INDIAN INSTITUTE OF TECHNOLOGY

KHARAGPUR

DEPARTMENT OF ELECTRONICS AND ELECTRICAL COMMUNICATION

IMAGE PROCESSING LABORATORY

ASSIGNMENT NUMBER 5

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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,

$$A \ominus B = (x \in Z^2 \mid (B)_x \subseteq A)$$

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 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

$$A \oplus B = \{c \in Z^2 \mid c = a + b \text{ for some } a \in A, b \in B\}$$

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.

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

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.

For erosion, we have to check if the structuring element is completely fit in the image pixel or not. So, to check the corner point, I have done zero padding. For zero padding,

START

set Array_for_padding to zero

For i=1 to image rows

For j=1 to image columns

Array_for_padding[i][j]=image_pixel[i]i[j]

endfor

END

After the zero-padding, I have moved the structuring element in the 2D array and if the structuring element fits in the current pixels, I have put the pixel for white colour in another 2D array to get the output image.

START

set output_image_array to zero

For i=1 to image rows

For j=1 to image columns

If structing element directly fits

    output_image_array[i][j]=0

else output_image_array[i][j]=255

endif

endfor

END

For dilation, I have moved the structuring element in the 2D array and if at least one element of the structuring element same with the current pixels, I have put the pixel for white colour in another 2D array to get the output image.

START

set output_image_array to zero

For i=1 to image rows

For j=1 to image columns

If at least one element of structuring element is same as current pixel

    output_image_array[i][j]=0

else output_image_array[i][j]=255

endif

endfor

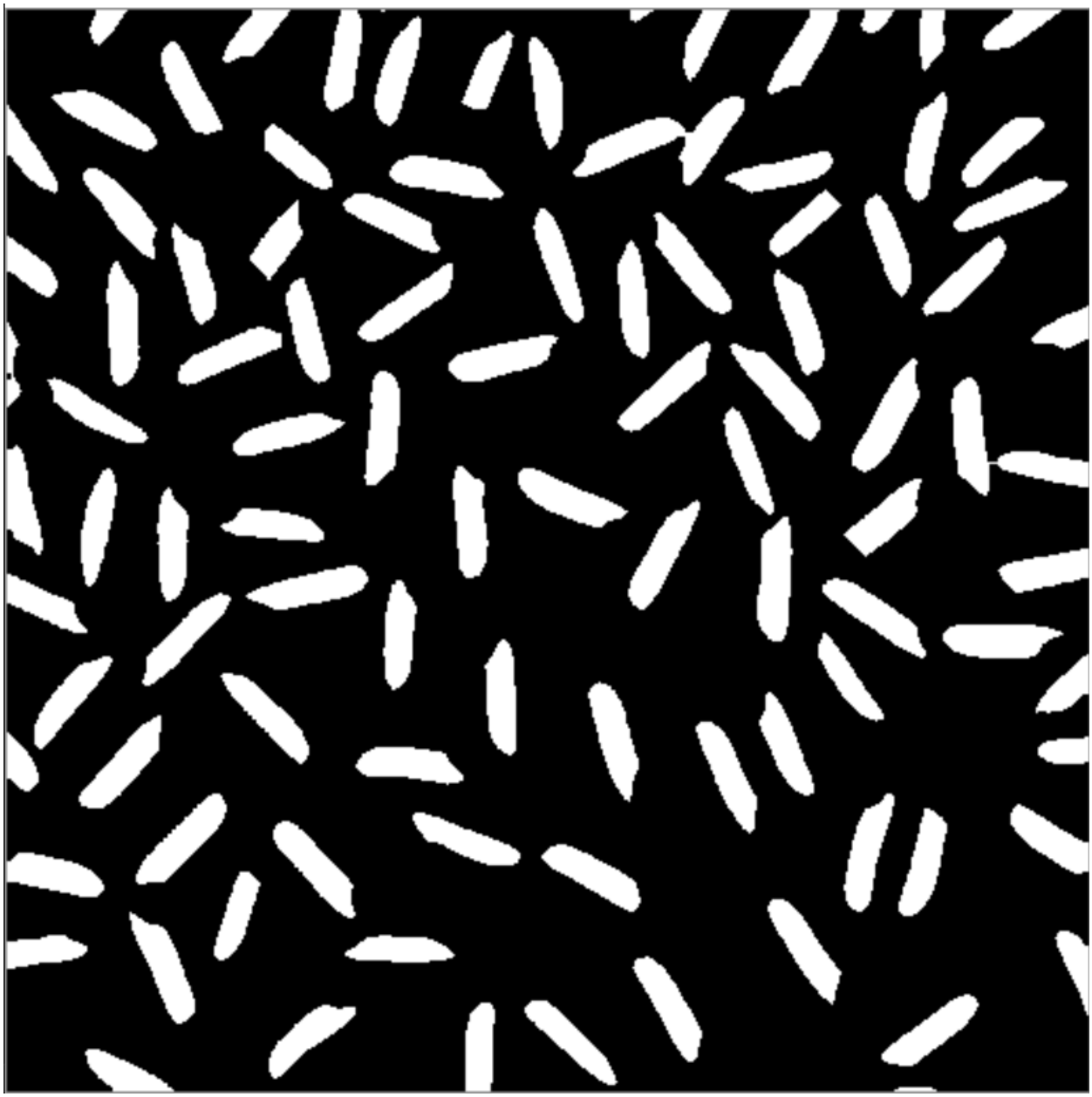
END

For opening, I have done erosion of the image at first and then use dilation of the output image to get the final output image.

