Activity 8: Morphological Operations

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OBJECTIVES

1) to analyze the effect of erosion and dilation to an image using different structure elements

2) to predict the effect of erosion and dilation by drawing

3) to verify the effect of erosion and dilation by coding

ALGORITHM

Here, we made the shapes to be eroded and dilated (original shape), and the structuring elements.

```
%% Initialization

xo = -6:1:6; yo = xo; [Xo,Yo] = meshgrid(xo,yo);
xe1 = -6:1:5; yo1 = -6:1:6; [Xe1,Yo1] = meshgrid(xe1,yo1);
xe = -6:1:5; ye = xe; [Xe,Ye] = meshgrid(xe,ye);

% shapes
squ = ((abs(Xo)<= 2.5).*(abs(Yo)<=2.5));
tri = ((Xe1<= 1 & Xe1>=-2).*(abs(Yo1-1)<=0.5)+(abs(Xe1+1)<=1.5).*(abs(Yo1)<=0.5)...
    +(abs(Xe1+2)<=0.5).*(abs(Yo1+1)<=0.5));
ho1 = ((Xe<=4 & Xe>=-5).*(Ye<=4 & Ye>=-5)-(Xe<=2 & Xe>=-3).*(Ye<=2 & Ye>=-3));
plu = ((abs(Xo)<= 0.5).*(abs(Yo)<=2.5)+(abs(Yo)<= 0.5).*(abs(Xo)<=2.5)-...
    (abs(Xo)<= 0.5).*(abs(Yo)<=0.5));

% structuring parameter
struct1 = [0 0 0 0; 0 1 1 0; 0 1 1 0; 0 0 0 0];
struct2 = [0 0 0; 0 1 0; 0 1 0; 0 0 0];
struct3 = [0 0 0 0; 0 1 1 0; 0 0 0 0];
struct4 = [0 0 0 0 0; 0 0 1 0 0; 0 1 1 1 0; 0 0 1 0 0; 0 0 0 0 0];
struct5 = [0 0 0 0; 0 0 1 0; 0 1 0 0; 0 0 0 0];
```

ALGORITHM

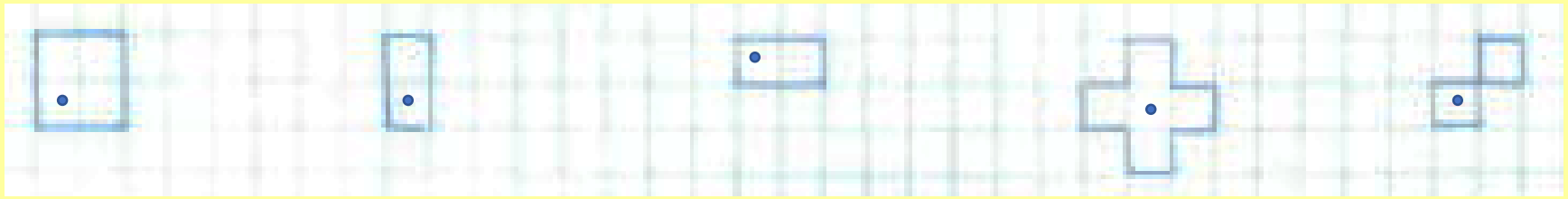
Here, the original shape is eroded and dilated using a structuring element.

Erosion: $A \ominus B = \{z | B_z \subseteq A\}$

Dilation: $A \oplus B = \{z | \hat{B}_z \cap A \neq 0\}$

```
% % square
sqDIL1=imdilate(squ,struct1);sqERO1=imerode(squ,struct1);
sqDIL2=imdilate(squ,struct2);sqERO2=imerode(squ,struct2);
sqDIL3=imdilate(squ,struct3);sqERO3=imerode(squ,struct3);
sqDIL4=imdilate(squ,struct4);sqERO4=imerode(squ,struct4);
sqDIL5=imdilate(squ,struct5);sqERO5=imerode(squ,struct5);
```

Hand-drawn structure elements



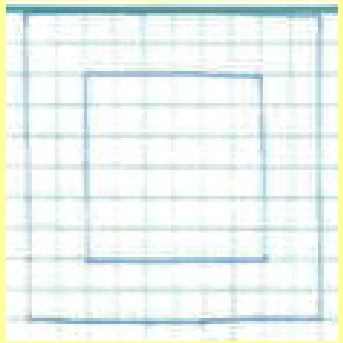
2 x 2 ones | 2 x 1 ones | 1 x 2 ones | cross | diagonal

Note: blue dot represents the chose origin

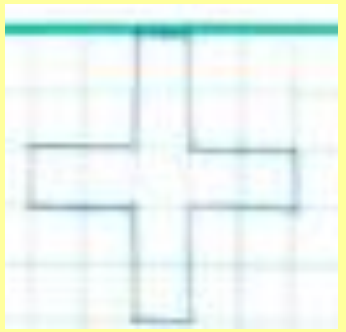
Hand-drawn shapes

5 x 5 square

triangle (base = 4, height = 3)

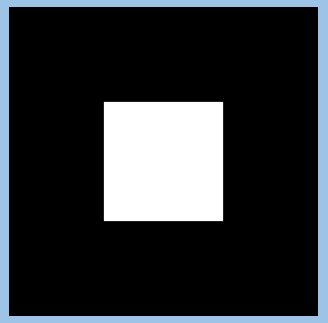


hollow 10 x 10 square (2 boxes thick)

