Automatic Lesion Detection in Dermoscopy Images

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Digital Image Processing

Abstract

The purpose of this project is to implement an automatic segmentation algorithm in MATLAB that identifies abnormal skin regions in dermoscopy images using classical image processing techniques. Class concepts such as gaussian filters, histogram equalization, global thresholding, and morphological operations, create an output image with a lesion boundary for automatic detection.

Method

Images Used

For the purpose of this project, the images used were from an online database (The International Skin Image Collaboration) where a sample pool of 900 dermascopic lesion images were downloaded. Images were then randomly selected for demonstration in this report.

MATLAB Code

All images were segmented in MATLAB in order to create the desired output.

Part 1 - Grayscale Conversion

Using concepts from *Lab 2,* the image was treated as a 2-D Intensity Function $f(x, y)$ and converted to grayscale. This was done in order to reduce noise and make thresholding simpler because it converts the image to a single channel of intensity.

```
% Part 1 - Convert Image to Grayscale
f = im2double(imread('ISIC_0011366.jpg'));
grayscale = rgb2gray(f);
figure;
imshow(grayscale,[]);
title('1. Original Grayscale Image');
```

Image 1: Part 1 of MATLAB Code for grayscale conversion

Part 2 - Spatial Smoothing

Utilizing Concepts from *Enhancement in Spatial Domain* and *Lab 3/4,* a gaussian lowpass filter was applied to the grayscale image in order to reduce high frequency noise and sharp transitions. Examples of this include tiny hairs, or skin texture imbalance. As a result, a smoothing histogram is produced and small distracting details are removed while maintaining the overall lesion structure.

```
% Part 2a - Gaussian Low Pass Smoothing
smooth = imgaussfilt(grayscale, 2);
figure;
imshow(smooth,[]);
title('2. Smoothed Image');
```

Image 2: MATLAB code for a gaussian low pass filter

From *Lab 4,* Adaptive Histogram Equalization is beneficial because from the sample images, the lesions around the surrounding skin were only slightly darker. Using Adaptive Histogram Equalization addresses this issue by increasing the contrast locally, so that the dark lesion is more visible. The intention of the histogram is to verify that the local contrast enhancement has spread the gray levels and created a clear distinction between the light and dark lesions. This is necessary because the later used Otsu thresholding method relies on this distribution.

```
% Part 2b - Adaptive Histogram Equalization
equalization = adapthisteq(smooth);
figure;
imshow(equalization,[]);
title('3. Adaptive Histogram Equalization');
figure;
imhist(equalization);
title('Histogram of Enhanced Image');
```

Image 3: MATLAB code for Adaptive Histogram Equalization

Part 3 - Global Thresholding

Using concepts from *Segmentation and Description* as well as *Lab 10*, Otsu's method is applied to the image to achieve global thresholding. The sample pool typically has a bright background with a dark lesion. The Otsu method automatically searches for a threshold that best creates a separation between the two classes. Using the symbol '~', keeps the darker region, representing the lesion.

```
% Part 3 - Global Thresholding - Otsu's Method
T = graythresh(equalization);
darker_region = ~imbinarize(equalization, T);
figure;
imshow(darker_region); title('4. Dark Region');
```

Image 4: MATLAB Code for Global Threshold

Part 4 - Mathematical Morphology

In order to create a clean region that represents the lesion mask, morphology is used. The methods used are derived from *Mathematical Morphology* and *Labs 8-9.* Area opening was first performed in order to remove small specks that are not a part of the lesion. A value of 50 pixels was chosen as the lower bound because it was just large enough to remove isolated noise specks without affecting the main lesion region. Opening was then used, which is essentially, erosion then dilation, to smooth out the boundaries and remove tiny bright gaps. A disk radius of 3 was chosen for this operation because anything lower didn't have a visible effect and larger than 3 would shrink or distort the lesion. Closing, which is dilation first then erosion, was then conducted, in order to fill the small dark breaks in the lesion outline. A slightly larger disk radius of 5 was used in this scenario because it best filled narrow gaps and connected small breaks along the lesion perimeter. Hole filling was added as an extra step in order to ensure that the lesion becomes one solid connected region.

```
% Part 4 Mathematical Morphology
bw = bwareaopen(darker_region, 50);
bw = imopen(bw,  strel('disk', 3));
bw = imclose(bw, strel('disk', 5));
bw = imfill(bw, 'holes');
figure;
imshow(bw); title('5. Image After Morphology');
```

