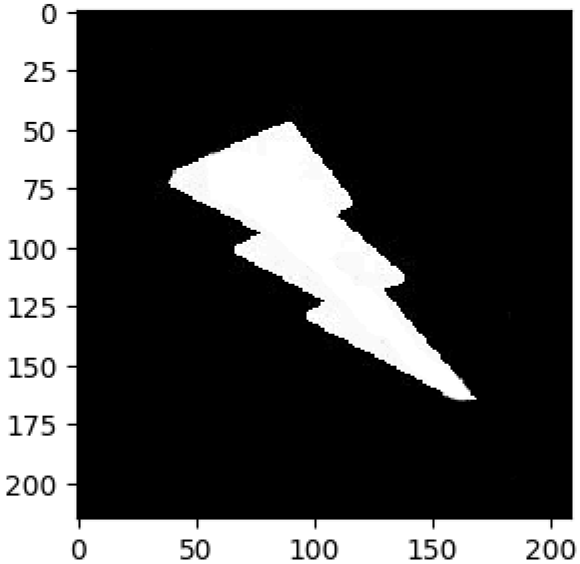
In [2]:
```
%matplotlib inline
from __future__ import print_function
#import ganymede
#ganymede.configure('uav.beaver.works')
import matplotlib.pyplot as plt
import numpy as np
import cv2
import os
```

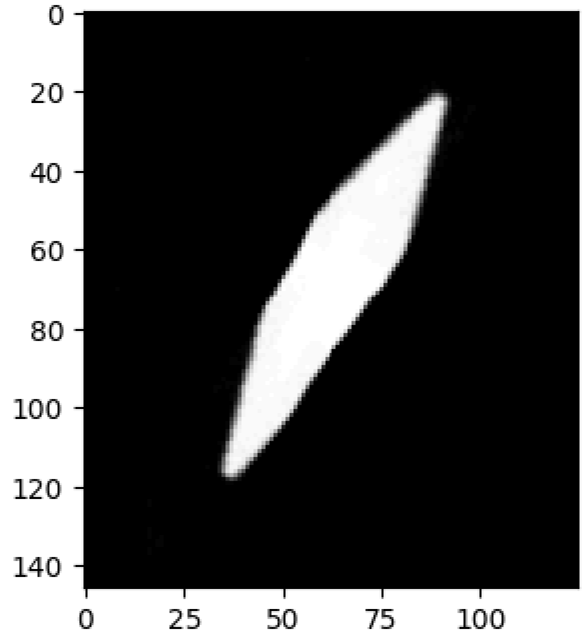
In [3]:
```
def check(p): pass
check(0)
```

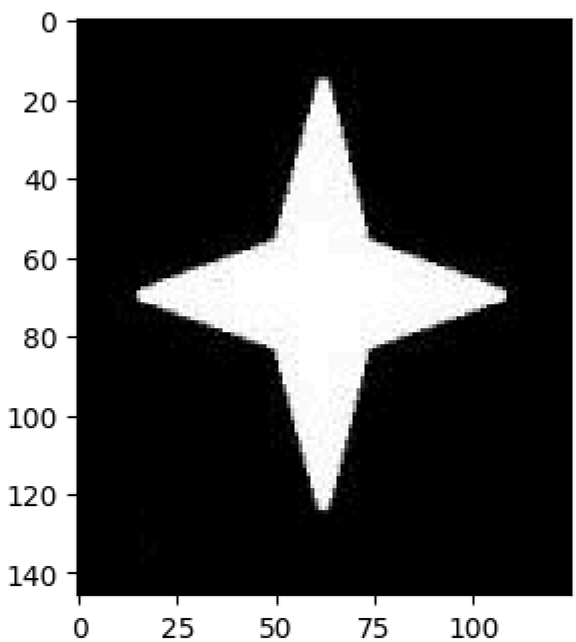
Note

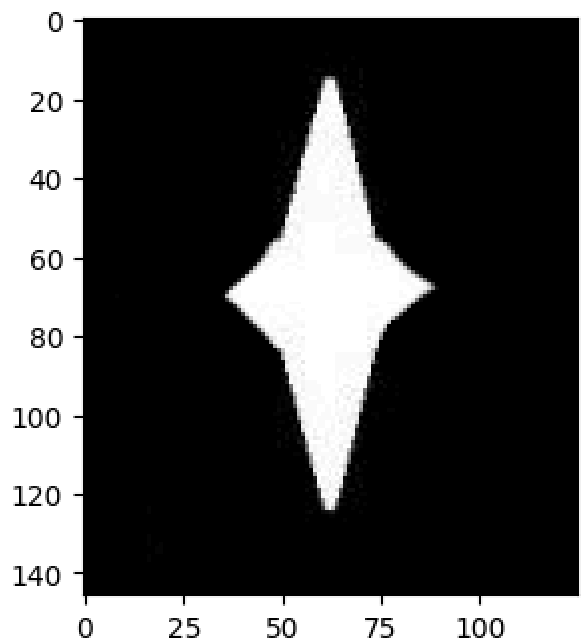
`cv2.imshow()` will not work in a notebook, even though the OpenCV tutorials use it.
Instead, use `plt.imshow` and family to visualize your results.