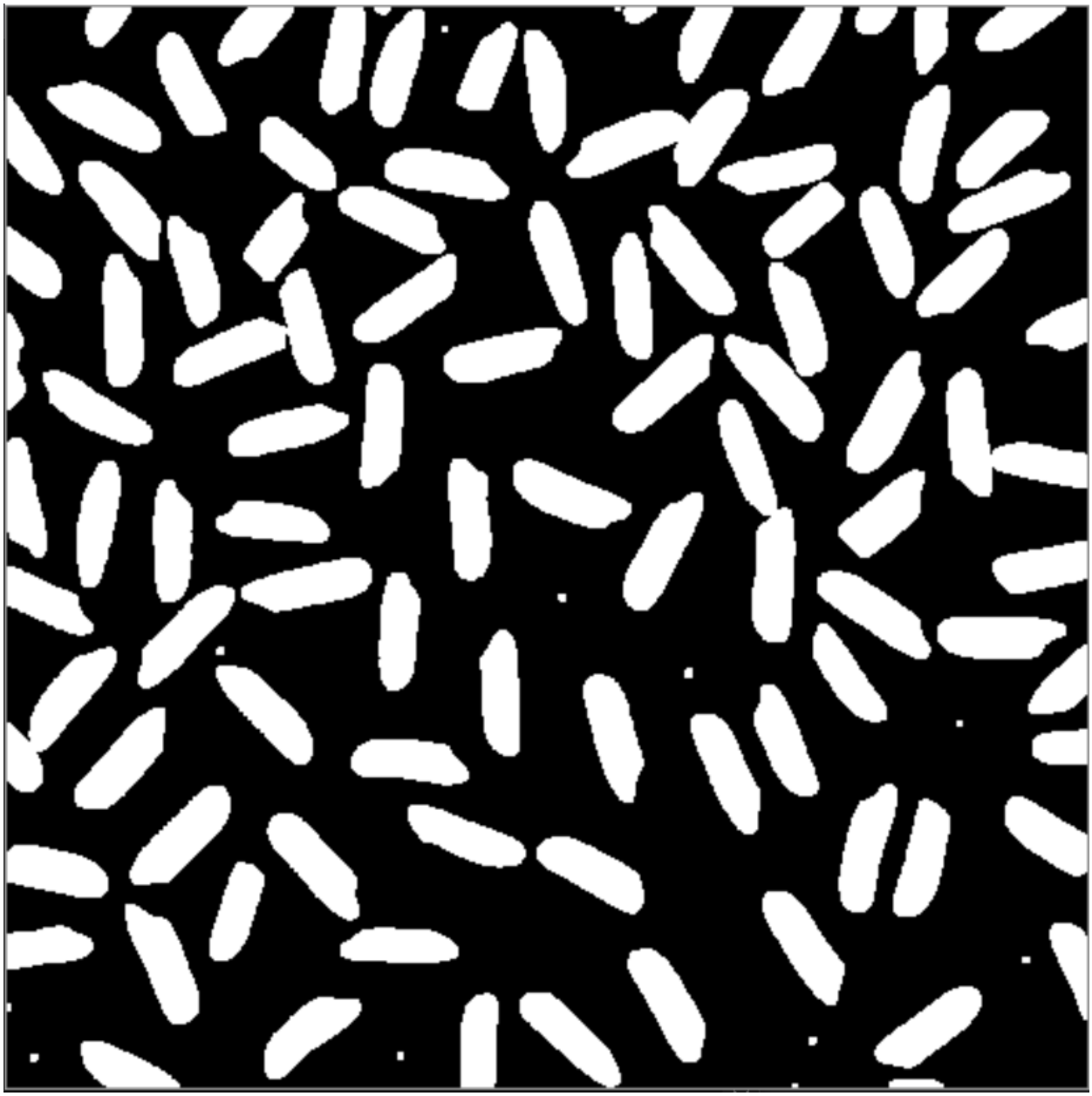
For closing, I have done dilation of the image at first and then use erosion of the output image to get the final output image.

Output:

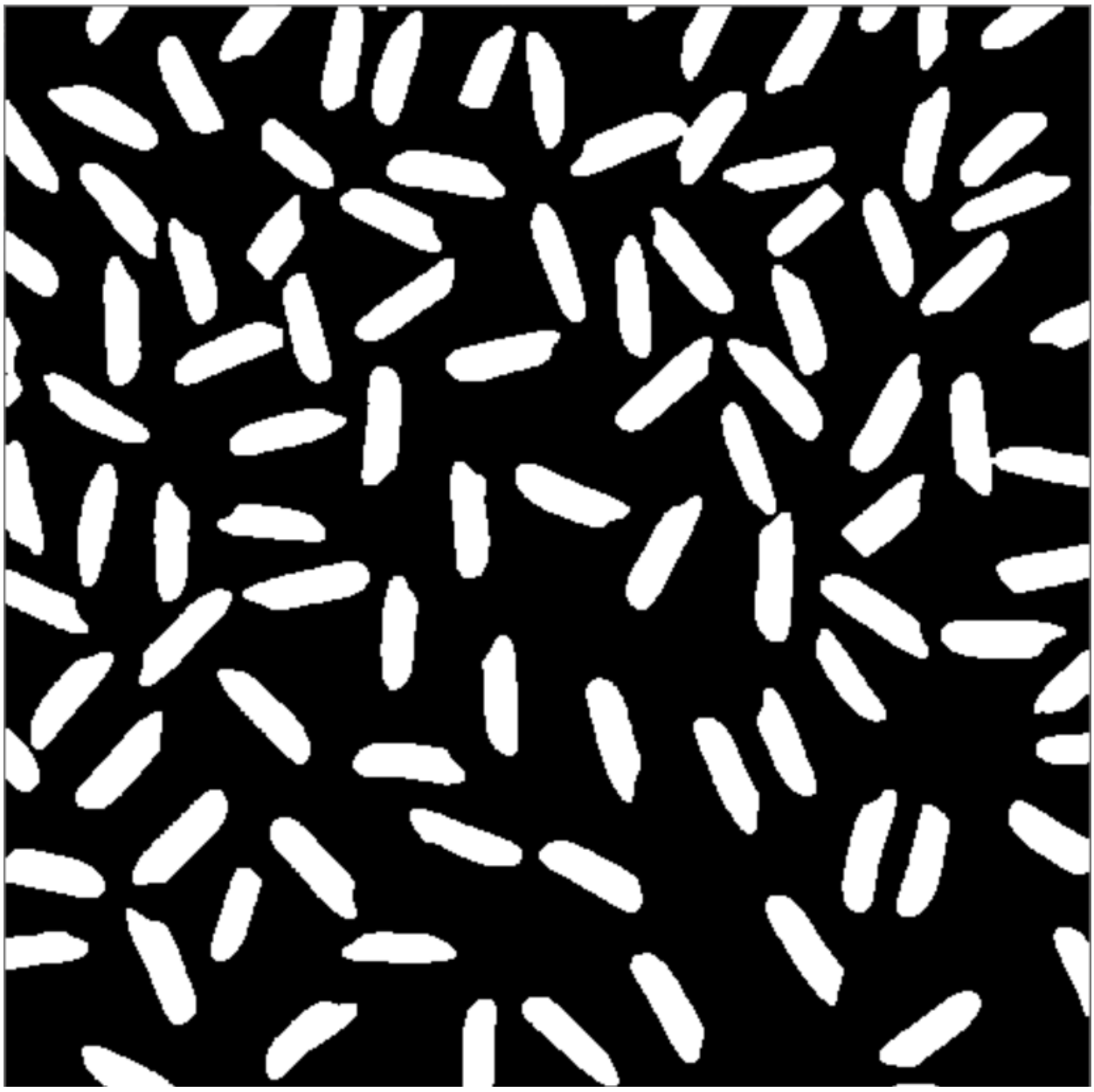
3x3 structuring element erosion



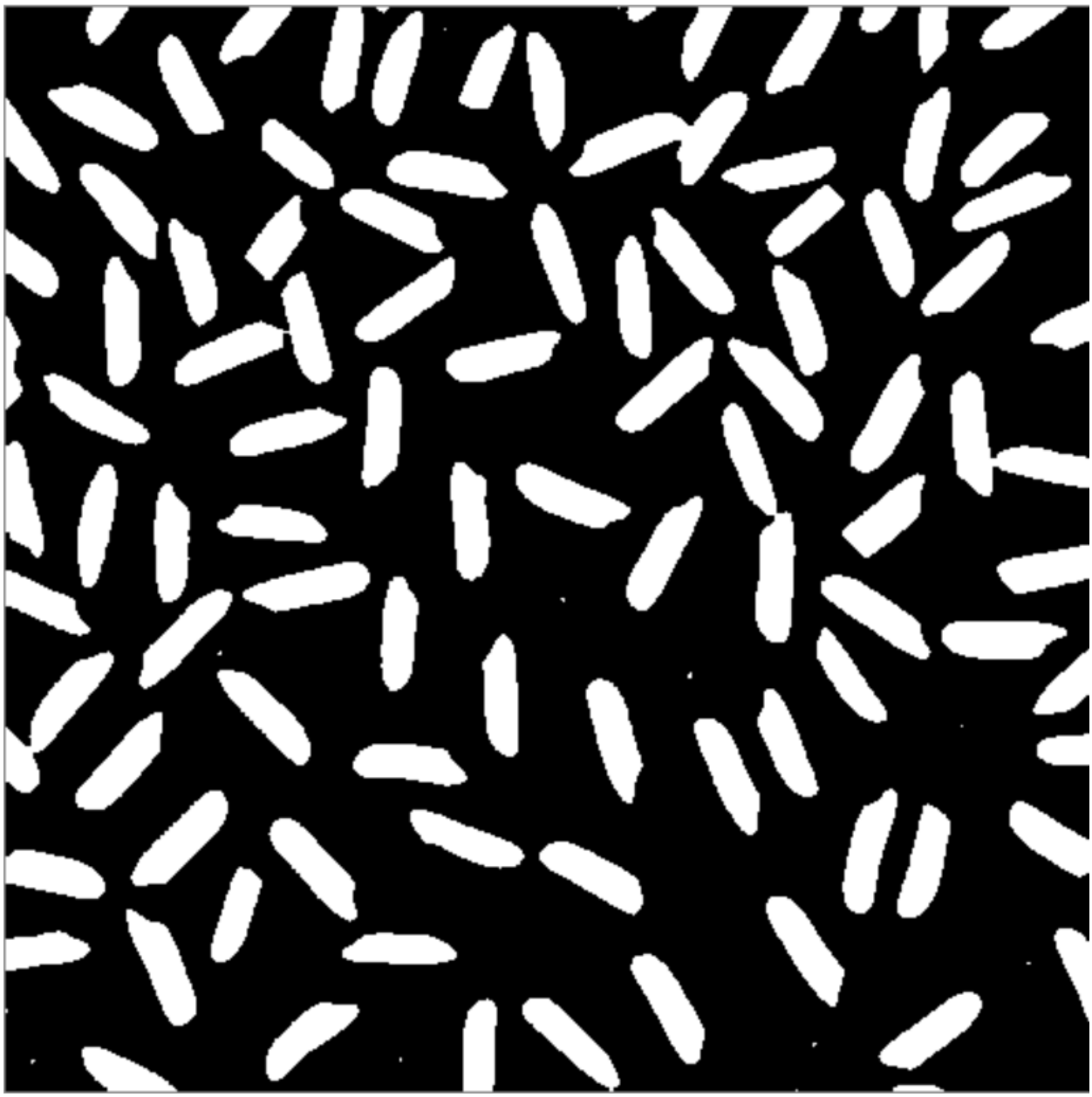
