```
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```

```python
%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
```

```
/home/saanvi/.local/lib/python3.10/site-packages/matplotlib/projections/__init__.py:63: UserWarning: Unable to import Axes3D. This may be due to multiple versions of Matplotlib being installed (e.g. as a system package and as a pip package). As a result, the 3D projection is not availabl
e.
  warnings.warn("Unable to import Axes3D. This may be due to multiple versions of "
```

```python
def check(p): pass
check(0)
```

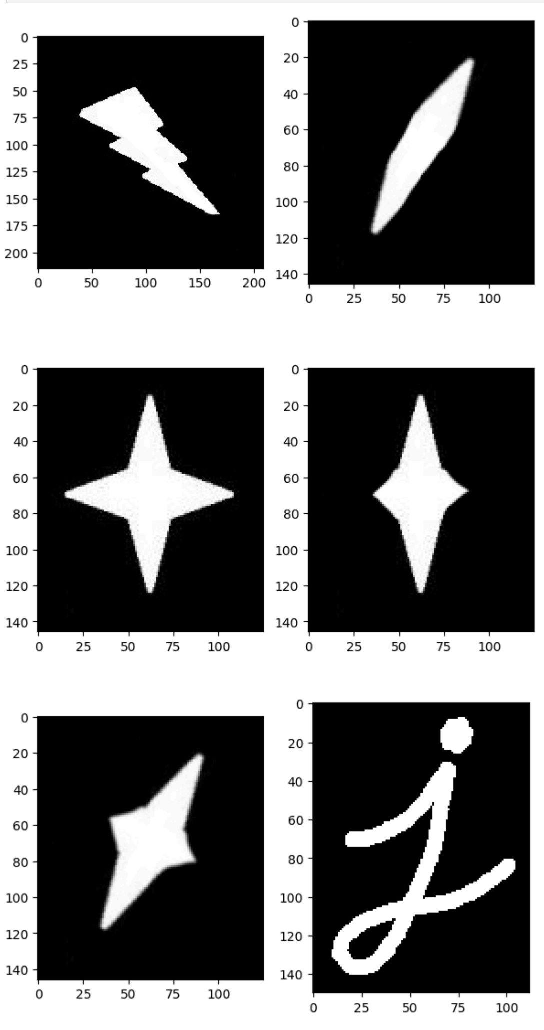
Note

`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.

```python
lightningbolt      = cv2.imread('shapes/lightningbolt.png', cv2.IMREAD_GRAYSCALE)
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_GRAYSCALE)
squishedturnedstar = cv2.imread('shapes/squishedturnedstar.png', cv2.IMREAD_GRAYSCALE)
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);
```



```python
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?

```python
# TODO
# Your Answer
Visually, I would expect the value to be more than 75 because the flattened array should have more pixels. The answer is 75 because the set function only shows unique intensity values.
```

Thresholding

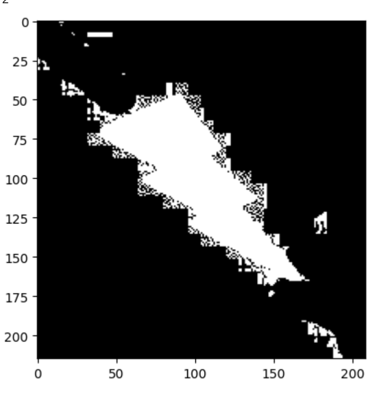
https://docs.opencv.org/3.4.1/d7/d4d/tutorial_py_thresholding.html

```python
_, lightningbolt = cv2.threshold(lightningbolt,0,255,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?

```python
## TODO
## Your answer

When the above values are used for thresholding, the gray values would either turn white or black, based on how light or dark the shade of gray is. Pixels with gray scale values from 0-127 would turn black, meanwhile pixels between 128-255 would turn white. A good value for thresholding
```

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

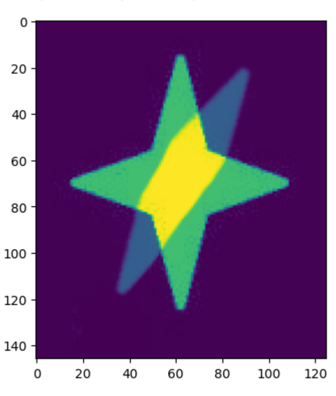
1. Blend lightningbolt and blob together

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`

```python
# 1. Blend
# TODO
dst = cv2.addWeighted(star, 0.7, blob, 0.3,0)
plt.imshow(dst)
```

```
&lt;matplotlib.image.AxesImage at 0x75cdbd11dfc0&gt;
```

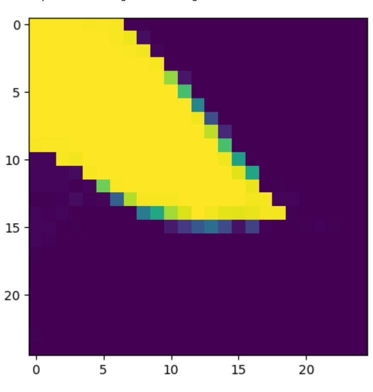


2. Find a ROI which contains the point of the lightning bolt

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

```python
ROI = lightningbolt[150:175, 150:175]
plt.imshow(ROI)
```

```
&lt;matplotlib.image.AxesImage at 0x75cdbf4747f0&gt;
```

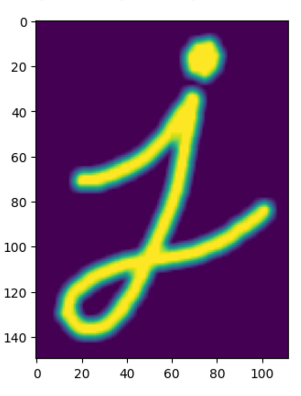


3. Use an averaging kernel on the letter j

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