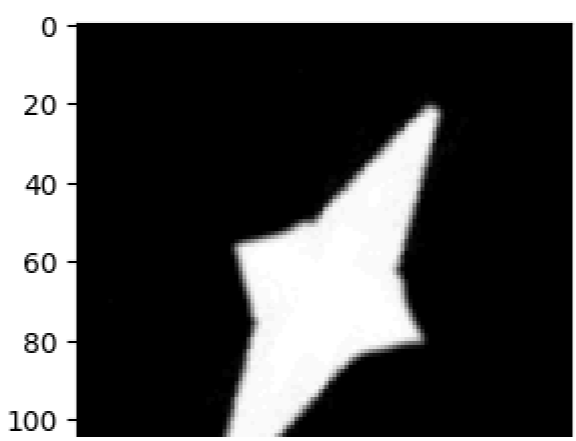
In [4]:
```
lightningbolt      = cv2.imread('shapes/lightningbolt.png', cv2.IMREAD_GRAYSCAL
blob               = cv2.imread('shapes/blob.png', cv2.IMREAD_GRAYSCALE)
star               = cv2.imread('shapes/star.png', cv2.IMREAD_GRAYSCALE)
squishedstar       = cv2.imread('shapes/squishedstar.png', cv2.IMREAD_GRAYSCAL
squishedturnedstar = cv2.imread('shapes/squishedturnedstar.png', cv2.IMREAD_GR
letterj            = cv2.imread('shapes/letterj.png', cv2.IMREAD_GRAYSCALE)

images = [lightningbolt, blob, star, squishedstar, squishedturnedstar, letterj

fig,ax = plt.subplots(nrows=3, ncols=2)
for a,i in zip(ax.flatten(), images):
    a.imshow(i, cmap='gray', interpolation='none');
fig.set_size_inches(7,14);
```

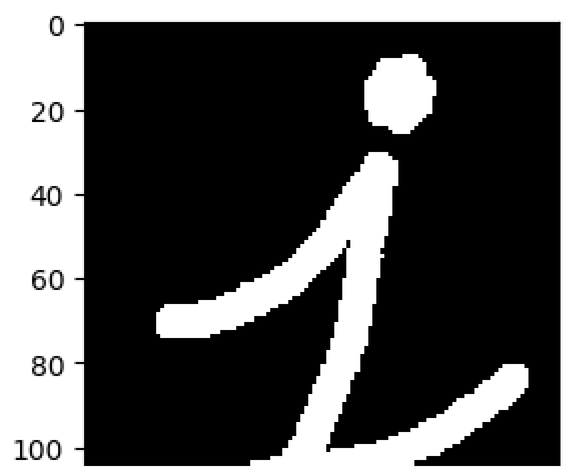

0
25
50
75
100
125
150
175
200
0 50 100 150 200

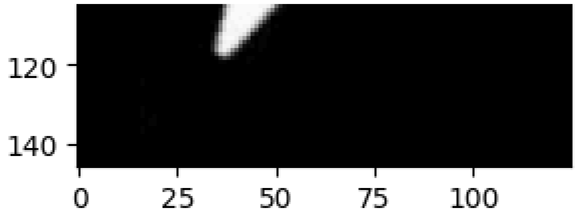

0
20
40
60
80
100
120
140
0 25 50 75 100

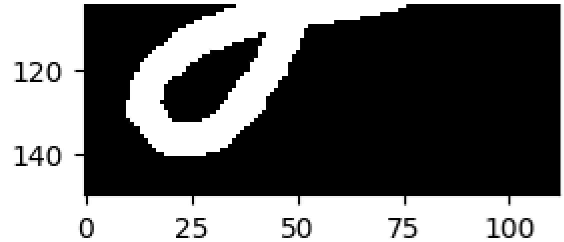

0
20
40
60
80
100
120
140
0 25 50 75 100


0
20
40
60
80
100
120
140
0 25 50 75 100


0
20
40
60
80
100


0
20
40
60
80
100





In [5]:
```
intensity_values = set(lightningbolt.flatten())
print(len(intensity_values))
```

75

Question:

What would you expect the value to be, visually? What explains the actual value?

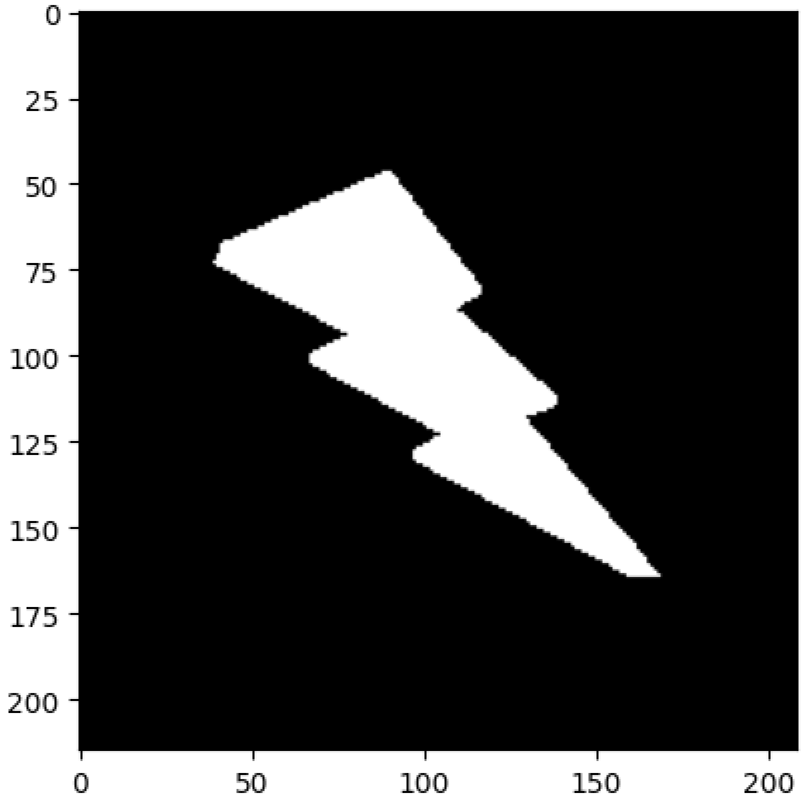
In [6]:
```
# TODO
# I would expect the value to be the number of unique colors present in the ima
```

Thresholding

https://docs.opencv.org/3.4.1/d7/d4d/tutorial_py_thresholding.html

In [7]:
```
_, lightningbolt = cv2.threshold(lightningbolt,150,255,cv2.THRESH_BINARY)

intensity_values = set(lightningbolt.flatten())
print(len(intensity_values))

plt.imshow(lightningbolt, cmap='gray');
```

2



Question

What happens when the above values are used for thresholding? What is a "good" value for thresholding the above images? Why?

