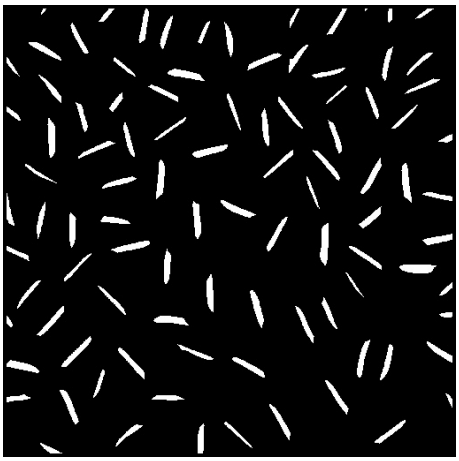
Kernel 1



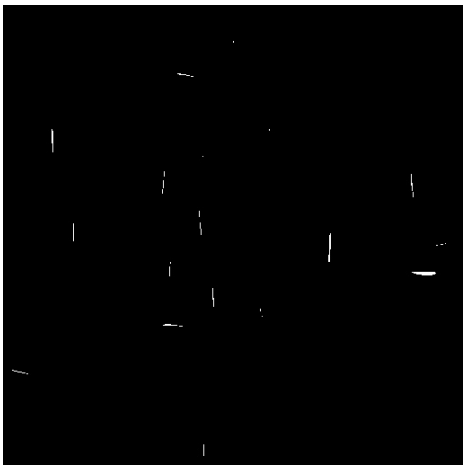
Kernel 2



Kernel 3

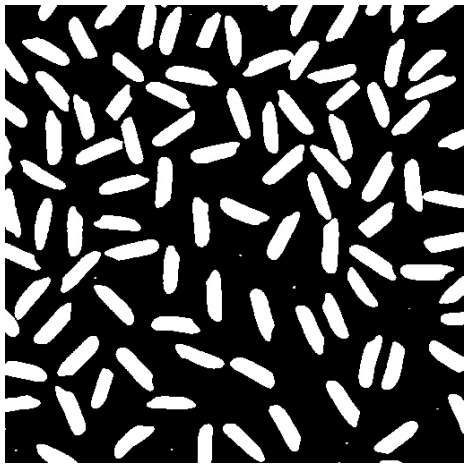


Kernel 9x9

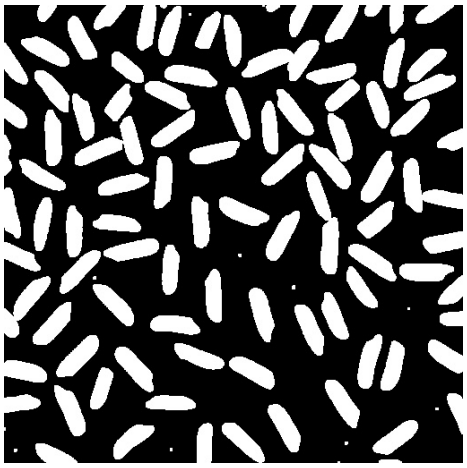


Kernel 15x15

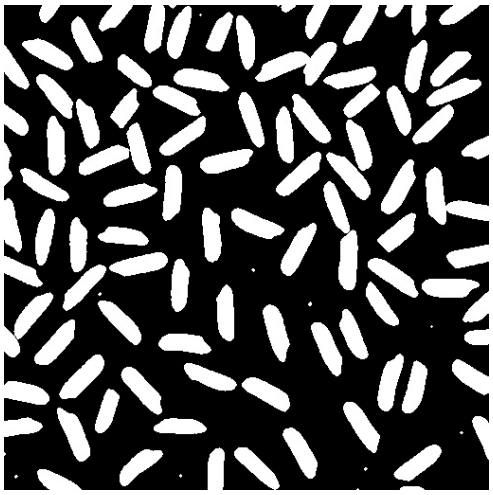
Dilation



Kernel 1

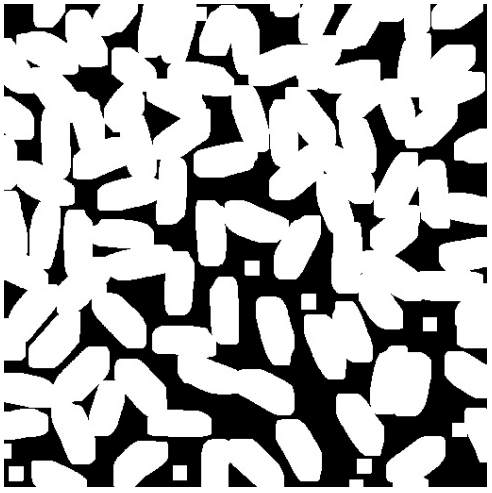


Kernel 2



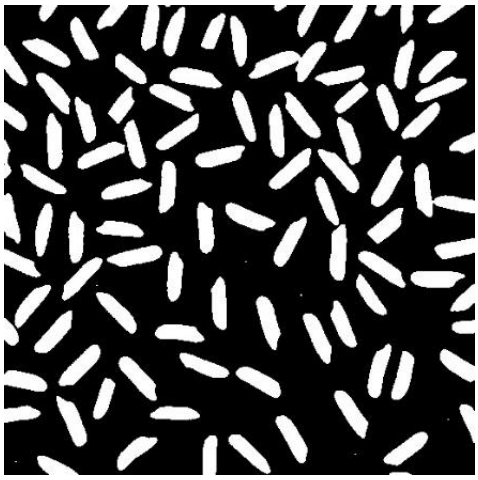
Kernel 3

Kernel 9x9

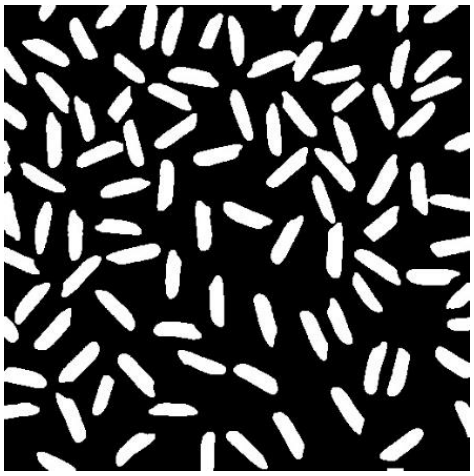


Kernel15x15

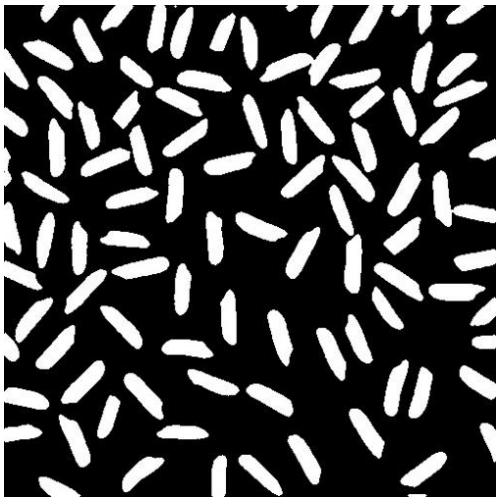
Opening



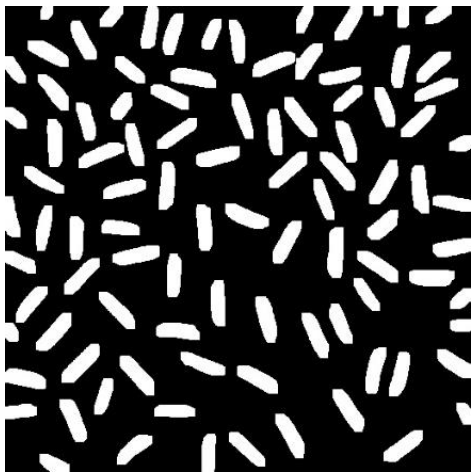
Kernel 1



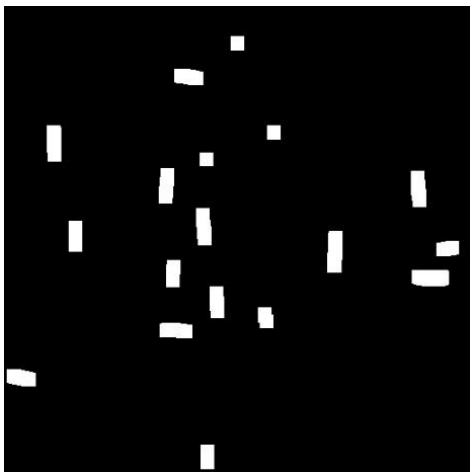
Kernel 2



Kernel 3

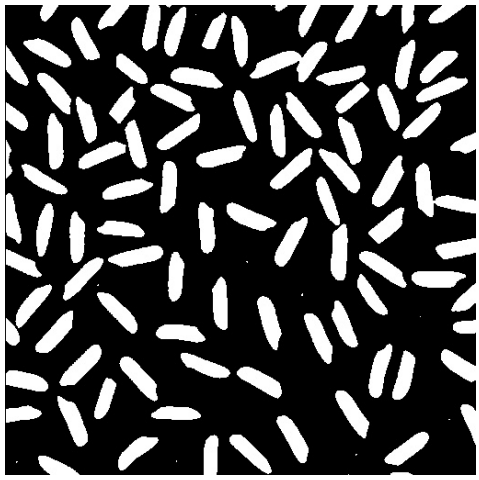


Kernel 9x9

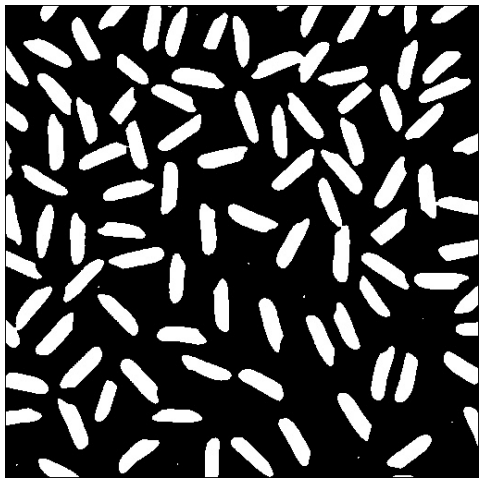


Kernel 15x15

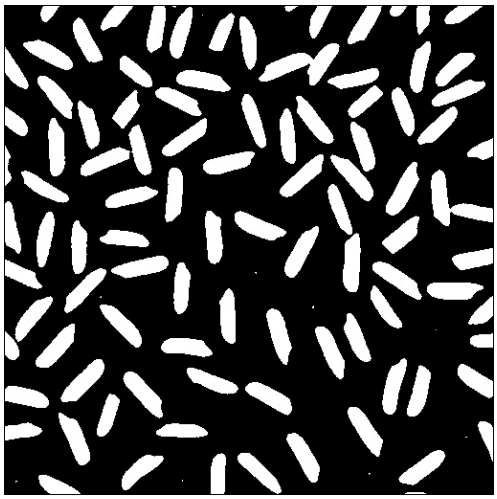
Closing



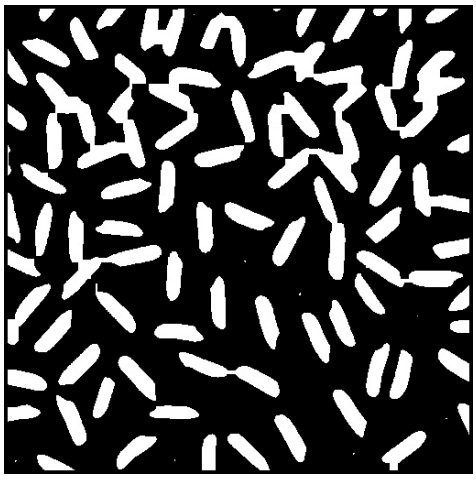