Image 5: MATLAB Code for Mathematical Morphology

Part 5 - Region Properties

After mathematical morphology is performed, the image output still has random white specks around the lesion area. This is highlighted in the following image,

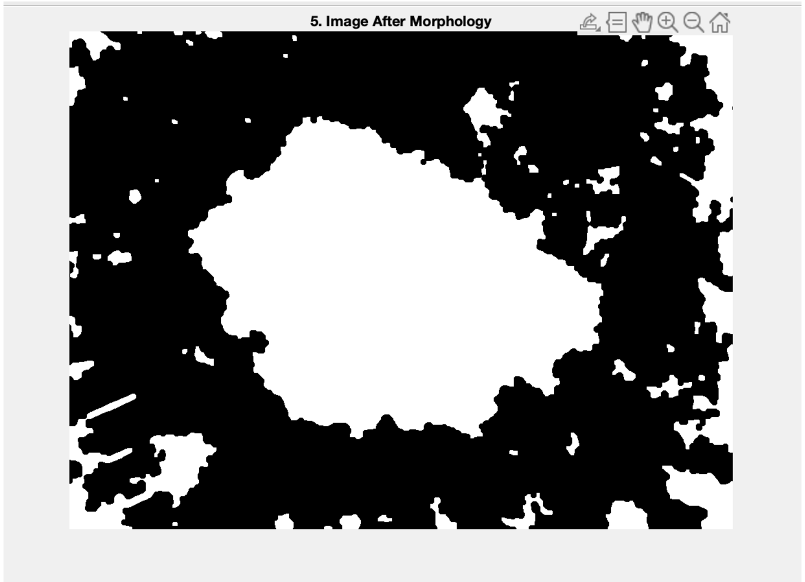


Image 6: Output image after morphology

The end goal is for the return to be the primary lesion without the random specks that surround it. In order to address this, area region properties from *Lab 11*, *Lab 9 (connected components),* and *Segmentation and Description* were utilized. The code treats the segmentation as the region based problem and selects the largest dark region by area as the lesion. The product is in image with only the primary lesion as shown below,

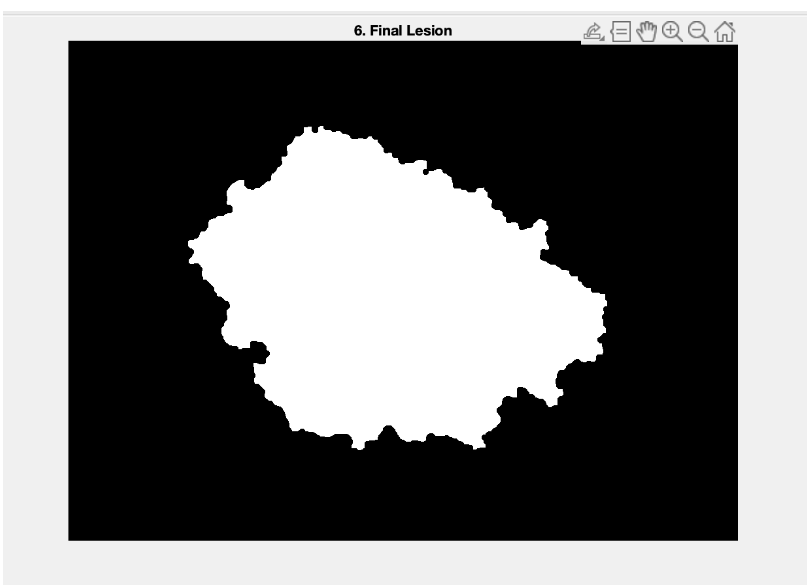


Image 7: Output image after area segmentation

```
% Part 5 - Main Lesion
[L, num] = bwlabel(bw);
mainL = regionprops(L, 'Area');
[~, idxMax] = max([mainL.Area]);
final_lesion = (L == idxMax);
figure;
imshow(final_lesion); title('6. Final Lesion');
```