In [8]:
```
## TODO
## The above values result in a very grainy/noisy image.  A good value would be
```

Exercises

Steps

1. Read each tutorial
   - Skim all parts of each tutorial to understand what each operation does
   - Focus on the part you will need for the requested transformation
2. Apply the transformation and visualize it

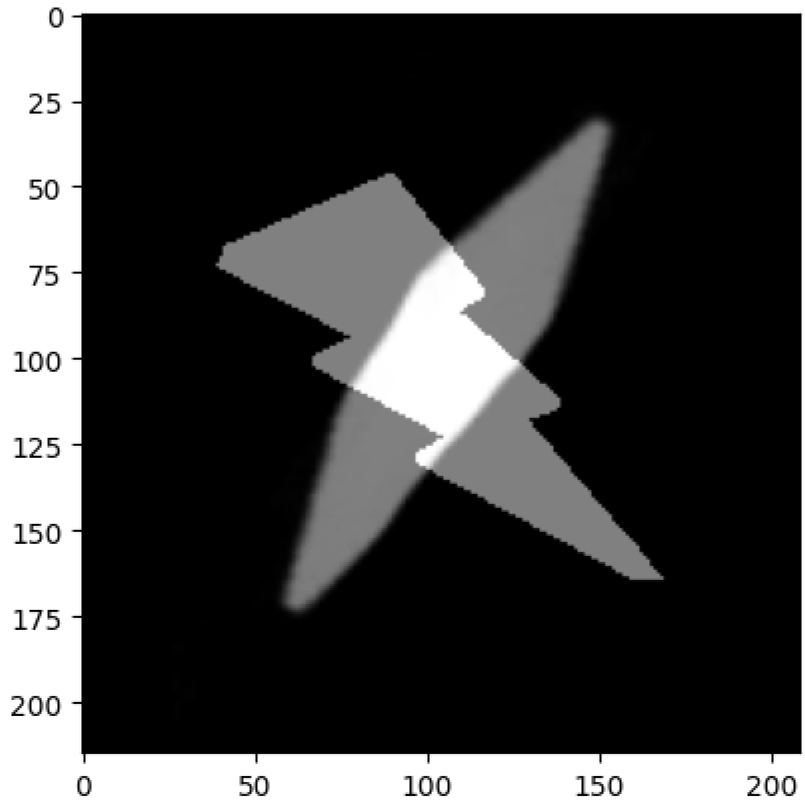
1. Blend lightningbolt and blob together

https://docs.opencv.org/3.4.1/d0/d86/tutorial_py_image_arithmetics.html

Remember: Don't use `imshow` from OpenCV, use `imshow` from `matplotlib`

In [12]:
```
# 1. Blend
rows,cols=lightningbolt.shape
blob2=cv2.resize(blob,(cols,rows))
blended=cv2.addWeighted(lightningbolt,0.5,blob2,0.5,0)
plt.imshow(blended,cmap="gray")
```

Out[12]:
```
<matplotlib.image.AxesImage at 0x119665d00>
```

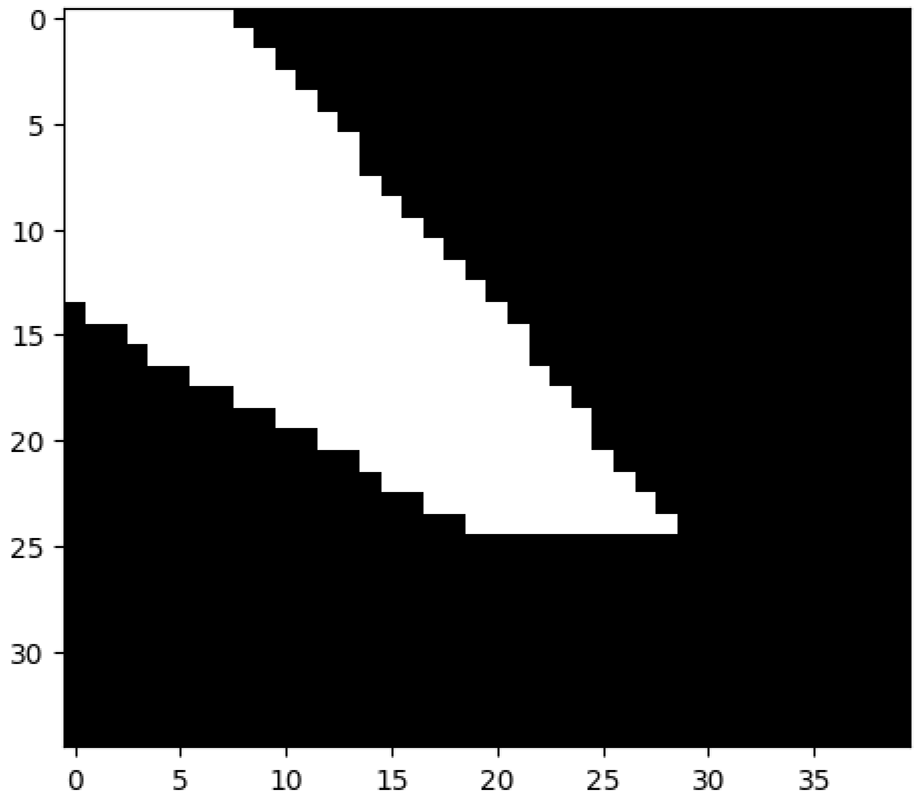


2. Find a ROI which contains the point of the lightning bolt

https://docs.opencv.org/3.4.1/d3/df2/tutorial_py_basic_ops.html

In [ ]:
```
# 2. ROI
point=lightningbolt[140:175, 140:180]
plt.imshow(point,cmap="gray")
```