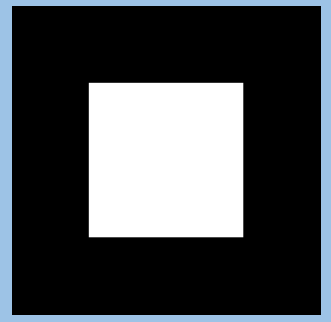
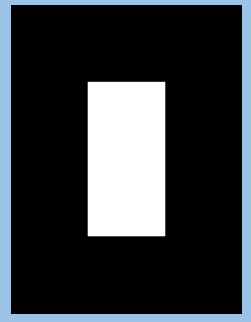
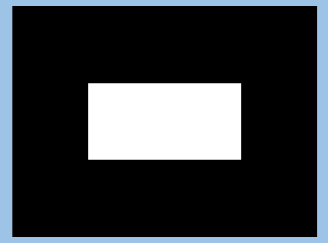
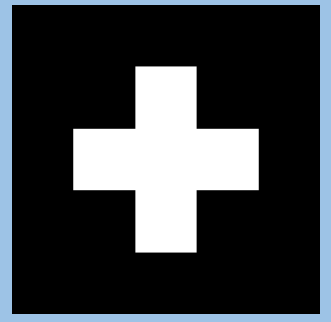
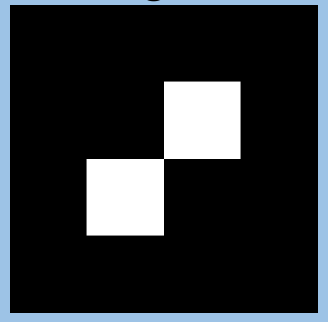
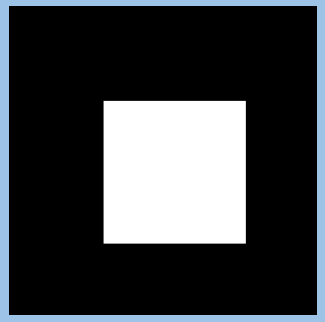
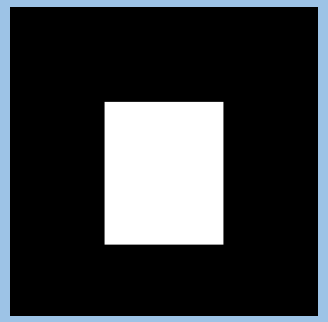
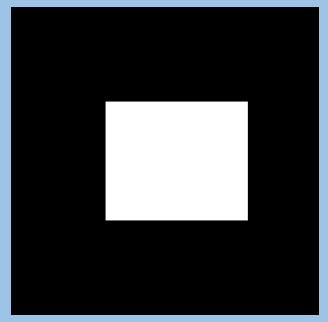
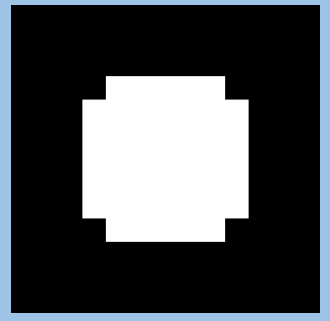
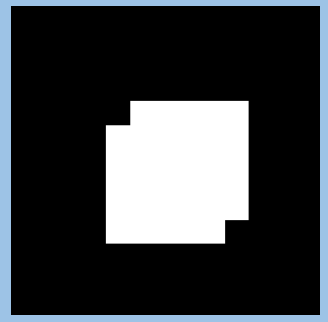
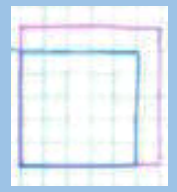
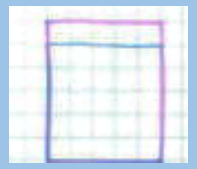
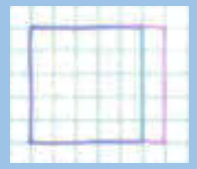
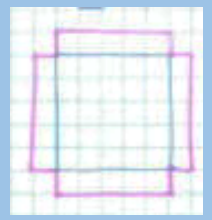
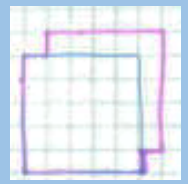


plus (5 box each line, 1 box thick)