Image 7: MATLAB Code for region properties

Part 6 - Boundary Overlay Visualization

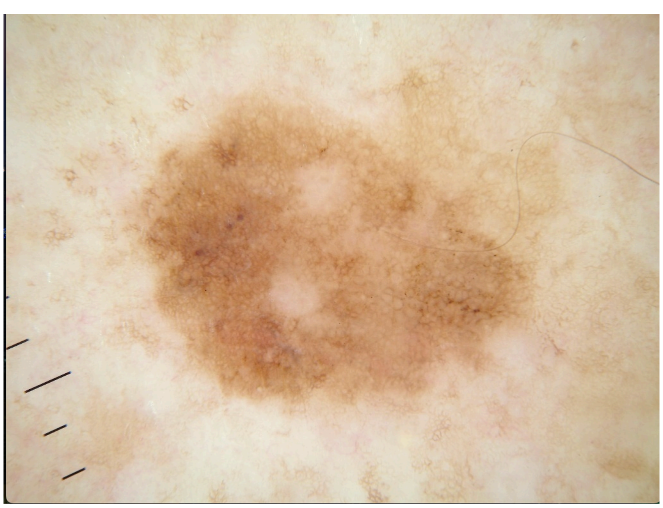
In order to visualize the segmentation results, concepts used in *Lab 10* and *Lab 11* for watershed, region growing, and more, were implemented for the final output. This shows exactly where the lesion boundary is and makes the segmentation result interpretable.

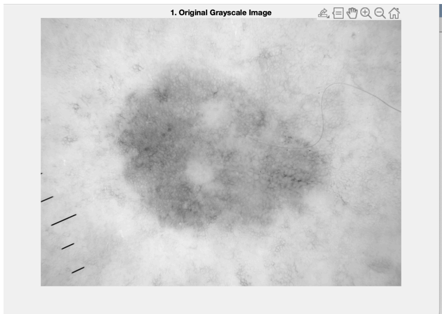
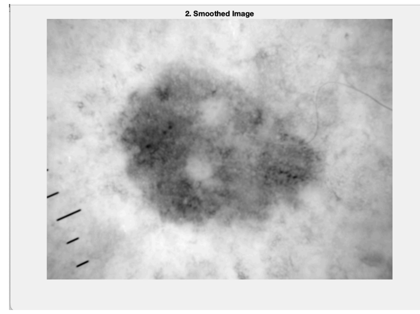
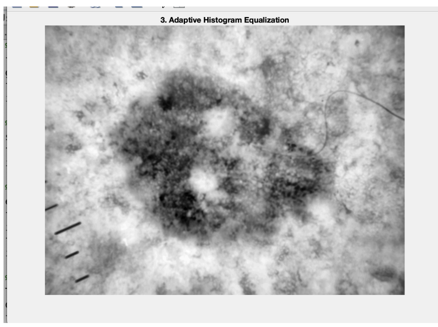
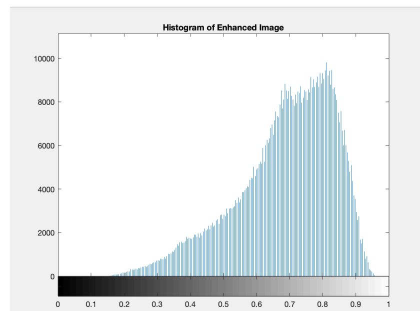
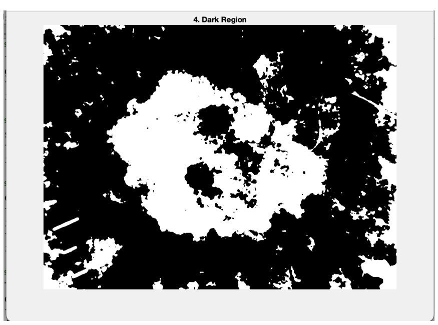
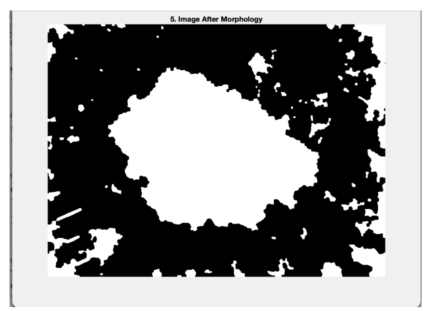
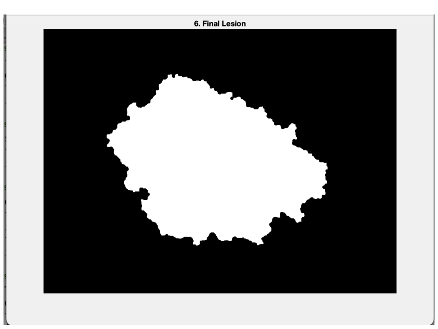
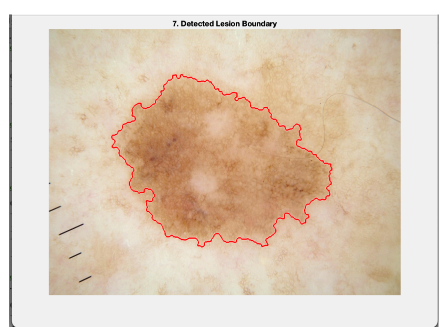
Results