Out[ ]:
```
<matplotlib.image.AxesImage at 0x11ad7eeb0>
```

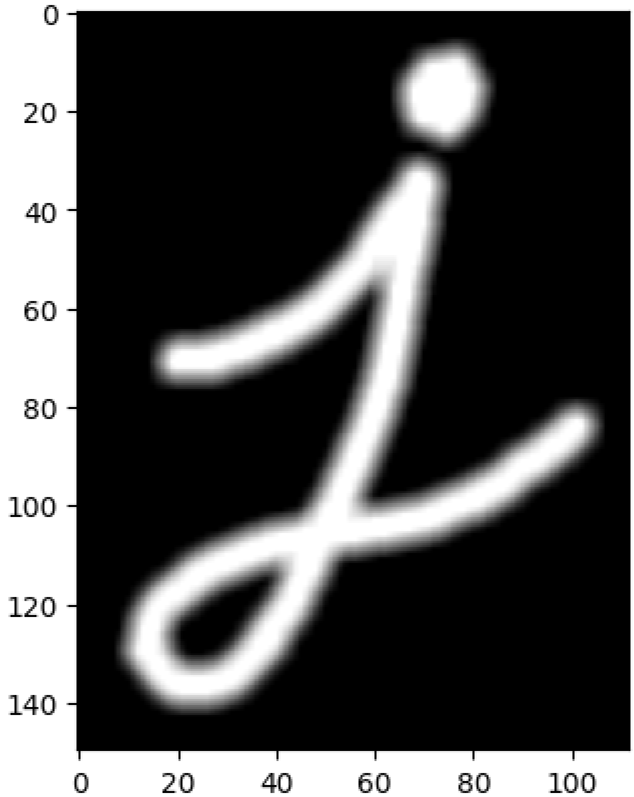


3. Use an averaging kernel on the letter j

https://docs.opencv.org/3.4.1/d4/d13/tutorial_py_filtering.html

In [ ]:
```
# 3.
avg=cv2.blur(letterj,(5,5))
plt.imshow(avg,cmap="gray")
```

Out[ ]: <matplotlib.image.AxesImage at 0x11aa6a2b0>



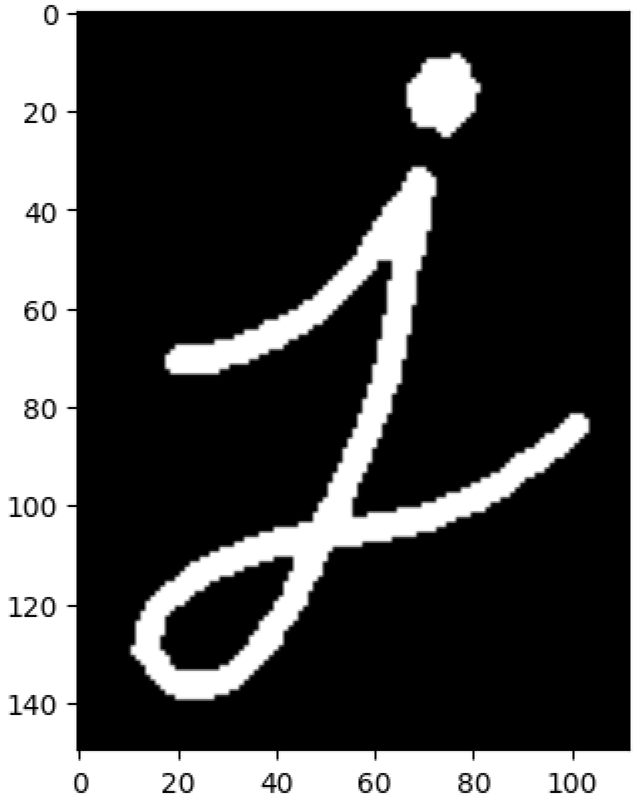
Morphology

https://docs.opencv.org/3.4.1/d9/d61/tutorial_py_morphological_ops.html

4. Perform erosion on j with a 3x3 kernel

In [ ]:
```
# 4
kernelthree=np.ones((3,3),np.uint8)
halferoded=cv2.erode(letterj,kernelthree,iterations=1)
plt.imshow(halferoded,cmap="gray")
```

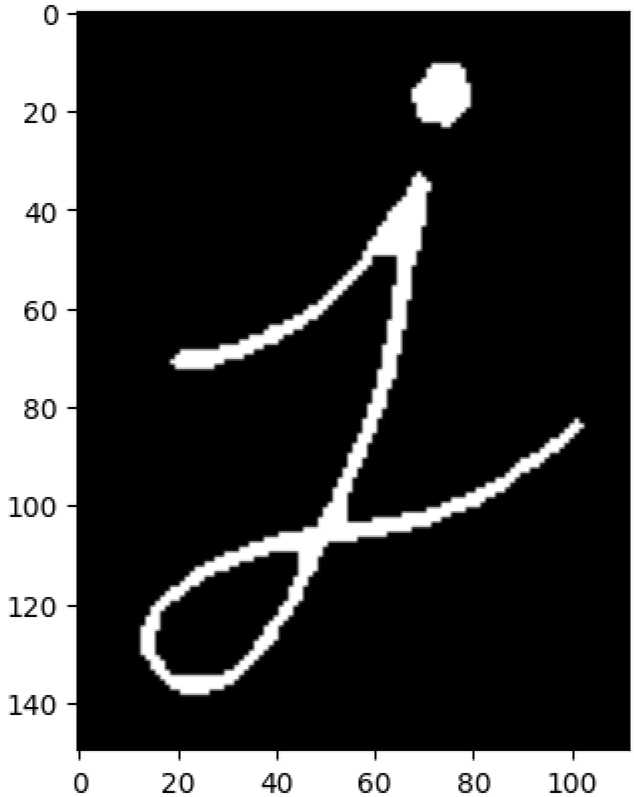
Out[ ]:
```
<matplotlib.image.AxesImage at 0x11b414160>
```



5. Perform erosion on j with a 5x5 kernel

In [ ]:
```
# 5
kernelfive=np.ones((5,5),np.uint8)
veryeroded=cv2.erode(letterj,kernelfive,iterations=1)
plt.imshow(veryeroded,cmap="gray")
```