Original shape

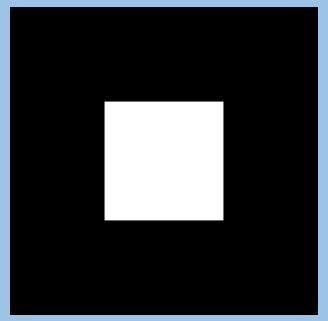


DILATION of 5x5 square

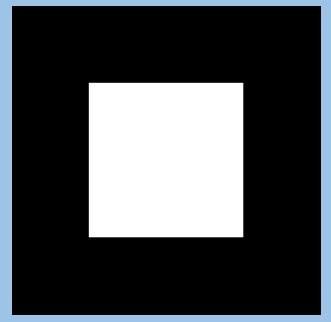
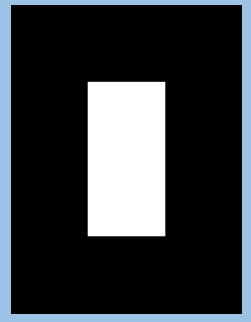
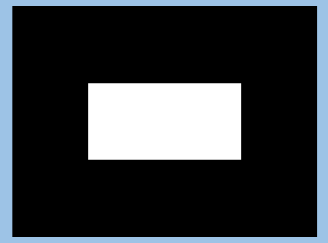
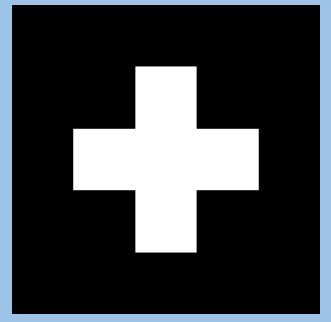
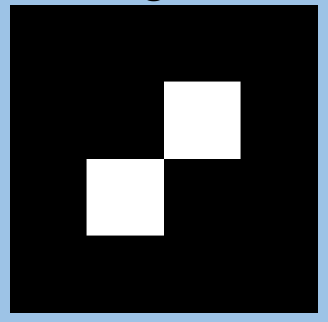
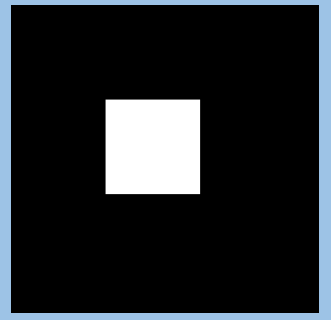
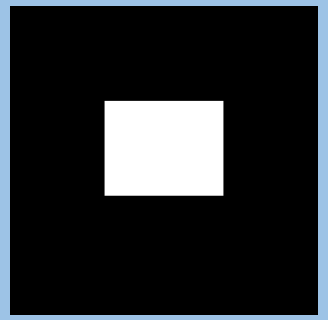
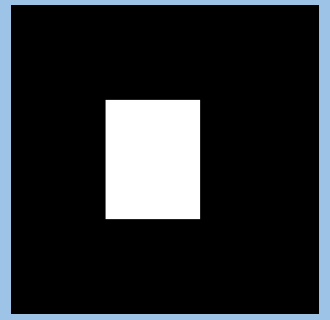
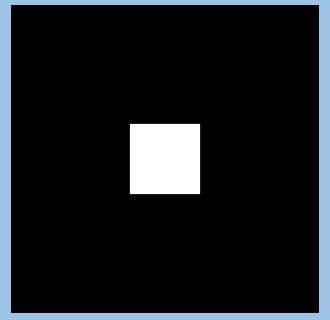
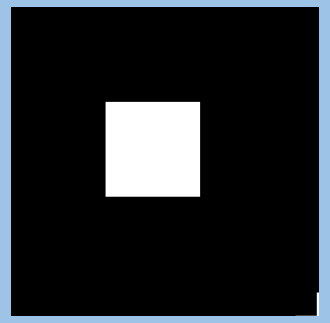
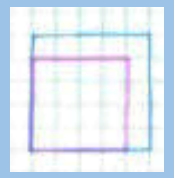
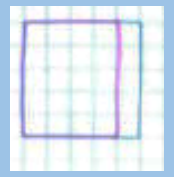
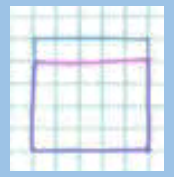
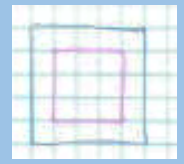
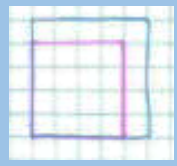
	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

Original shape

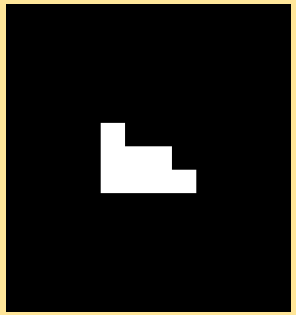


EROSION of 5x5 square

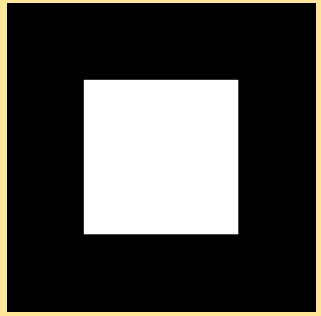
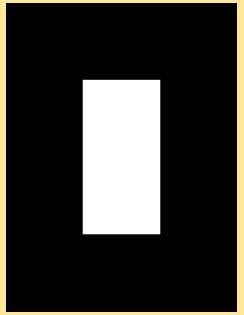
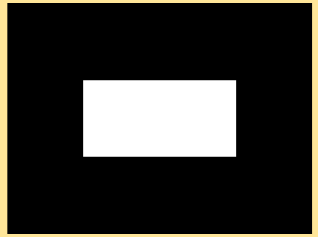
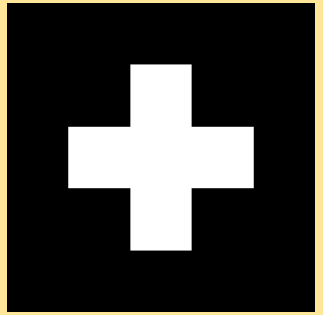
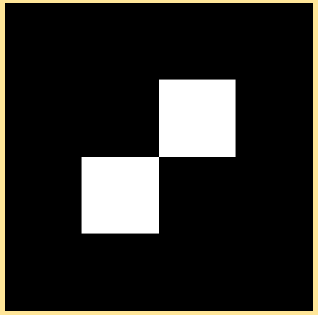
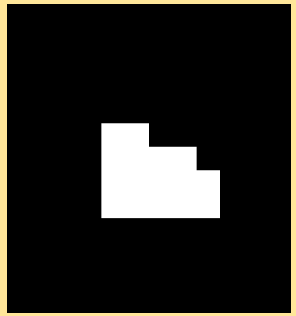
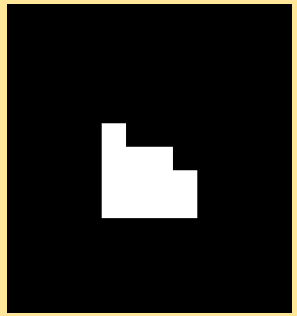
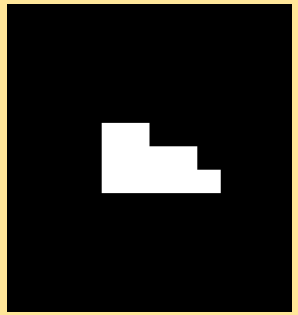
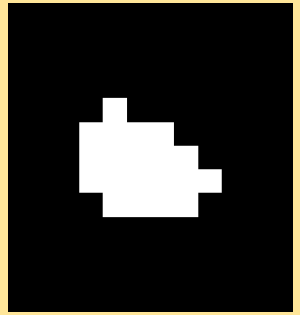
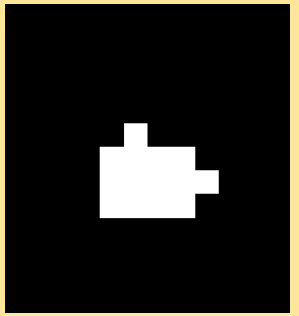
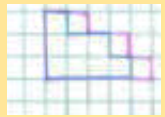
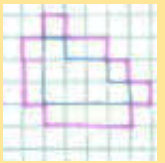
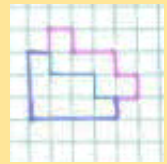
	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