3x3 Dilation



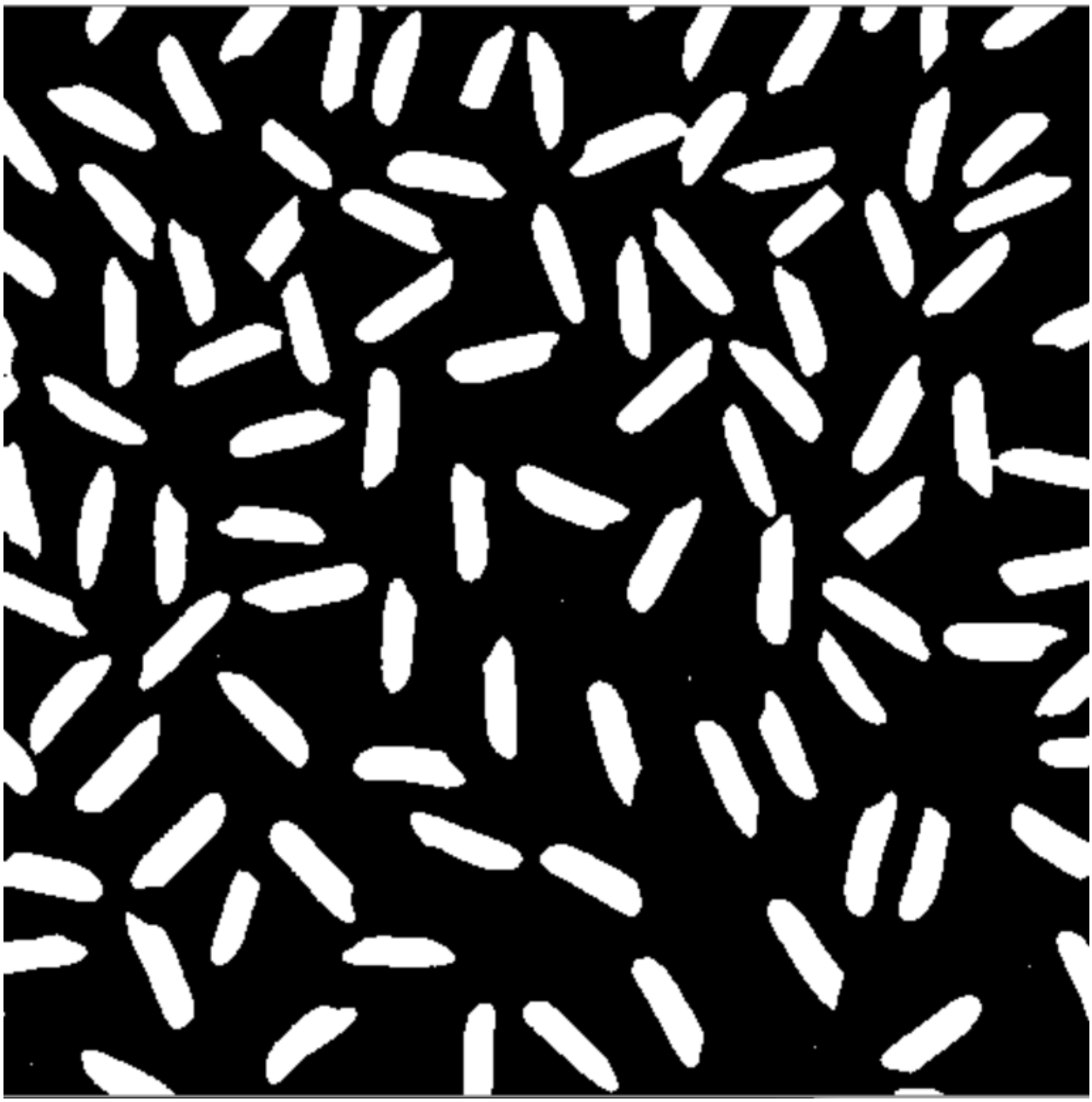
3x3 opening:



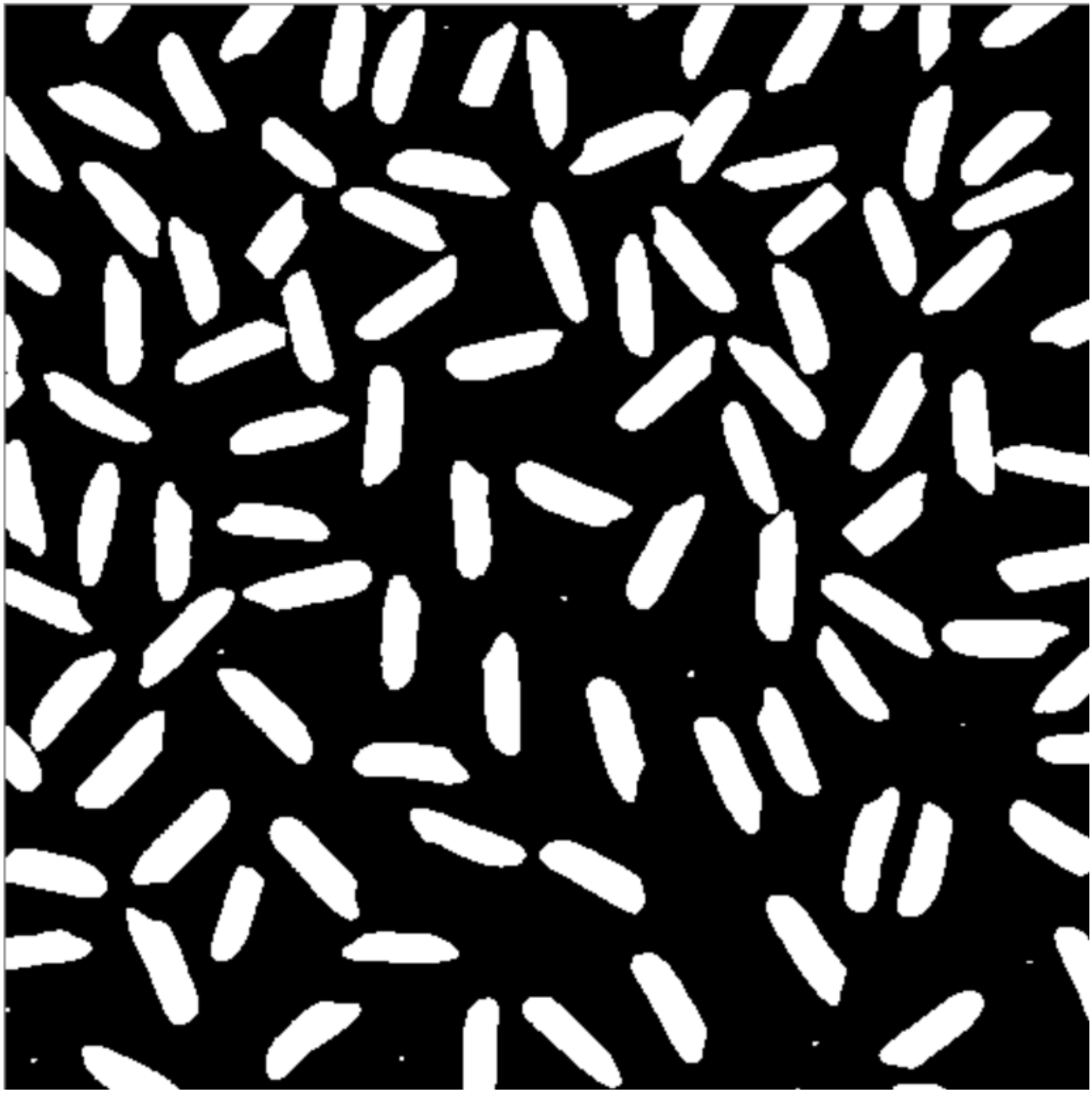
3x3 closing:



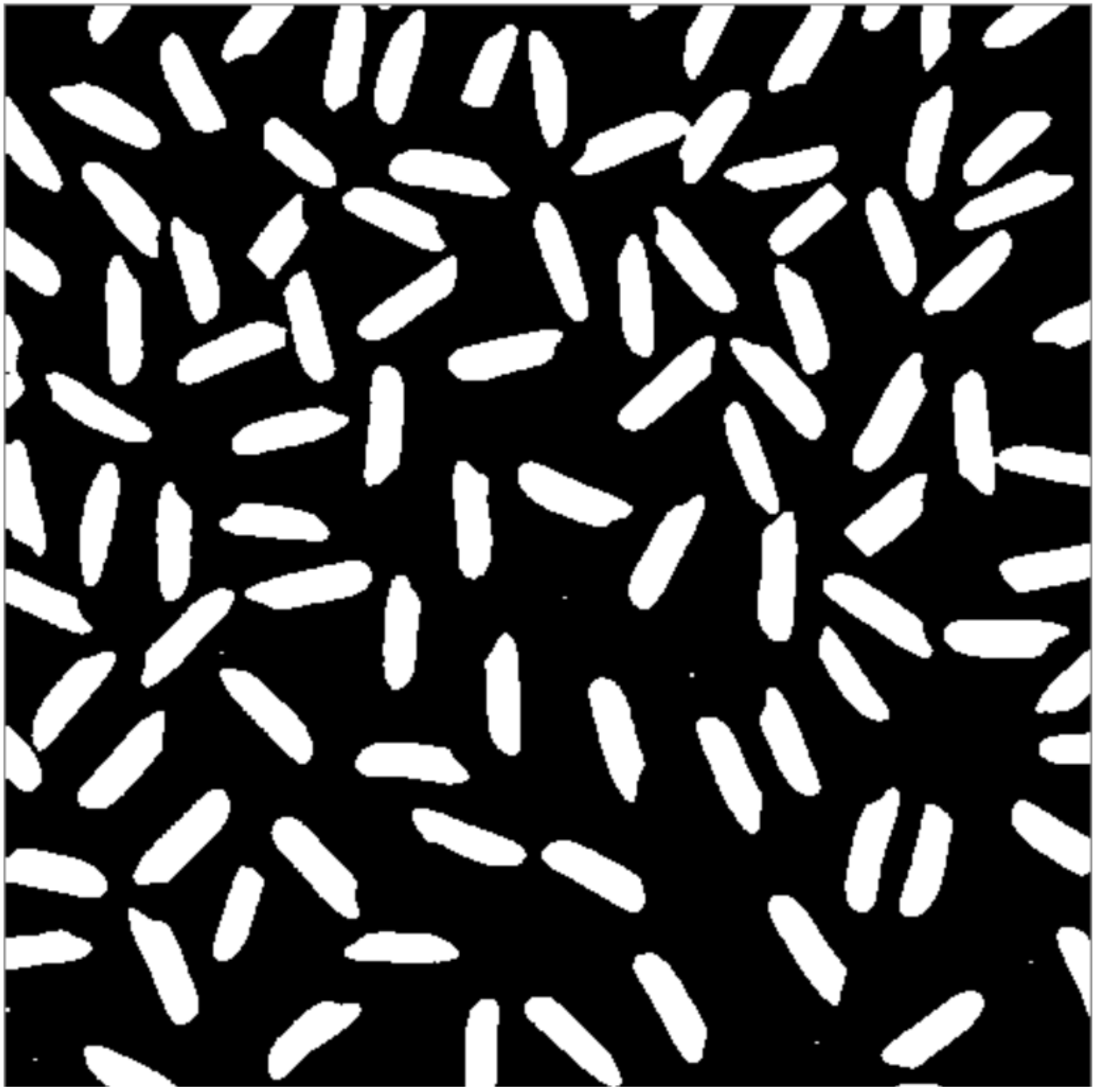
1x2 erosion:



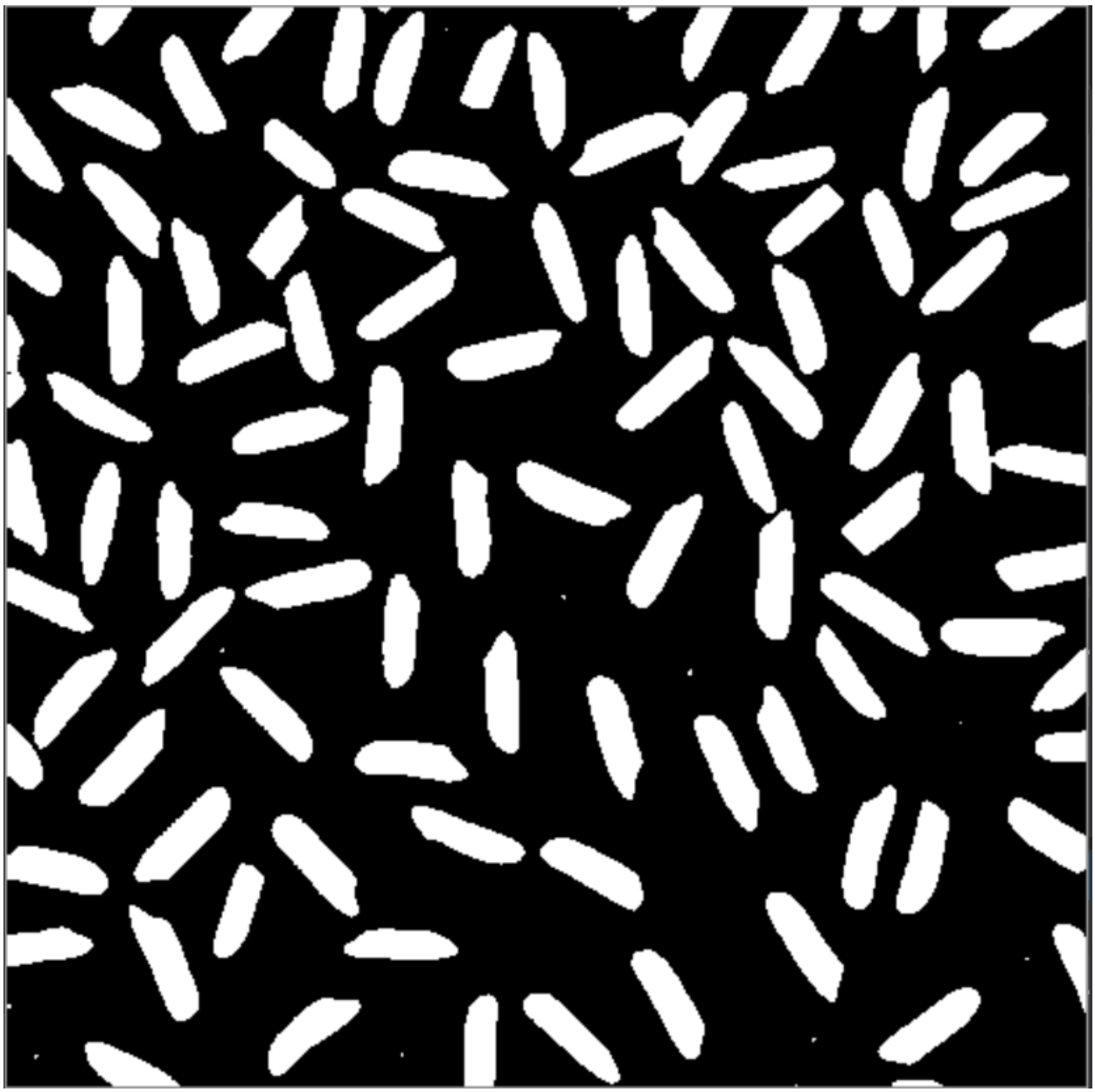
1x2 dilation:



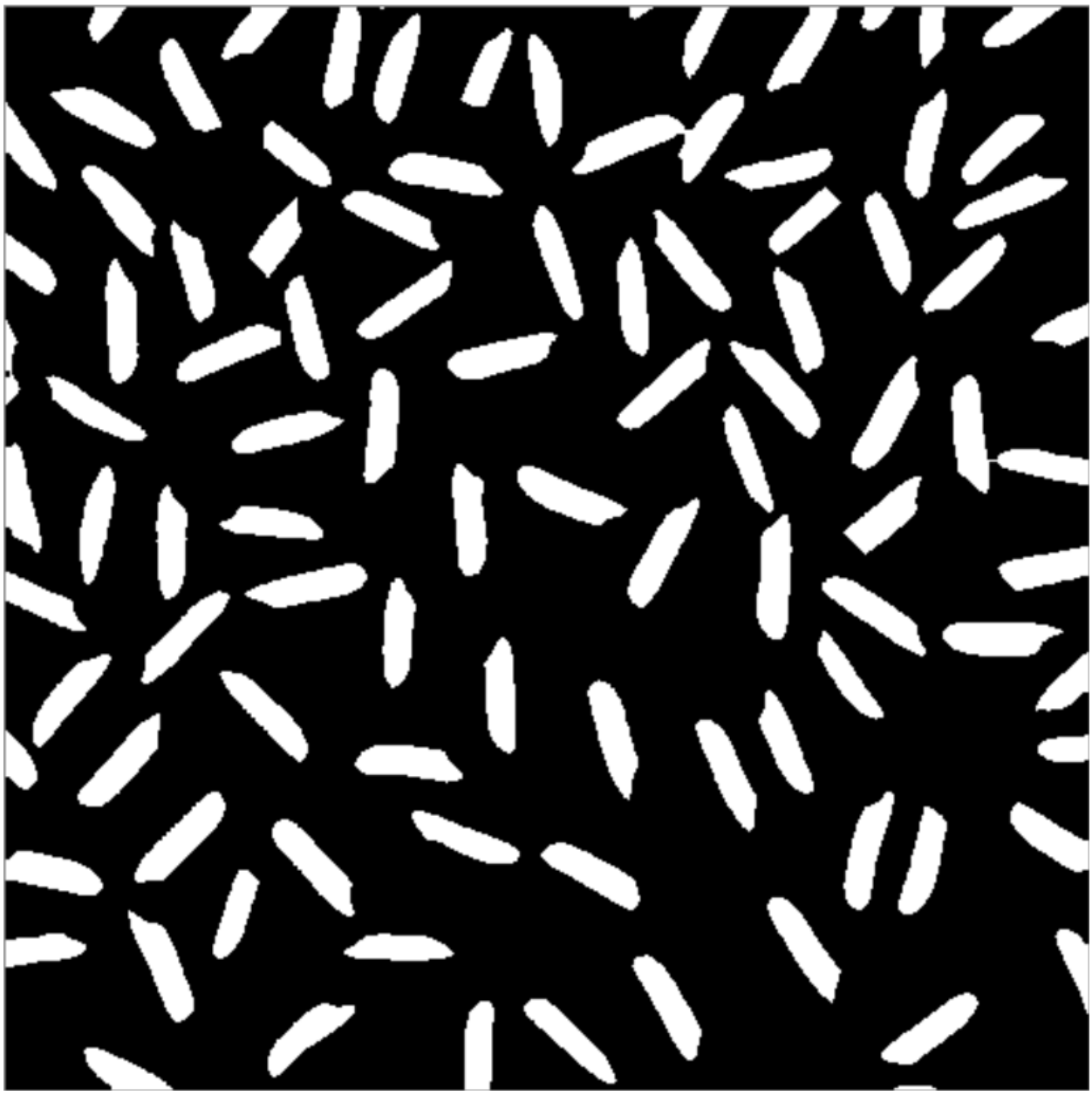
1x2 opening:



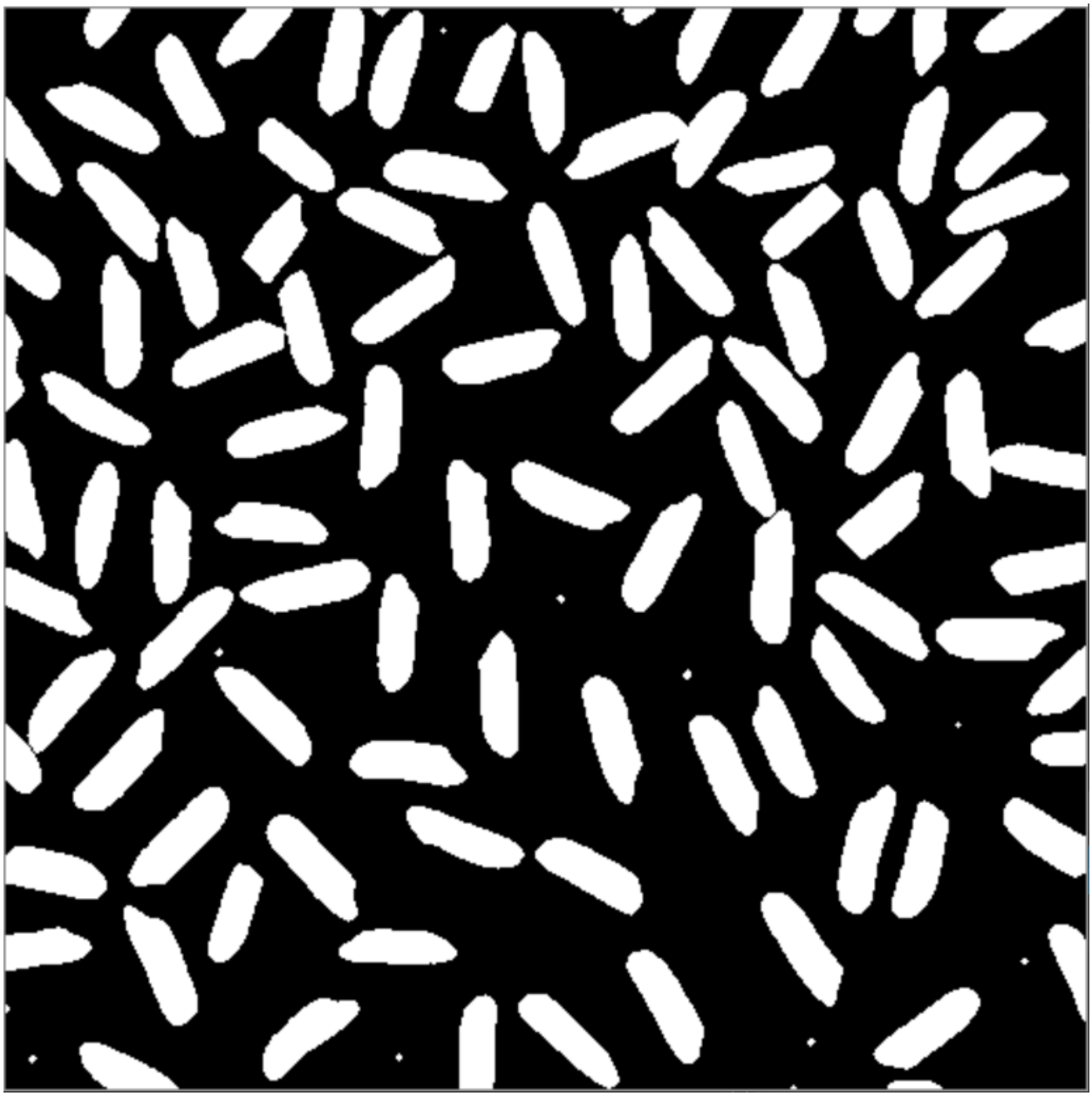
1x2 closing:



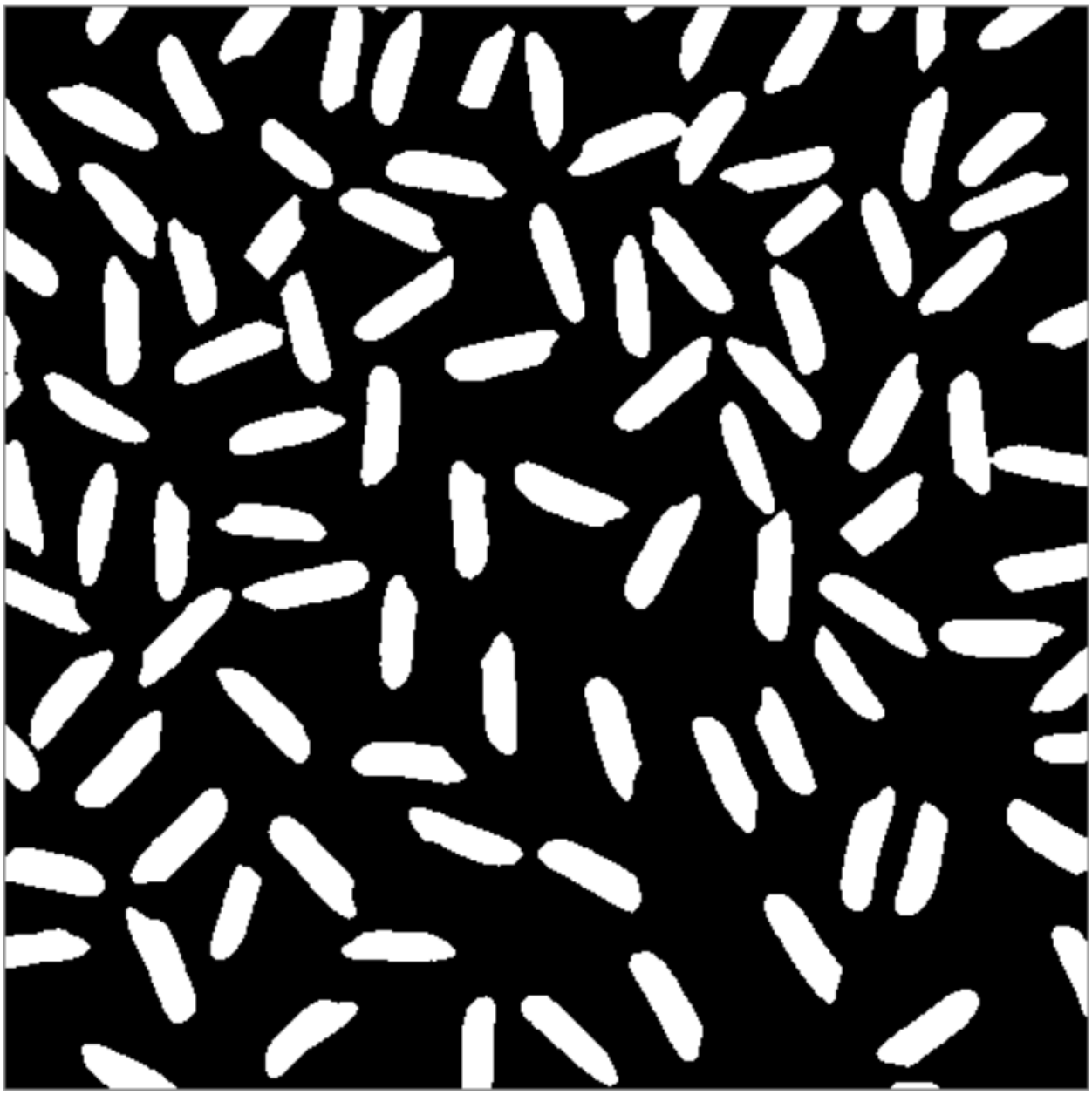
Diamond Structure Erosion:



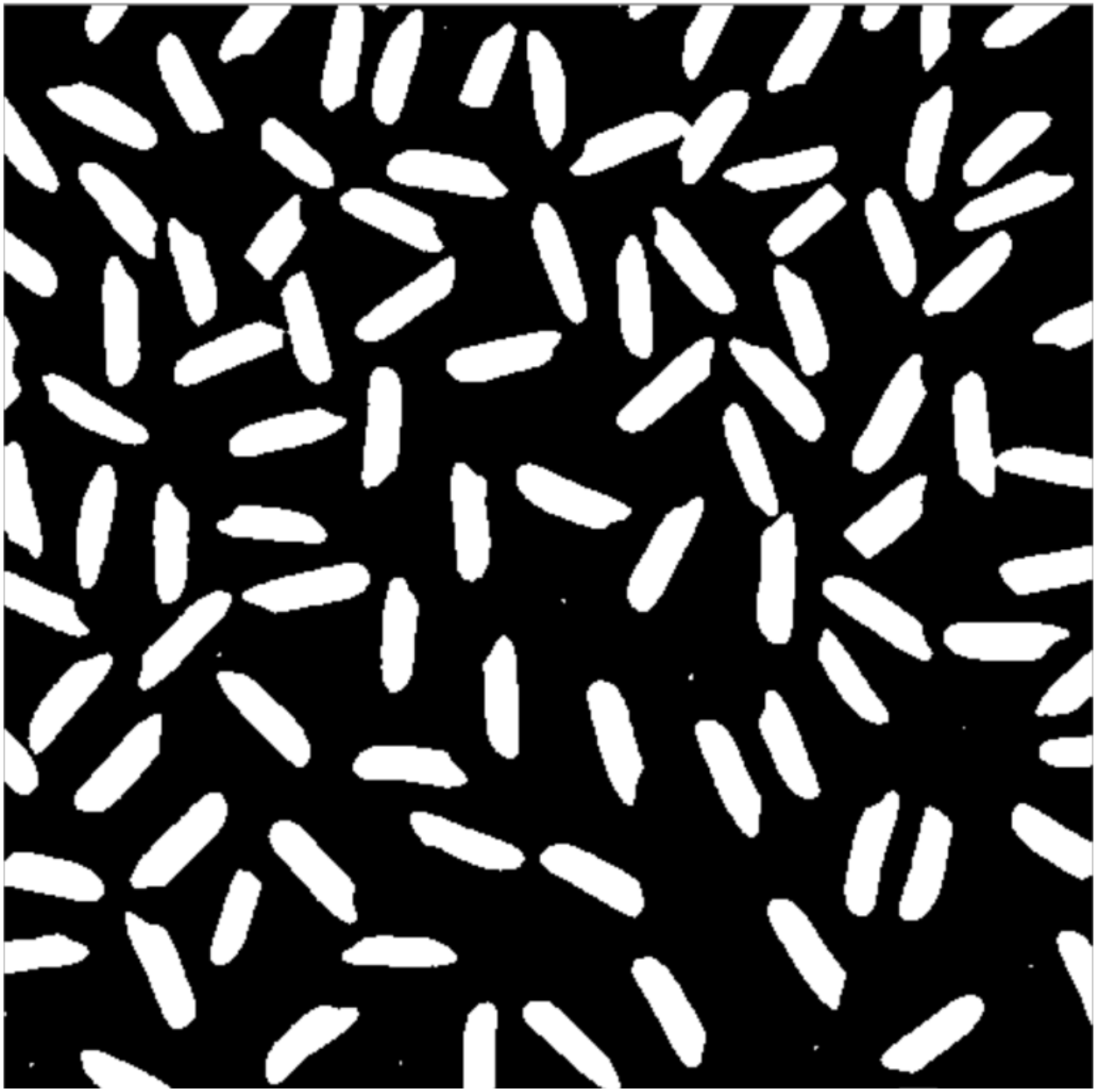
Diamond Structure Dilation:



Diamond Structure opening:



Diamond Structure Closing:



Analysis:

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.

Sources

- https://en.wikipedia.org/wiki/Mathematics
- https://www.geeksforgeeks.org/morphological-operations-in-matlab/
- https://www.mathworks.com/help/images/morphological-dilation-and-erosion.html
- http://graphics.ics.uci.edu/CS111/Slides/woodsandgonzalez.pdf