Out[ ]:
```
<matplotlib.image.AxesImage at 0x11b491b20>
```



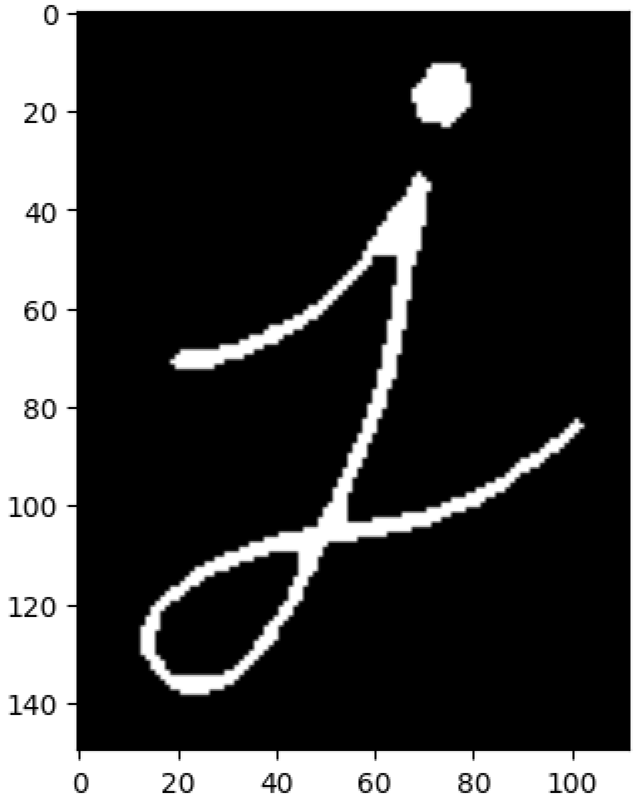
6. Perform erosion on j with **two** iterations, using a kernel size of your choice

Hint: look at the OpenCV API documentation. It is possible to perform two iterations of erosion in one line of Python!

https://docs.opencv.org/3.4.1/d4/d86/group__imgproc__filter.html#gaeb1e0c1033e3f6b891a25

In [ ]:
```
# 6
kernelthree=np.ones((3,3),np.uint8)
eroded=cv2.erode(letterj,kernelthree,iterations=2)
plt.imshow(eroded,cmap="gray")
```

Out[ ]: <matplotlib.image.AxesImage at 0x11b5105b0>



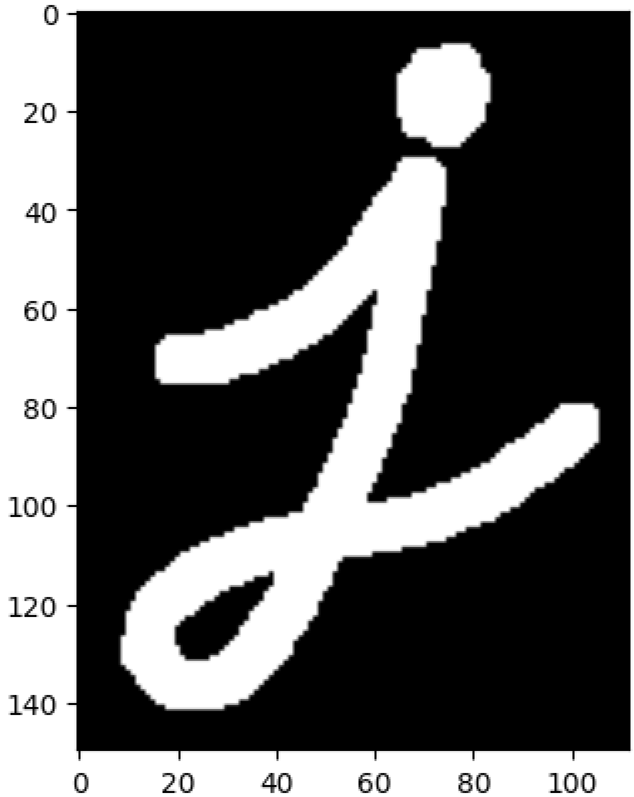
7. Perform dilation on j with a 3x3 kernel

In [ ]:

```
# 7
kernelthree=np.ones((3,3),np.uint8)
halfdilated=cv2.dilate(letterj,kernelthree,iterations=1)
plt.imshow(halfdilated,cmap="gray")
```

Out[ ]:

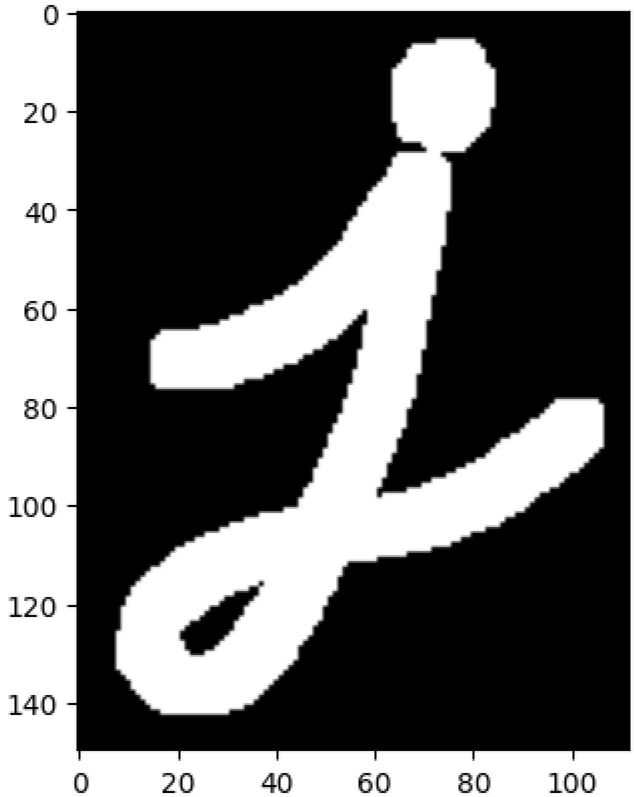
```
<matplotlib.image.AxesImage at 0x11b586640>
```



8. Perform dilation on j with a 5x5 kernel

In [ ]:
```
# 8
kernelfive=np.ones((5,5),np.uint8)
dilated=cv2.dilate(letterj,kernelfive,iterations=1)
plt.imshow(dilated,cmap="gray")
```

Out[ ]:
```
<matplotlib.image.AxesImage at 0x11b5dbe20>
```



9. What is the effect of kernel size on morphology operations?

In [ ]:
```
# 9
# The kernel size impacts the area of effect any operation can have.  The large
```

10. What is the difference betweeen repeated iterations of a morphology operation with a small kernel, versus a single iteration with a large kernel?