The results after the segmentation in MATLAB are shown below. A total of 8 outputs are created, with the first being the original grayscale image, and the last being the colored image with the boundary highlighted in red. The outputs in between these are the steps it took to get to the final result, as mentioned in the method.

Example 1

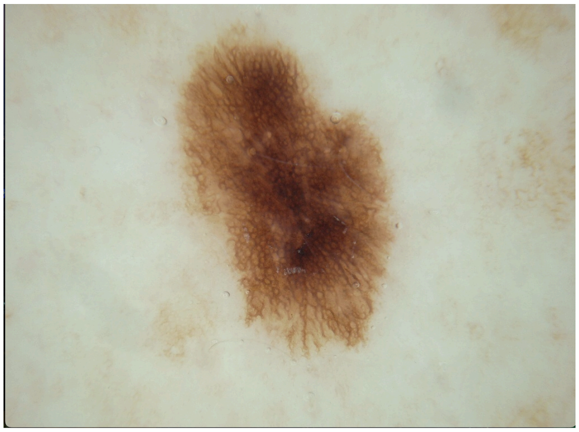
Original Image:

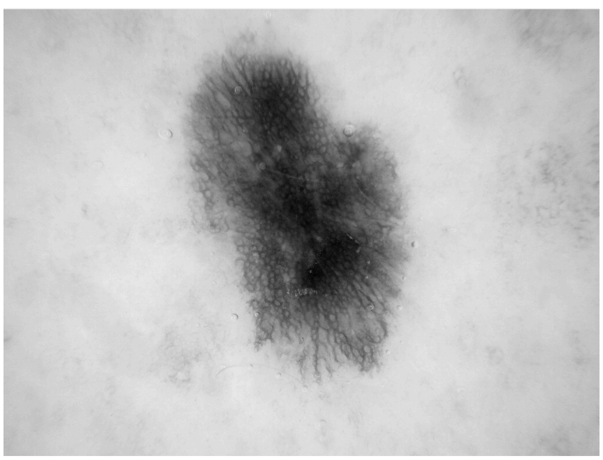
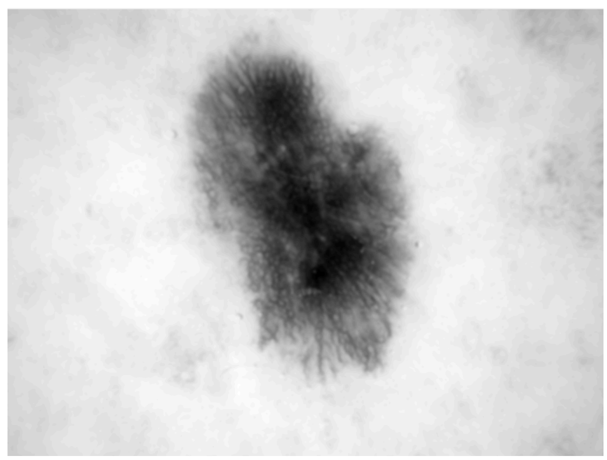
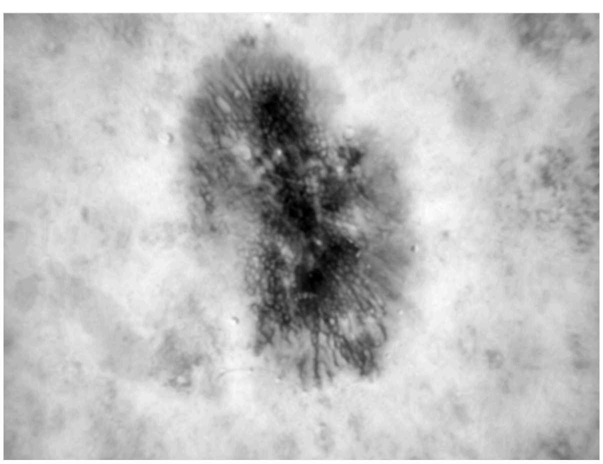
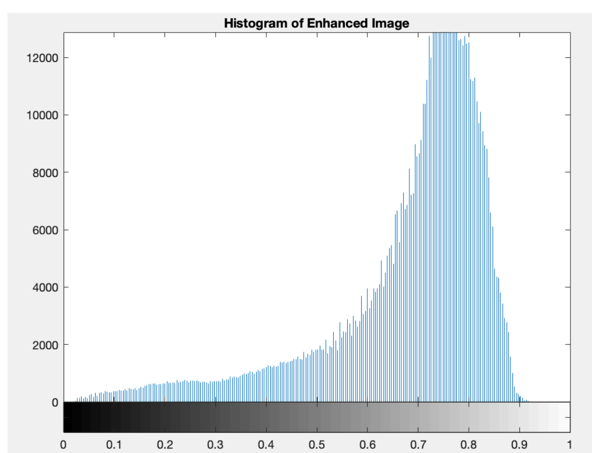