Original shape

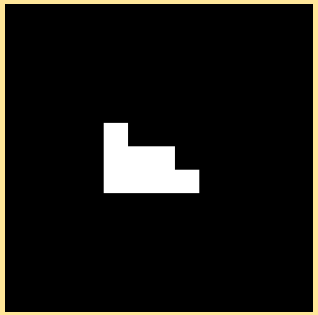


DILATION of triangle

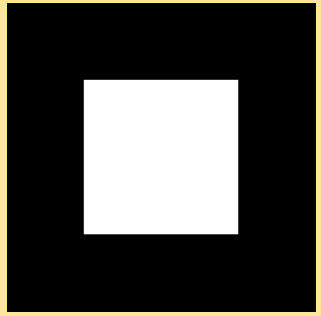
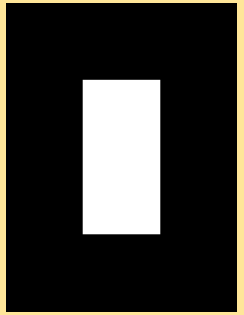
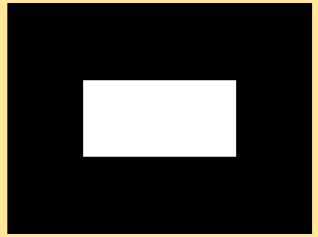
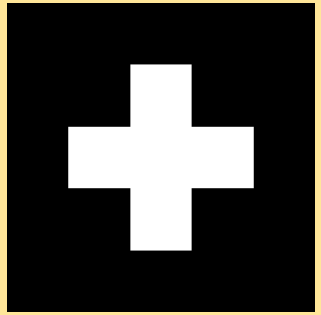
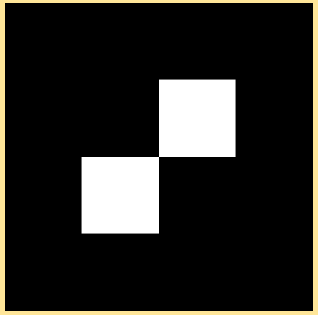
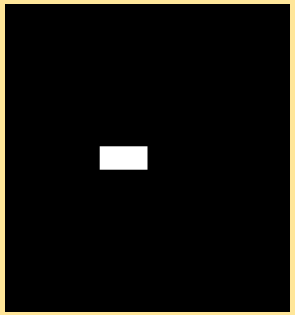
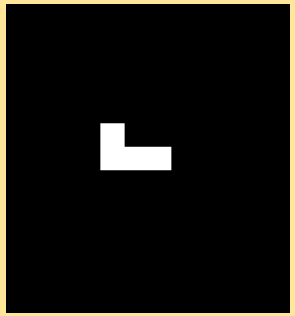
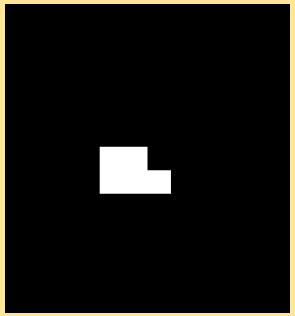
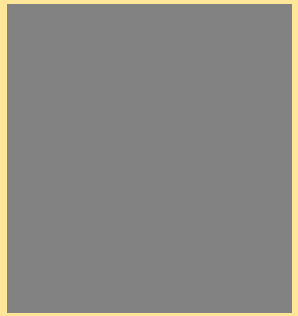
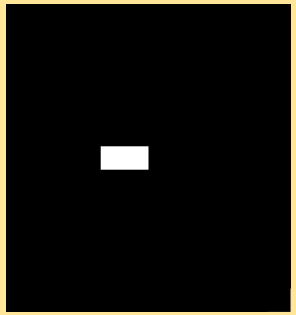
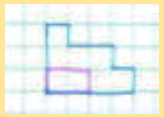
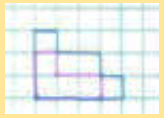
	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