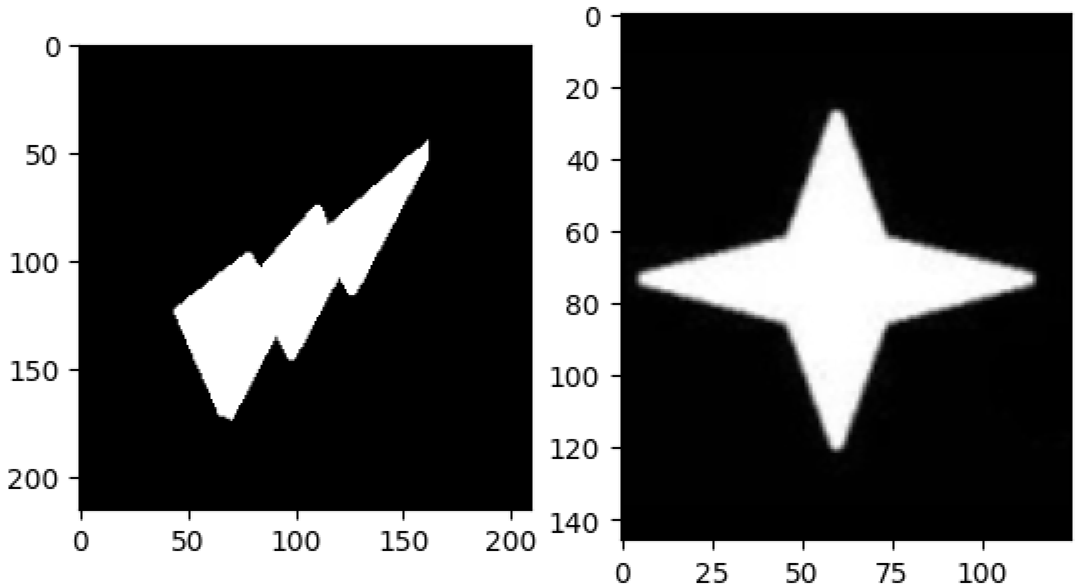
In [ ]:
```
# 10
# Theoretically speaking, there is no difference.  Practically, repeating a sma
```

11. Rotate the lightningbolt and star by 90 degrees

https://docs.opencv.org/3.4.1/da/d6e/tutorial_py_geometric_transformations.html

In [ ]:
```
# 11
rows1,cols1=lightningbolt.shape
rows2,cols2=star.shape
M1=cv2.getRotationMatrix2D((cols1/2,rows1/2),90,1)
M2=cv2.getRotationMatrix2D((cols2/2,rows2/2),90,1)
rotatedbolt=cv2.warpAffine(lightningbolt,M1,(cols1,rows1))
rotatedstar=cv2.warpAffine(star,M2,(cols2,rows2))
fig,ax = plt.subplots(nrows=1, ncols=2)
for i in range(2):
```

```
    a=ax[i]
    if (i==0):
        a.imshow(rotatedbolt,cmap="gray")
    else:
        a.imshow(rotatedstar,cmap="gray")
```



12. STRETCH GOAL:

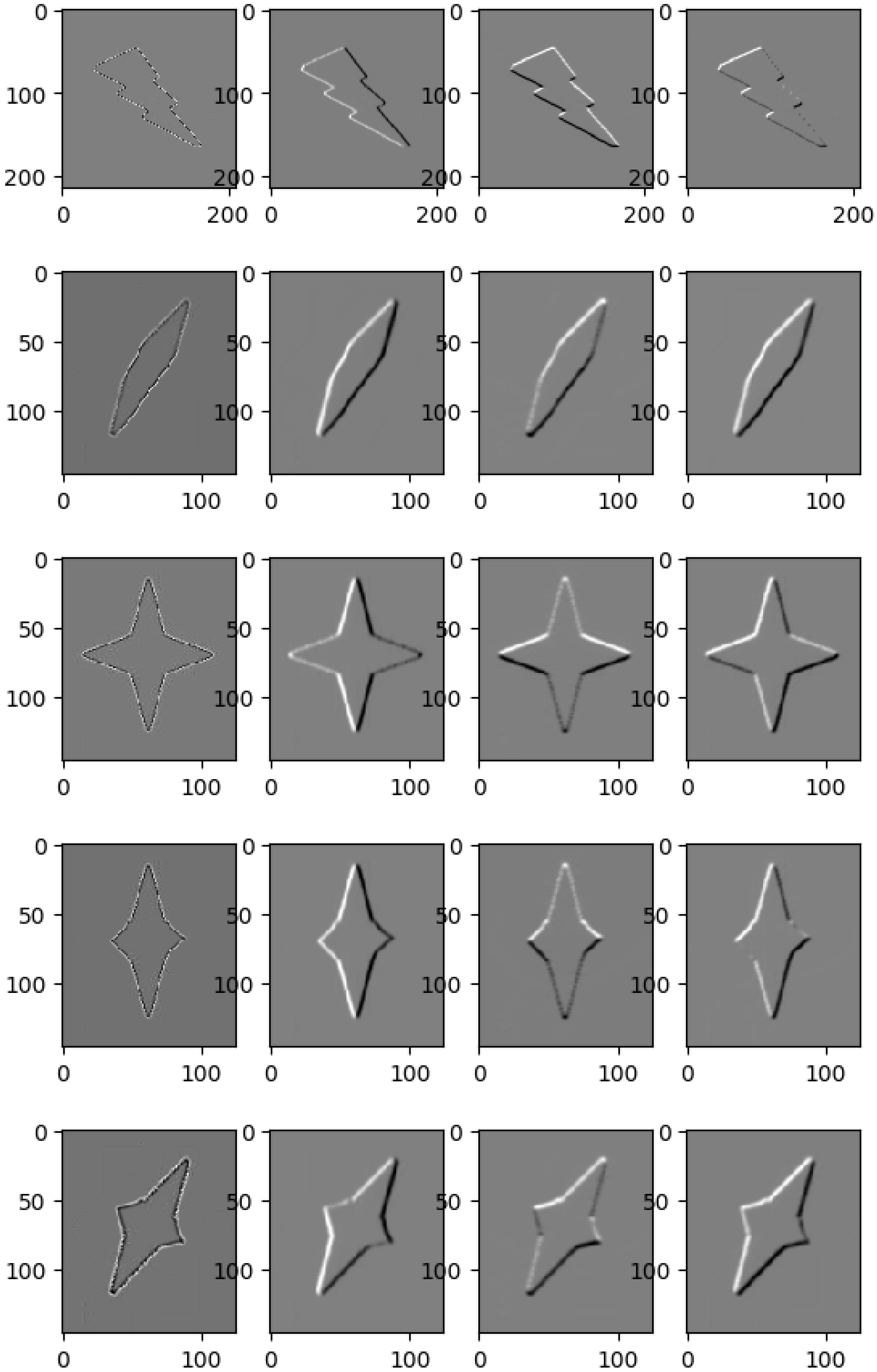
Visualize the result of Laplacian, Sobel X, and Sobel Y on all of the images. Also, produce a combined image of both Sobel X and Sobel Y for each image. Is Exercise 1 the best way to do this? Are there other options?