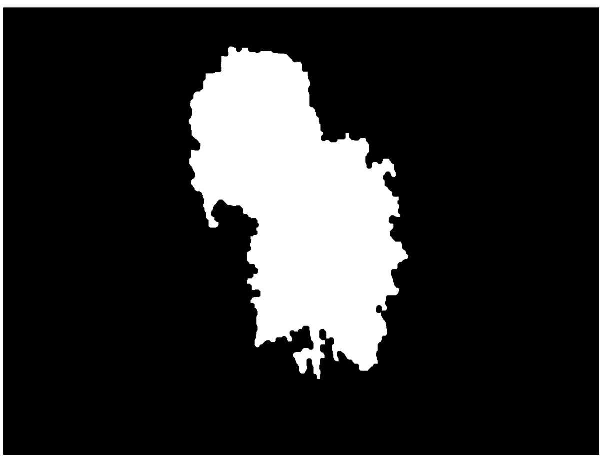
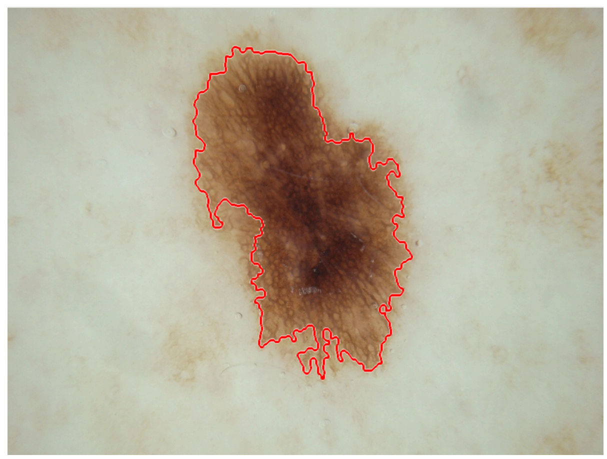
Grayscale Conversion (Part 1) 	**Spatial Smoothing (Part 2)** 
Adaptive Histogram Equalization (Part 2) 	**Adaptive Histogram Equalization (Part 2)** 
Global Thresholding Otsu's Method (Part 3) 	**Mathematical Morphology (Part 4)** 
Region Properties (Part 5) 	**Final Result (Part 6)** 

Example 2

Original Image:

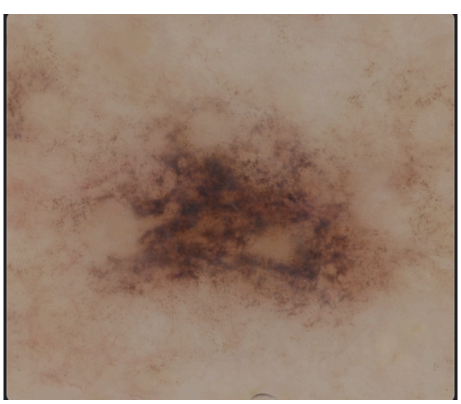


Grayscale Conversion (Part 1)	Spatial Smoothing (Part 2)
	
Adaptive Histogram Equalization (Part 2)	**Adaptive Histogram Equalization (Part 2)**
	

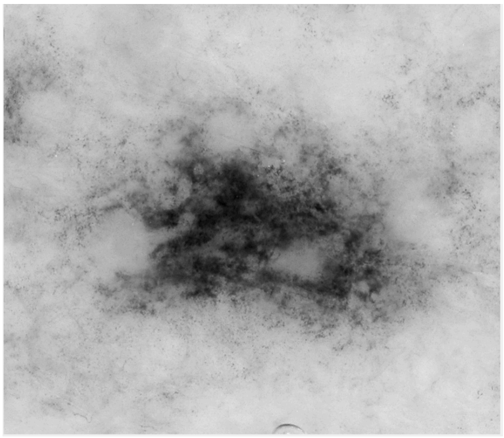
Global Thresholding Otsu's Method (Part 3)	**Mathematical Morphology (Part 4)**
	
Region Properties (Part 5)	**Final Result (Part 6)**
	

Example 3

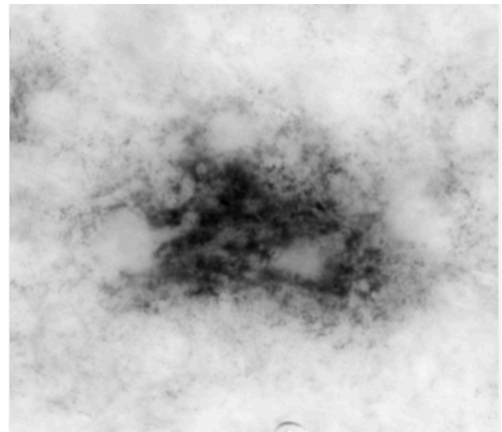
Original Image:



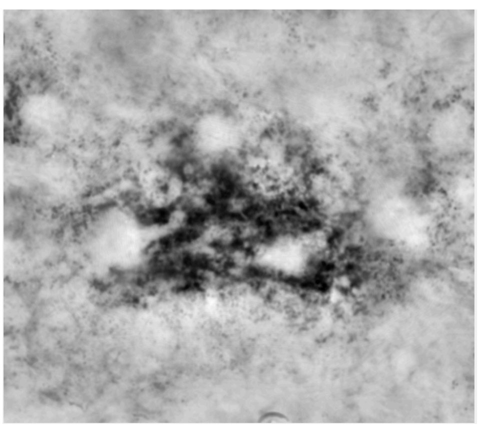
Grayscale Conversion (Part 1)



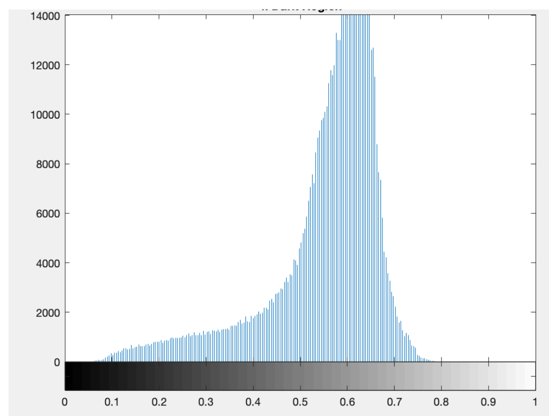
Spatial Smoothing (Part 2)



