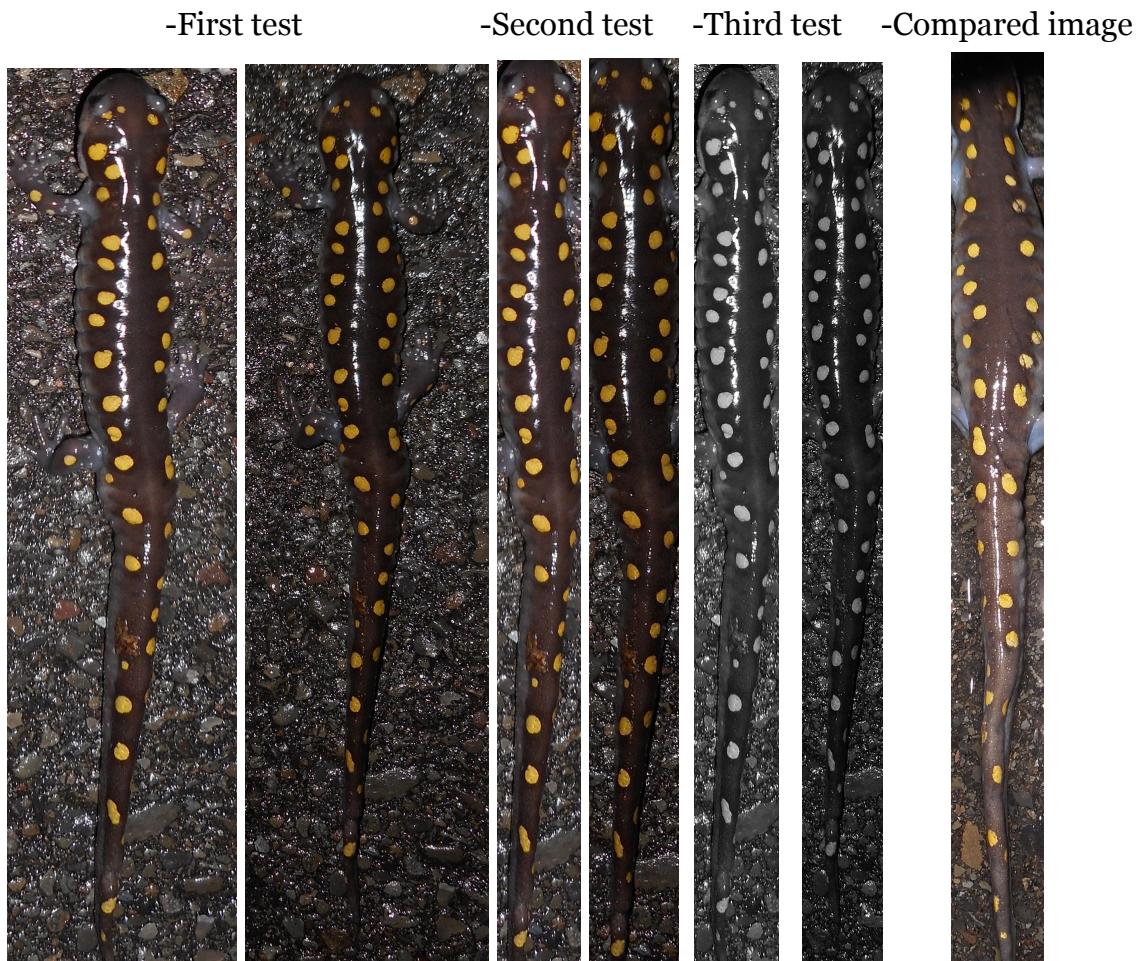


Image Recognition Research Checkpoints

Checkpoint 1: Initial attempt at comparing images

- ★ In order to apply Mean Squared Error which finds the difference in pixel values between a set of images, we will be using the compare-metric on imagemagick.
- ★ We are testing various crops and gray-scaling to see if the results will give us a noticeable difference in the accuracy of the MSE.
- ★ The test was conducted with multiple sets of images, but below we will show the results of individual tests.