Original shape

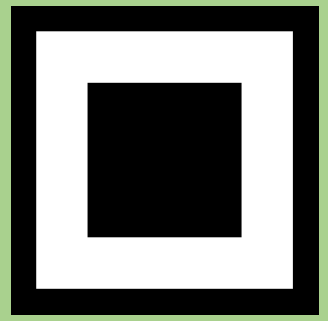


EROSION of triangle

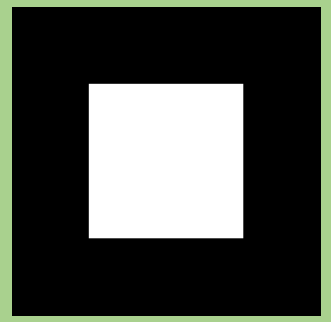
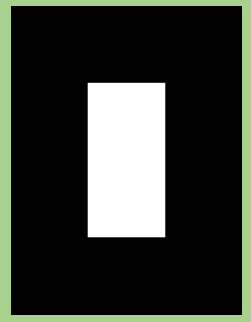
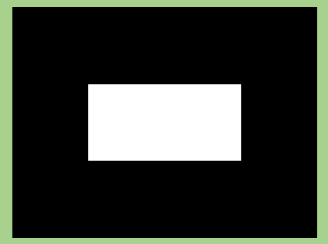
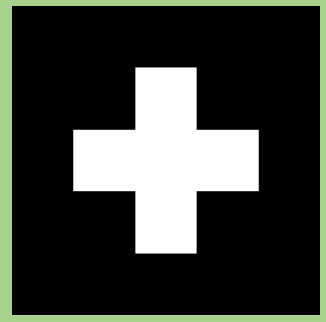
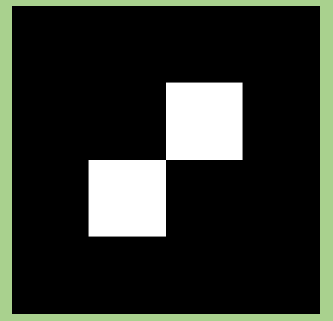
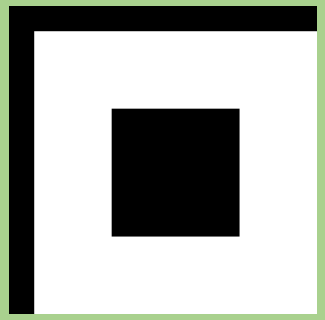
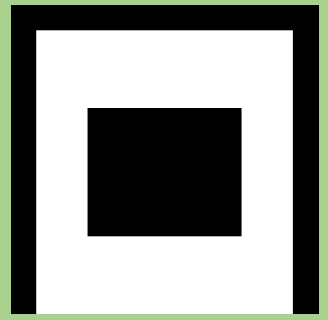
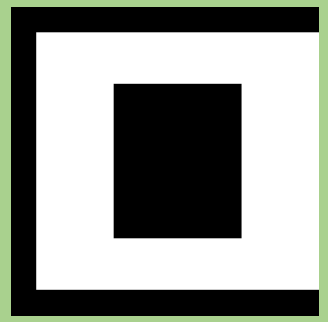
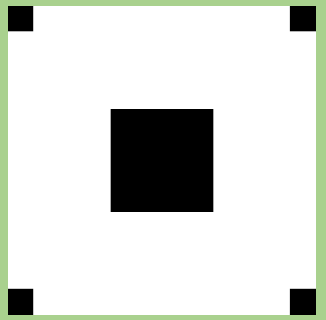
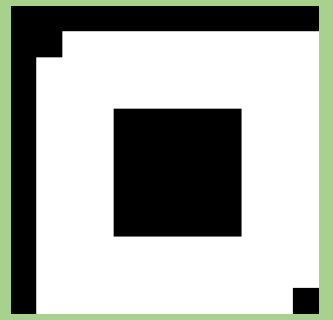
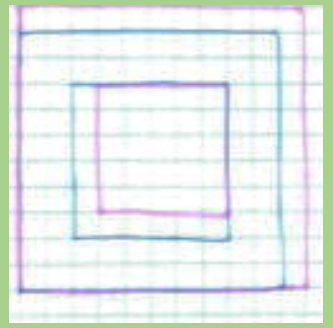
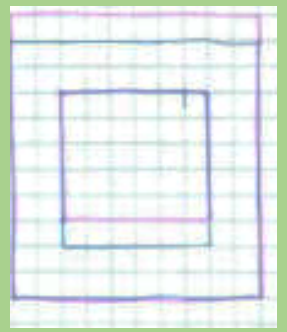
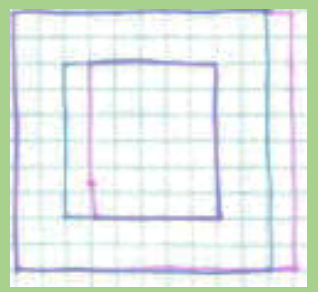
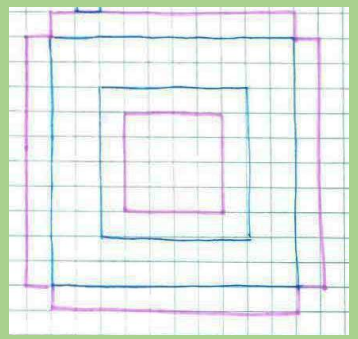
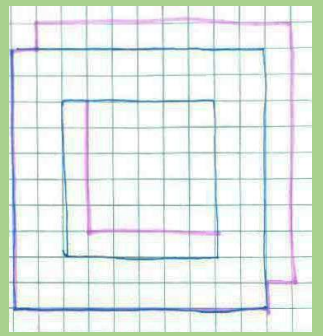
	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