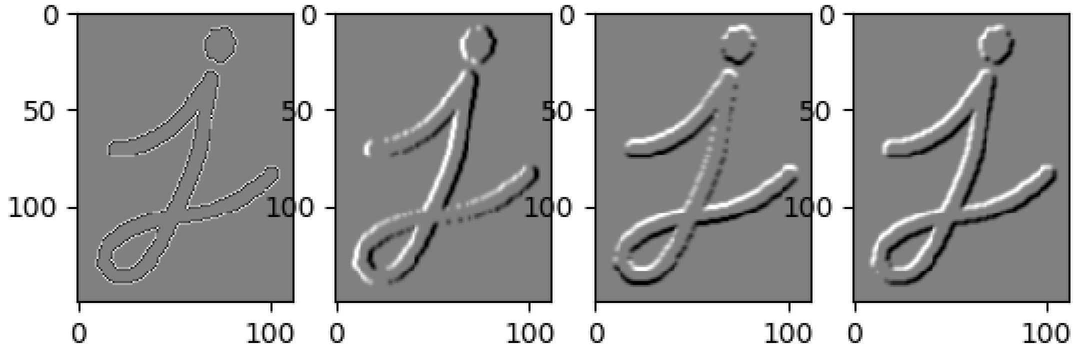
You should have 4 outputs (Laplacian, SobelX, SobelY, and the combination) for each input image visualized at the end.

https://docs.opencv.org/3.4.1/d5/d0f/tutorial_py_gradients.html

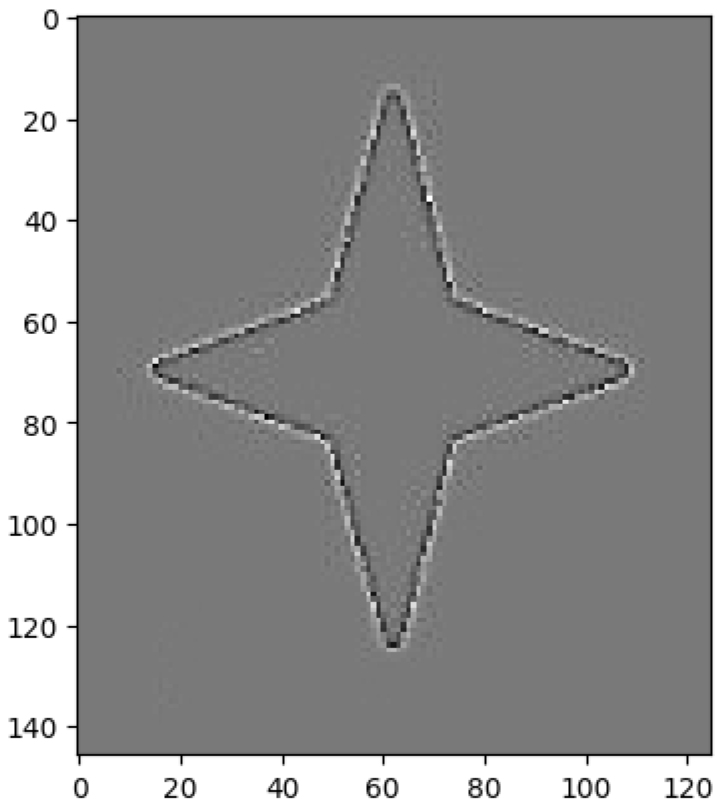
In [ ]:

```
def Laplace(img):
    return cv2.Laplacian(img,cv2.CV_64F)
def SobelX(img):
    return cv2.Sobel(img,cv2.CV_64F,1,0,ksize=5)
def SobelY(img):
    return cv2.Sobel(img,cv2.CV_64F,0,1,ksize=5)
def SobelSum(img):
    return cv2.addWeighted(SobelX(img),0.5,SobelY(img),0.5,0)
transformations=[Laplace, SobelX, SobelY, SobelSum]
for i in images:
    fig,ax = plt.subplots(nrows=1, ncols=4)
    for x in range(4):
        a=ax.flatten()[x]
        t=transformations[x]
        a.imshow(t(i), cmap="gray", interpolation="none")
```