1. Same salamander before crop:
 - a. Command: compare -metric rmse 2017_O-16.jpg 2017_O-17.jpg null
 - b. Result:

- i. *Mean square error:* 16053.5
 - ii. *Percentage of difference:* 24% (0.24496)

- 2. Same salamander after crop:
 - a. Command: compare -metric rmse image1.jpg image2.jpg null
 - b. Result:
 - i. *Mean square error:* 15240.5
 - ii. *Percentage of difference:* 23% (0.232555)

- 3. Same salamander after crop and gray-scale:
 - a. Command: compare -metric rmse 2017_O-16.png 2017_O-17.png null
 - b. Result:
 - i. *Mean square error:* 13651.9
 - ii. *Percentage of difference:* 21% (0.208314)

Checking results using different images

- 1. Different salamanders before crop:
 - a. Command: compare -metric rmse 2017_O-16.jpg 2017_O-2.jpg null
 - b. Result:
 - i. *Mean square error:* 16386.9
 - ii. *Percentage of difference:* 25% (0.250049)

- 2. Different salamanders after crop and gray-scale:
 - a. Command: compare -metric rmse image1.jpg image3.jpg null
 - b. Result:
 - i. *Mean square error:* 15631.8
 - ii. *Percentage of difference:* 24% (0.238526)

- ★ Conclusion: The MSE of different salamanders is slightly higher than the MSE of the same salamander. However this was not a big enough difference to define a threshold and we would like to lower the overall MSE in future attempts. This current method is not reliable.

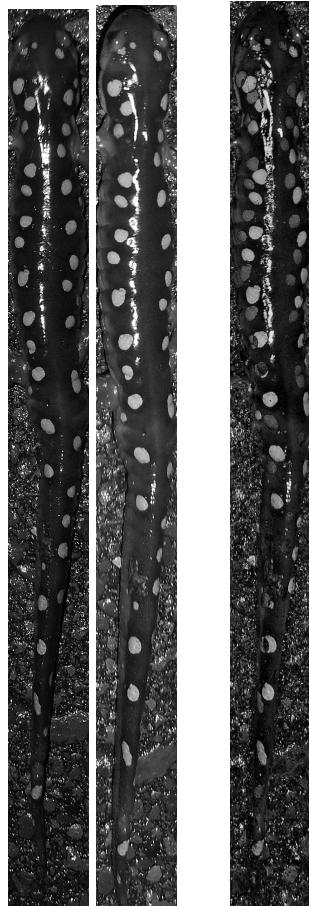
Checkpoint 2: Composite

- ★ We have decided to overlap the images using composite on imagemagick in an attempt to eliminate an extra step in comparing the two salamanders.

Image1 + image 2 = Diff



Image3 + image4 = Diff



- Compositing images:
 - command : composite image1.png image2.png -compose difference diff3.png

Checkpoint 3: Aligning the Spine and Extracting the spots

- ★ We will now use the image and mask feature on Adobe Photoshop to extract the spots from the image. We will also use puppet warp to align the spine in hopes that it breeds a more accurate system for comparing the salamanders.

Same salamander



Different salamander



1. Same salamander after aligning and extracting spots:
 - a. Command: compare -metric rmse 16.png 17.png null
 - b. Result:
 - i. *Mean square error:* 9383.39
 - ii. *Percentage of difference:* 14% (0.143181)
2. Different salamanders after aligning and extracting spots::
 - a. Command: compare -metric rmse 17.png NM_R.png null

- b. Result:
 - i. *Mean square error: 9641.27*
 - ii. *Percentage of difference: 15% (0.147116)*
 - 3. Different salamanders after aligning and extracting spots::
 - a. Command: compare -metric rmse 16.png 17.png null
 - b. Result:
 - i. *Mean square error: 8912.38*
 - ii. *Percentage of difference: 14% (0.135994)*
- ★ Conclusion : We now lack a difference between images of the same and different salamanders. However, this method resulted in a lower value for the MSE calculated.

Checkpoint 4: Testing different comparison metrics

- ★ We are attempting to see if changing the metric from MSE will make a difference.

- ★ PSNR
 - Peak Signal to noise ratio (used in image compression papers)
 - The ratio of mean square difference to the maximum mean square that can exist between any two images, expressed as a decibel Value.
 - The higher the PSNR the closer the images are, with a maximum difference occurring at 1. A PSNR of 20 means differences are 1/100 of maximum.

- ★ Verbose
 - Adding -verbose will provide more specific information about each separate channel.