Original shape

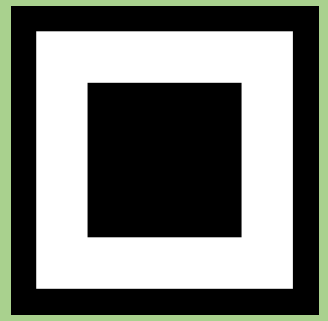


DILATION of hollow

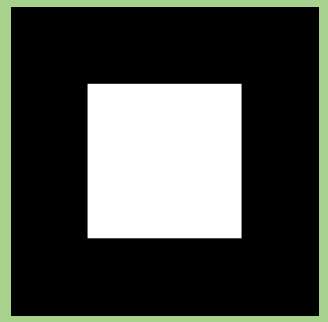
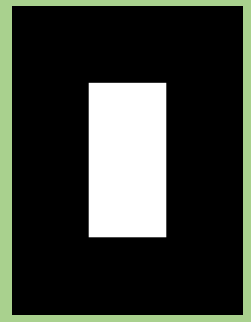
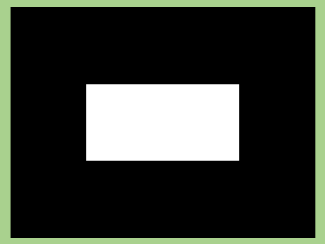
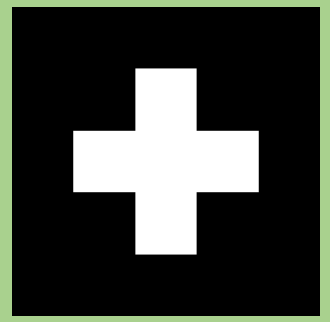
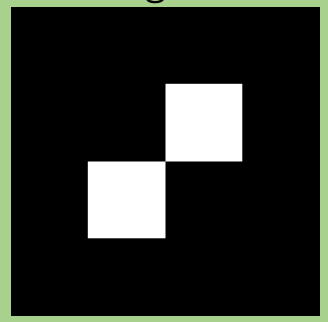
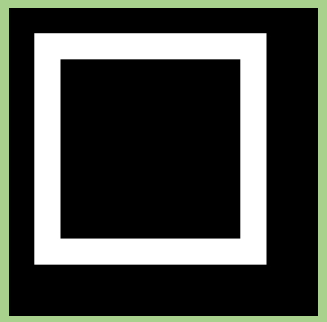
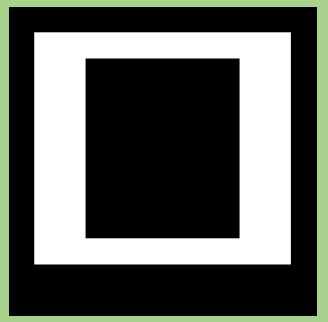
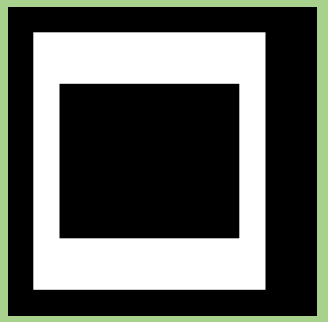
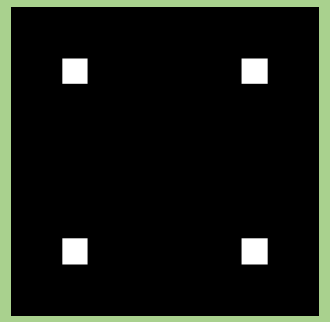
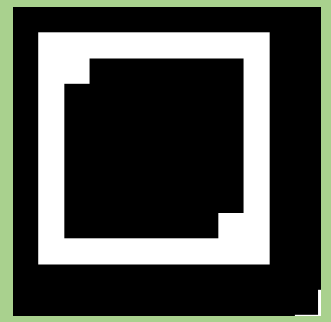
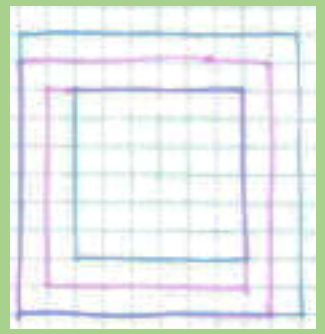
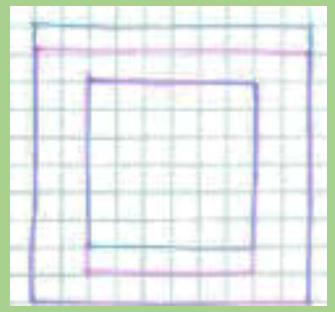
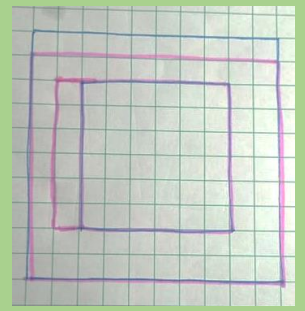
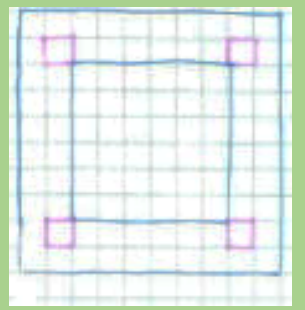
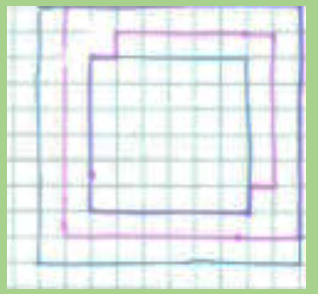
	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