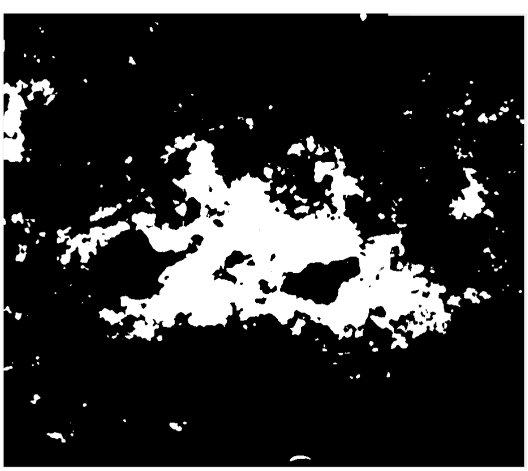
Adaptive Histogram Equalization (Part 2)



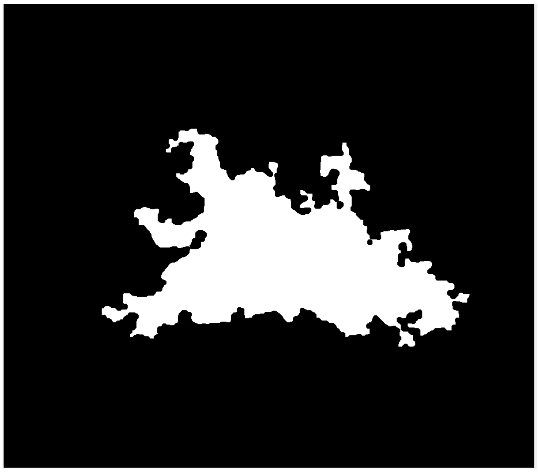
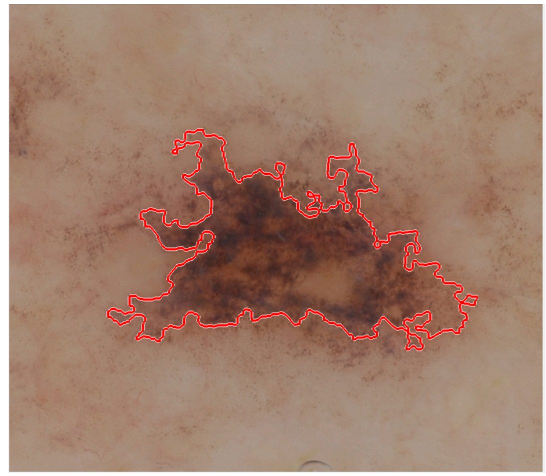
Adaptive Histogram Equalization (Part 2)



Global Thresholding Otsu's Method (Part 3)

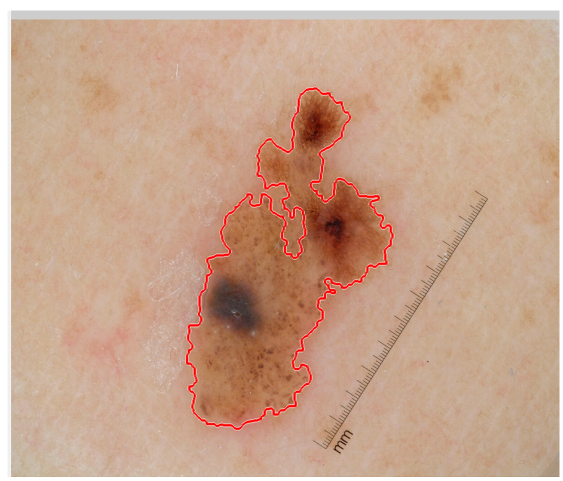


Mathematical Morphology (Part 4)

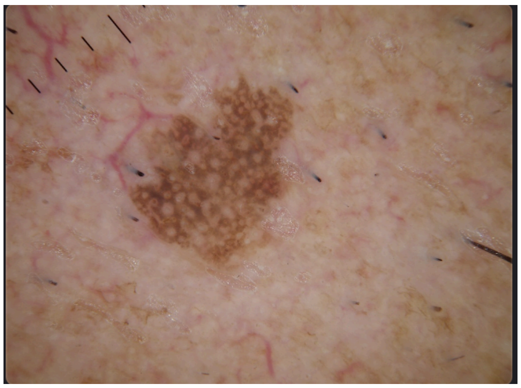
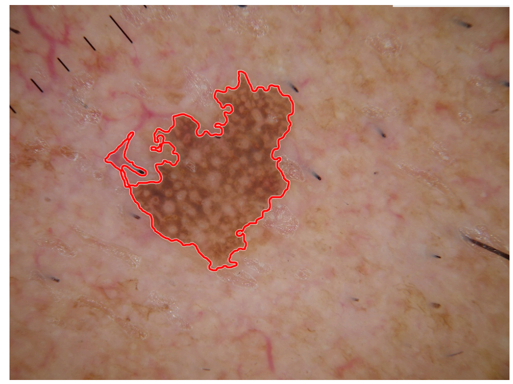
Region Properties (Part 5)	Final Result (Part 6)
	