PSNR

1. Same salamanders:

- a. Command: compare -metric psnr 17.png 16.png null

- b. Result:

- i. *PSNR: 16.8823*

2. Different Salamanders:

- a. Command: compare -metric psnr 16.png NM_R.png null

- b. Result:

- i. *PSNR: 17.3296*

3. Different Salamanders 2:

- a. Command: compare -metric psnr 17.png NM_R.png null

- b. Result:

- i. *PSNR: 16.6468*

Verbose

1. Same Salamander:

- a. Command: magick compare -verbose -metric mae 17.png 16.png null

- b. Result:

- ```
17.png PNG 139x1193 139x1193+0+0 8-bit sRGB 59102B 0.020u 0:00.009
```

- ```
16_R.png PNG 175x1500 175x1500+0+0 8-bit sRGB 81012B 0.010u
```

- ```
0:00.019
```

- ```
Image: 17.png
```

Offset: o,o
Channel distortion: MAE
 red: 2346.31 (0.0358023)
 green: 3181.15 (0.0485412)
 blue: 4995.89 (0.0762323)
 alpha: o (o)
 all: 2630.83 (0.040144)
17.png=>null PNG 139x1193=>175x1500 175x1500+o+o 8-bit sRGB
47441B 0.09ou 0:00.080

2. Different Salamander:

- Command: magick compare -verbose -metric mae 17.png 16.png null
- Result:
17.png PNG 139x1193 139x1193+o+o 8-bit sRGB 59102B 0.01ou 0:00.009
NM_R.png PNG 177x1500 177x1500+o+o 8-bit sRGB 78298B 0.02ou
0:00.019
Image: 17.png
Offset: o,o
Channel distortion: MAE
 red: 2691.9 (0.0410758)
 green: 3195.6 (0.0487618)
 blue: 4747.1 (0.0724361)
 alpha: o (o)
 all: 2658.65 (0.0405684)
17.png=>null PNG 139x1193=>177x1500 177x1500+o+o 8-bit sRGB
47410B 0.06ou 0:00.069

3. Different Salamander 2:

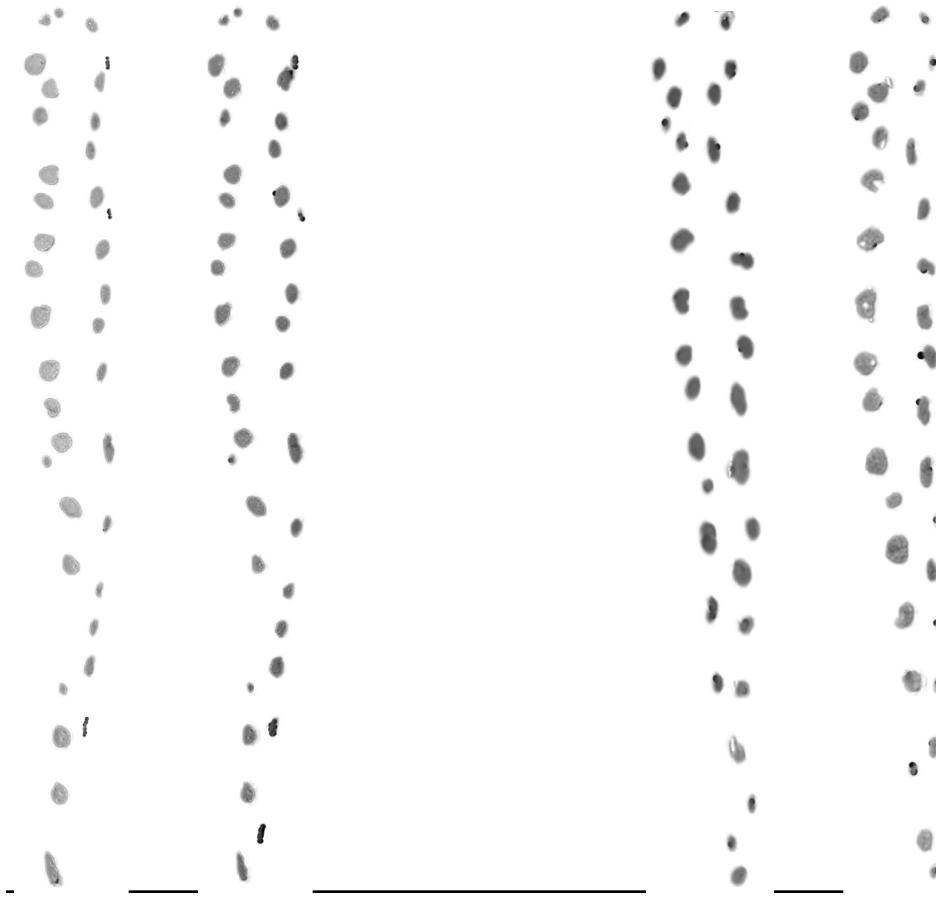
- Command: magick compare -verbose -metric mae 17.png 16.png null
- Result:
Image: 16_R.png
Offset: o,o
Channel distortion: MAE
 red: 2456.98 (0.0374911)
 green: 2995.28 (0.0457051)
 blue: 4852.53 (0.0740448)
 alpha: o (o)
 all: 2576.2 (0.0393103)