Original shape

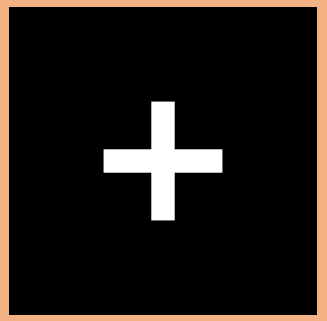


EROSION of hollow

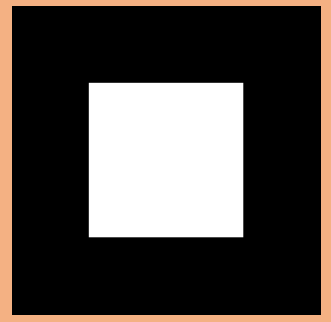
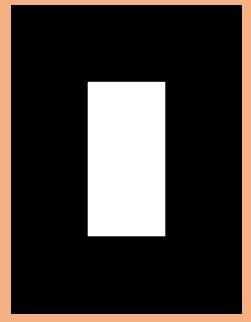
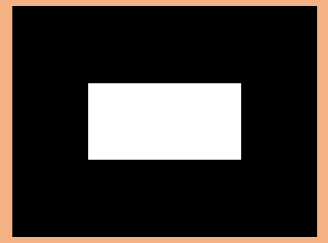
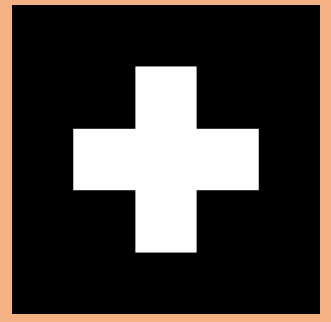
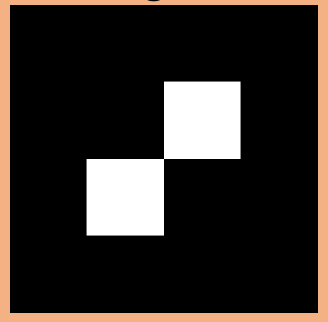
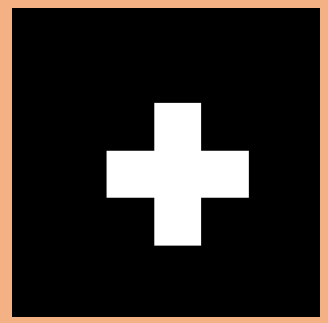
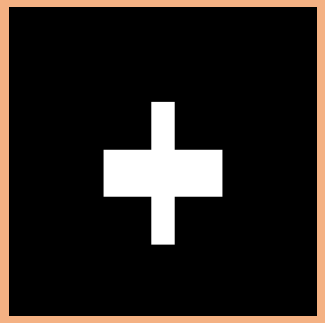
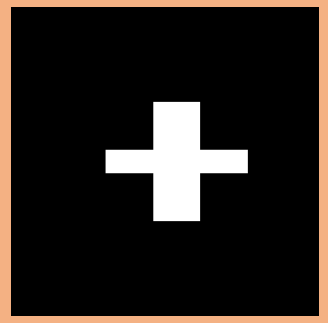
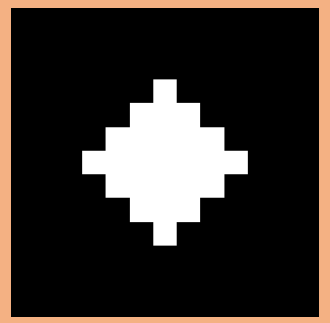
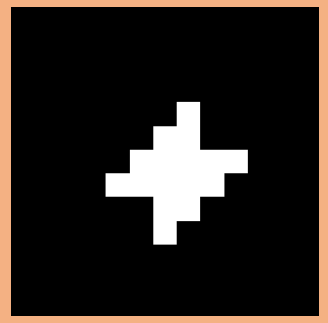
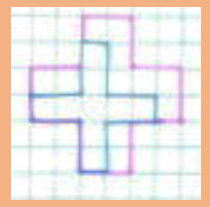
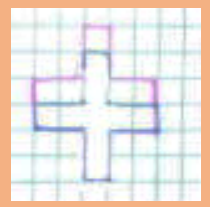
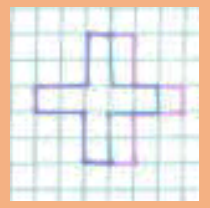
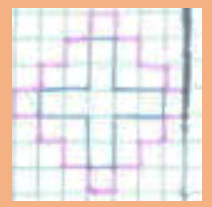
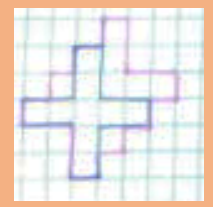
	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