```python
# 3
# TODO
blur = cv2.blur(letterj, (5,5))
plt.imshow(blur)
```

```
&lt;matplotlib.image.AxesImage at [illegible]&gt;
```



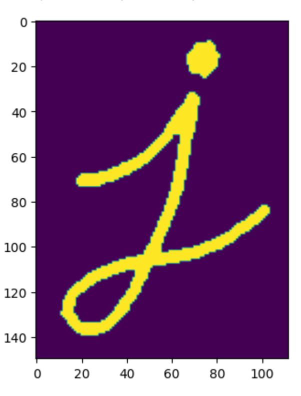
Morphology

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

4. Perform erosion on j with a 3x3 kernel

```python
# 4
# TODO
kernel = np.ones((3,3),np.uint8)
erosion = cv2.erode(letterj,kernel,iterations = 1)
plt.imshow(erosion)
```

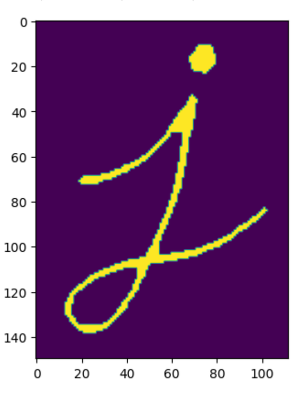
```
&lt;matplotlib.image.AxesImage at [illegible]&gt;
```



5. Perform erosion on j with a 5x5 kernel

```python
# 5
# TODO
kernel = np.ones((5,5),np.uint8)
erosion = cv2.erode(letterj,kernel,iterations = 1)
plt.imshow(erosion)
```

```
&lt;matplotlib.image.AxesImage at [illegible]&gt;
```



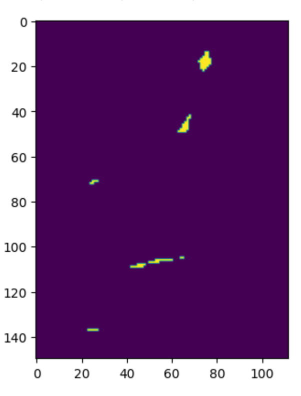
6. Perform erosion on j with **two** iterations, using a kernel size of your choice

Hint: look at the OpenCV API documentation. Is it possible to perform two iterations of erosion in one line of Python?

[illegible]

```python
# 6
# TODO
kernel = np.ones((4,4),np.uint8)
erosion = cv2.erode(letterj,kernel,iterations = 2)
plt.imshow(erosion)
```

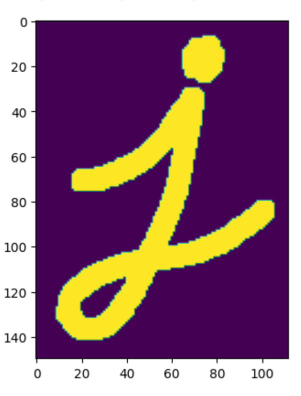
```
&lt;matplotlib.image.AxesImage at [illegible]&gt;
```



7. Perform dilation on j with a 3x3 kernel

```python
# 7
# TODO
kernel = np.ones((3,3), np.uint8)
dilation = cv2.dilate(letterj,kernel,iterations = 1)
plt.imshow(dilation)
```

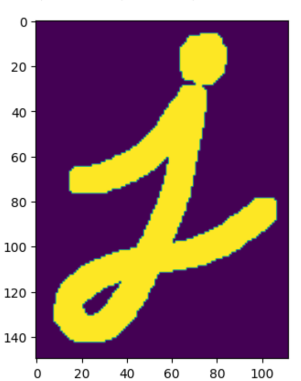
```
&lt;matplotlib.image.AxesImage at [illegible]&gt;
```



8. Perform dilation on j with a 5x5 kernel

```python
kernel = np.ones((5,5), np.uint8)
dilation = cv2.dilate(letterj,kernel,iterations = 1)
plt.imshow(dilation)
```

```
&lt;matplotlib.image.AxesImage at 0x75cdbc3bf4f0&gt;
```



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

```python
# 9
# TODO
The larger the kernel size, the more intense the change. For example, eroded with a 5x5 kernal makes the image more eroded than it would be with a 3x3 kernal.
```

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

```python
# 10
# TODO
Repeated iterations, although less intense because on a small kernel, cause the transformation to occur the indicated number of times. On the other hand, a single iteration with a large kernel would cause one, more extreme, change to occur to the image.
```

11. Rotate the lightningbolt and star by 90 degrees

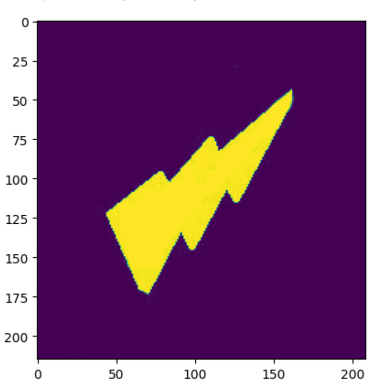
https://docs.opencv.org/3.4.1/da/d6e/tutorial_py_geometric_transformations.html

```python
# 11
# TODO

rows,cols = star.shape
M = cv2.getRotationMatrix2D((cols/2,rows/2),90,1)
dst = cv2.warpAffine(star,M,(cols,rows))
plt.imshow(dst)

rows,cols = lightningbolt.shape
M = cv2.getRotationMatrix2D((cols/2,rows/2),90,1)
dst = cv2.warpAffine(lightningbolt,M,(cols,rows))
plt.imshow(dst)
```

```
&lt;matplotlib.image.AxesImage at 0x75cdbd11d060&gt;
```



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

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`