For the purpose of space conversion, the following examples will depict the original image and the final result only.

Example 4

Original Image	Final Result
	

Example 5

Original Image	Final Result
	

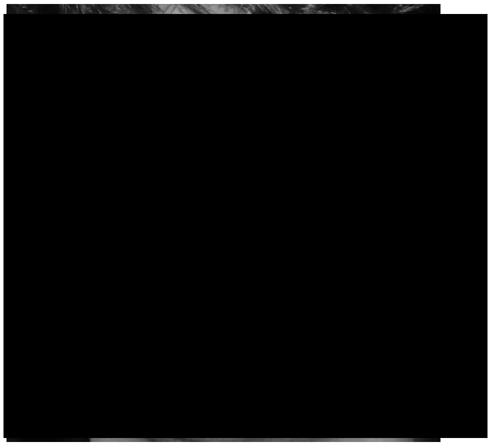
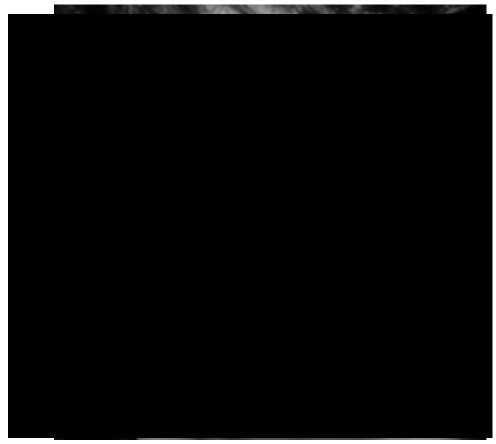
Discussion

Limitations and Negative Results

It is important to emphasize that this method will only be successful for closeup dermoscopy images. If a full face image were to be used, the output is not as accurate. This is because there is uneven lighting across the face. In addition, there are many small dark details such as pores, eyebrows, and hair. With the current method, otsu's method will not function properly because the histogram is not bimodal. Furthermore, thresholding thinks of the many small dark details as lesions which creates an inaccurate result. An example of this is shown below. **For the purpose of confidentiality, the following examples have been redacted.**

Original Image:

[redacted]

Grayscale Conversion (Part 1) 	**Spatial Smoothing (Part 2)** 
Adaptive Histogram Equalization (Part 2) 	**Adaptive Histogram Equalization (Part 2)** 
Global Thresholding Otsu's Method (Part 3) 	**Mathematical Morphology (Part 4)** 

Region Properties (Part 5)	**Final Result (Part 6)**
	

If full face images wanted to be used, watershed would be a better approach. This is because watershed relies on gradients, not intensity, so it can withstand the uneven brightness better. In addition, with watershed, markers can be used to ignore irrelevant regions. It can also handle complex boundaries much better in order to identify a clear contrast.

References

baeldung. (2023, March 23). *Understanding Otsu's Method for Image Segmentation | Baeldung on Computer Science*. Www.baeldung.com. https://www.baeldung.com/cs/otsu-segmentation

ISIC Challenge. (2016). Challenge.isic-Archive.com. https://challenge.isic-archive.com/data/

Measure properties of image regions - MATLAB regionprops. (n.d.). Www.mathworks.com. https://www.mathworks.com/help/images/ref/regionprops.html

Remove small objects from binary image - MATLAB bwareaopen. (n.d.). Www.mathworks.com. https://www.mathworks.com/help/images/ref/bwareaopen.html

Righetti, R. (2025). *Lecture and Lab Slides* . ECEN 447.