Original shape

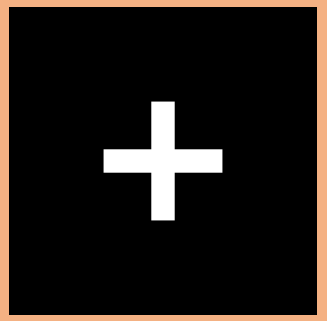


DILATION of plus

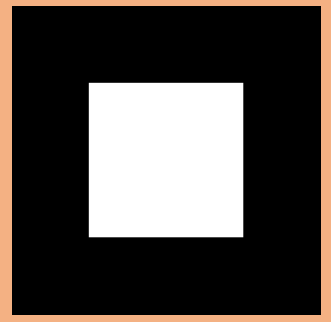
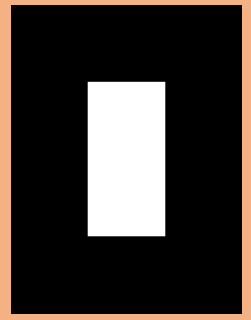
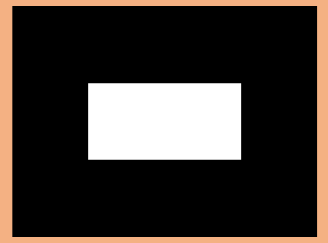
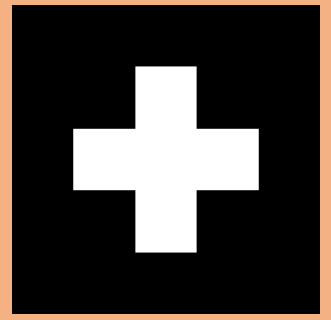
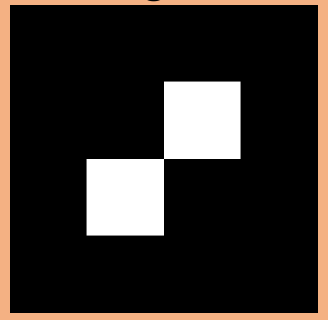
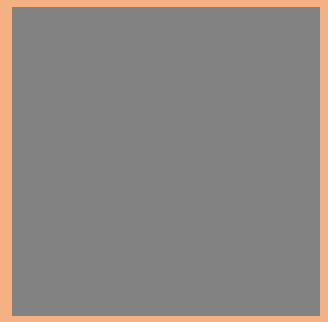
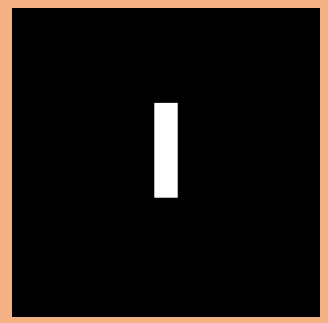
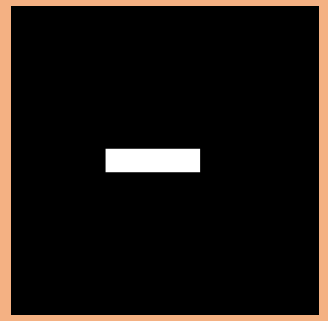
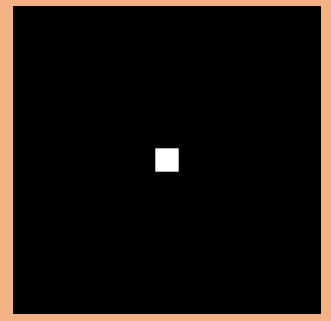
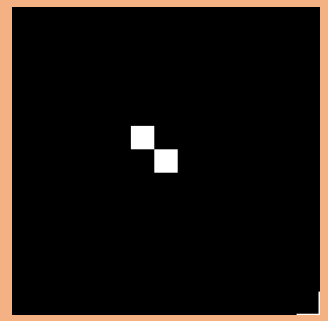
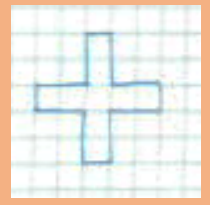
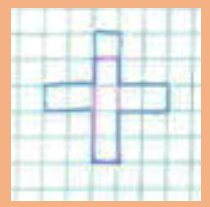
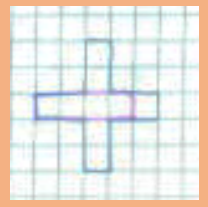
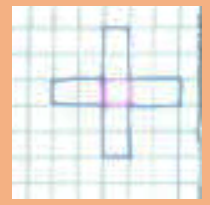
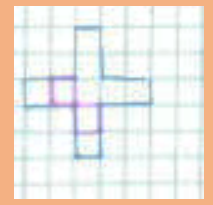
	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

Original shape



EROSION of plus

	2 x 2 ones	2 x 1 ones	1 x 2 ones	cross	diagonal
Structuring Element					
Coded Results					
Predicted Results					

Note: blue outline is the boundary of the original shape, and pink/violet outline is the boundary of the final shape

OBSERVATIONS & ANALYSIS

- Erosion reduces the size of the original shape depending on the size, shape and origin of the structuring element.
- Dilation increases the size of the original shape depending on the size, shape and origin of the structuring element.
- The predicted and the coded results of both morphological operations are the same.
- The origin of the structuring element does not affect the resulting shape but it does affect the orientation of the image.
- If the size of the structuring element is comparable to the size of the original shape, the change is large and in some cases, erosion results to a blank image (gray coded result).

OBSERVATIONS & ANALYSIS

- The resulting image of the morphological operation is somehow patterned from the shape structuring element (e.g. when plus and diagonal structuring elements were used).
- Erosion or dilation with a square structuring element reduces or adds the size of the shape in the horizontal and vertical direction.
- Erosion or dilation with a horizontal structuring element reduces or adds along the horizontal direction.
- Erosion or dilation with a vertical structuring element reduces or adds along the vertical direction.

Self Evaluation: 10/10