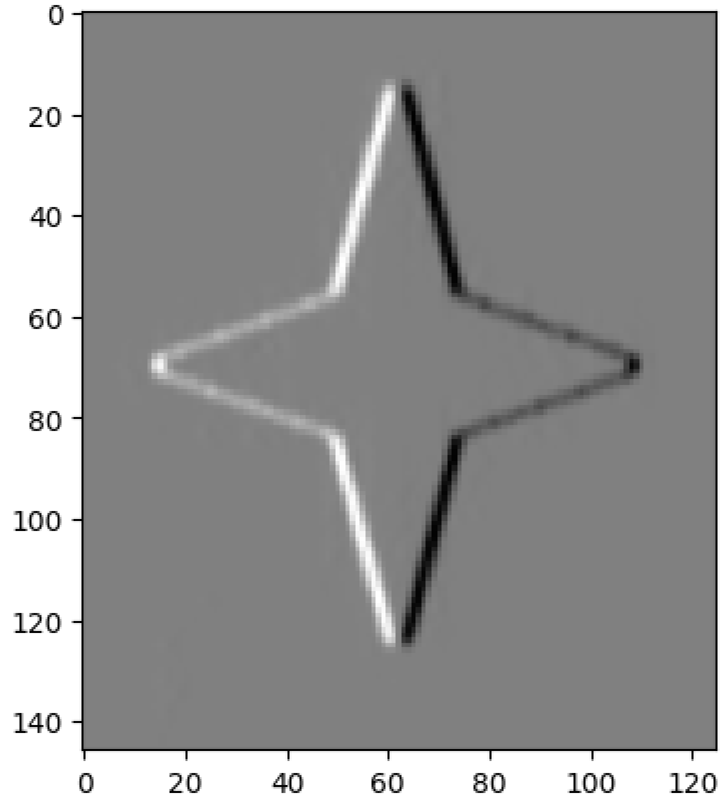


In [ ]:
```
plt.imshow(cv2.Laplacian(star,cv2.CV_64F),cmap="gray",interpolation="none")
Sobelx=cv2.Sobel(star,cv2.CV_64F,1,0,ksize=5)
Sobely=cv2.Sobel(star,cv2.CV_64F,0,1,ksize=5)
```



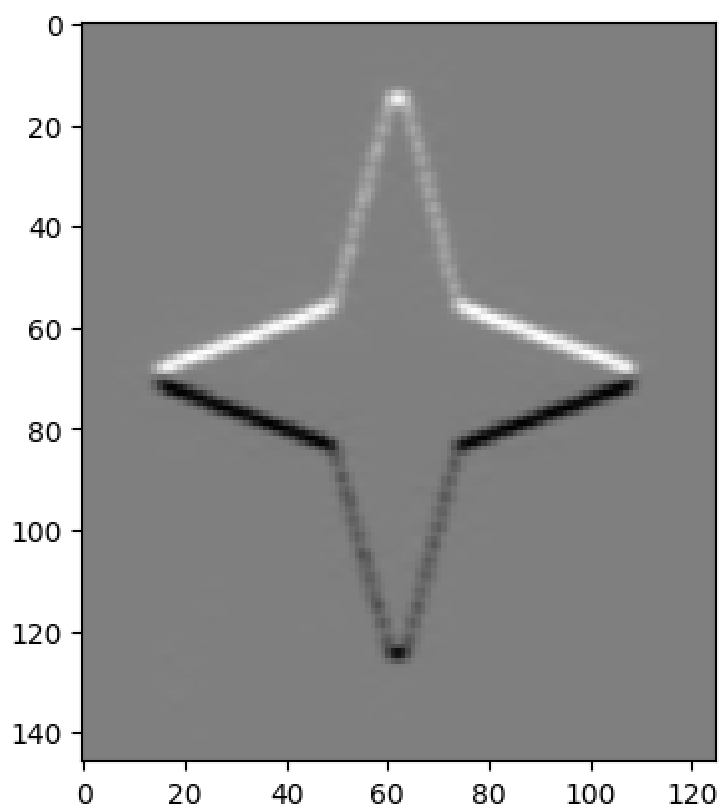
In [ ]:
```
plt.imshow(Sobelx,cmap="gray",interpolation="none")
```

Out[ ]: <matplotlib.image.AxesImage at 0x11d1b4e50>



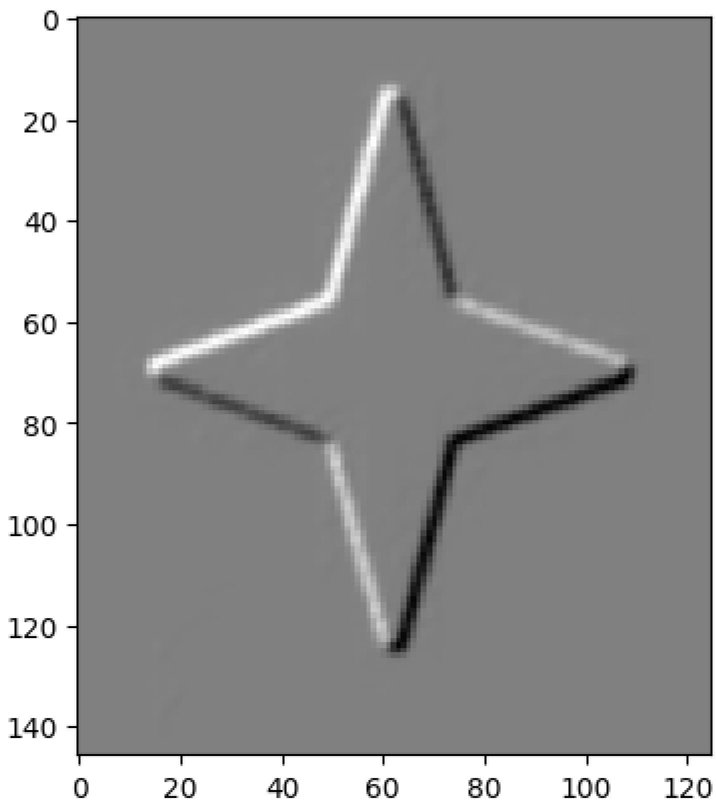
In [ ]:
```
plt.imshow(Sobely,cmap="gray",interpolation="none")
```

Out[ ]: <matplotlib.image.AxesImage at 0x11d1c4280>



In [ ]:
```
plt.imshow(cv2.addWeighted(Sobelx,0.5,Sobely,0.5,0),cmap="gray",interpolation='
```

Out[ ]: <matplotlib.image.AxesImage at 0x11d241340>



When you are done:

You should have one or more images for each exercise.

1. Double-check that you filled in your name at the top of the notebook!
2. Click `File` -> `Export Notebook As` -> `PDF`
3. Email the PDF to `YOURTEAMNAME@beaver.works`