16_R.png=>null PNG 175x1500=>177x1500 177x1500+0+0 8-bit sRGB
57411B 0.08ou 0:00.09

- ★ Conclusion: We found that PSNR is not giving us anything more precise than MSE. We also believe that while verbose shows us specific channel's MSE, we find that gray-scaling the images leads to more accurate results, so it isn't necessary.

Final Checkpoint: Reintroducing Gray-Scale

- ★ After many attempts at finding the right method, we would like to combine our best performing methods and see if we can find a valid method for comparing salamanders.



1. Same Salamander 1 gray scaled and spots aligned poorly:
 - a. Command: compare -metric rmse 17_Gray.png 16_NT.png null
 - b. Result:
 - i. *Mean square error: 8571.52*
 - ii. *Percentage of difference: 13% (0.130793)*
2. Same Salamander 2 gray-scaled and spots aligned poorly:
 - a. Command: compare -metric rmse 2016_R.png 2013_S.png null
 - b. Result:

- i. Mean square error: 10201.4
 - ii. *Percentage of difference: 16% (0.155663)*

- 3. Different Salamander 1 gray-scaled and spots aligned poorly:
 - a. Command: compare -metric rmse 16_Gray.png NM_Gray.png null
 - b. Result:
 - i. Mean square error: 7223.85
 - ii. *Percentage of difference: 11% (0.110229)*

- 4. Different Salamander 2 gray-scaled and spots aligned poorly:
 - a. Command: compare -metric rmse 17_Gray.png NM_Gray.png null
 - b. Result:
 - i. Mean square error: 8501.49
 - ii. *Percentage of difference: 13% (0.129724)*

★ Comment: The problem is that the two pictures were not aligned therefore some of the spots appear bigger than the others in the picture. We did get it to align manually and fixed the curve but the accuracy may have to do with the fact that the spots are not all the same size in the two pictures due to the curve. If we can find a method to accurately correct the curve, we will definitely see more accurate results.

- 1. Same Salamander 1 gray-scaled and spots aligned:
 - a. Command: compare -metric rmse 16_Gray.png 17_Gray.png null
 - b. Result:
 - i. Mean square error: 5065.95
 - ii. *Percentage of difference: 8% (0.0773014)*

- 2. Same Salamander 2 gray-scaled and spots aligned:
 - a. Command: compare -metric rmse 2016_R.png 2013_SR.png null
 - b. Result:
 - i. Mean square error: 3288.47
 - ii. *Percentage of difference: 5% (0.0501788)*

- 3. Different Salamander 1 gray-scaled and spots aligned:
 - a. Command: compare -metric rmse 17_Gray.png 2016_17.png null
 - b. Result:
 - i. Mean square error: 7941.57
 - ii. *Percentage of difference: 12% (0.121181)*

4. Different Salamander 2 gray-scaled and spots aligned:
 - a. Command: compare -metric rmse 16_Gray.png 2016_17.png null
 - b. Result:
 - i. Mean square error: 7556.15
 - ii. Percentage of difference: 12%(0.115299)
- ★ Conclusion: The difference between two matched images is now below 8%. We now have a method that can show us when two salamander images are compared and have a MSE of below 8%, we know it is two images of the same salamander. This proves that the spots of a salamander can be used as a feature for classifying salamanders in a noisy background. In the future, we will attempt to design a program that can automatically normalize these pictures and compare resulting images.