Kernel 1



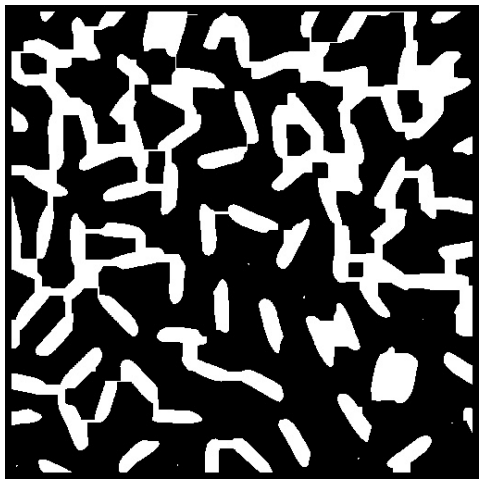
Kernel 2



Kernel 3



Kernel 9x9



Kernel 15x15

Discussion

Erosion operation when applied shrank the overall foreground size, and the shrinking was more profound as the kernel size increased. From the obtained plots we can see that it split apart big rice grains into smaller ones and also smoothed the surface boundaries.

Dilation operation increased overall area of the foreground, and the bigger kernels with more 1s led to bigger size expansion. From the obtained plots we can see that it joined multiple smaller units of rice grains and also filled the noise within the image.

Opening operation plots show that it helped in removing the protrusions on the object surfaces, also removed any necks between adjacent rice grains and overall smoothened the rice grains. Increasing the kernel size can be seen as making the rice grains into a smoothened blob. This is due to the fact that opening performs erosion first, hence it removes all the connecting gulfs and then performs dilation therefore making the rice grains bigger.

Closing operation plots show that is helped to fill in the internal gaps, but also joined multiple smaller rice grains to a big one. It fuses the narrow breaks and thin gulfs between rice grains. Increasing the kernel size can be seen as joining multiple grains that are connected by necks, which get bigger as kernel grows. This is observed due to the fact that closing performs dilations first, hence it makes the connecting gulfs bigger and then performs erosion therefore making the grains smaller but the connections still remain.