Ex6: Segmentation

E5ADSB, 39/2, Janus, Sep 2020

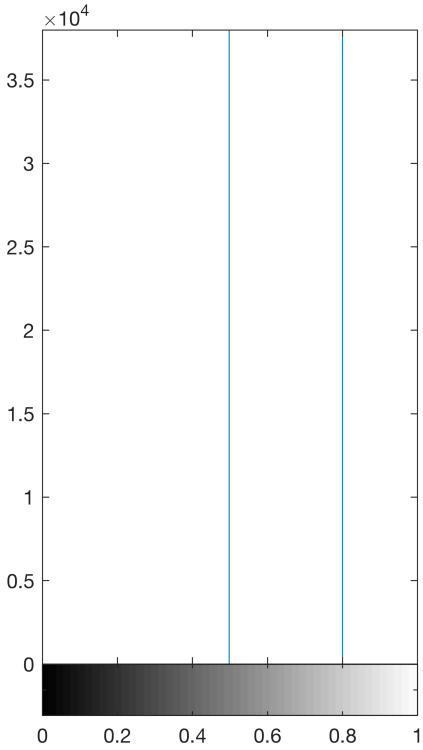
```
clc; close all; clear all;
```

Part 1. Segmentation based on thresholding

1. Load the image "constant_gray_region.tif" and show it.
2. Show the histogram of the image, and choose a suitable threshold value for segmenting the image into foreground (the object) and background. The result should be a binary image with 1 as foreground and 0 as background.
3. Find the Laplacian of the original image and show the absolute value (of the Laplacian). What do you see?
4. Another way to find the boundaries in an image is using morphological boundary extraction: $\mathcal{B}(A) = A - (A \ominus B)$. Try it!

```
I = im2double(imread('img/constant_gray_region.tif'));
```

```
figure;
subplot(121)
imshow(I);
subplot(122)
imhist(I);
```



The histogram shows a bimodal distribution. A manual choice for the threshold will be a value inbetween the two modes

```
T = 0.5*(0.8 + 0.5)         % Manual choice of threshold halfway inbetween modes
```

```
T = 0.6500
```

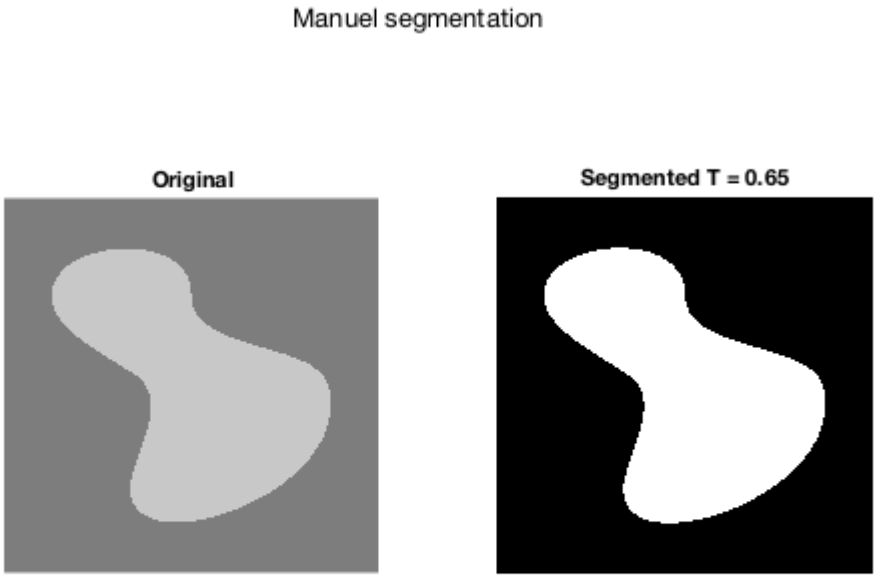
```
T_otsu = graythresh(I)       % Using Otsu 1979
```

```
T_otsu = 0.6471
```

The automatic choice of global threshold yields a value close to the manual.

Thresholding the image

```
I_seg = I > T;               % Segmentation
figure;
subplot(121)
imshow(I);
title('Original')
subplot(122)
imshow(I_seg);
title(['Segmented T = ', num2str(T)])
sgtitle('Manuel segmentation')
```



Segmentation using the Laplacian operator, ∇^2.

```
g2 = [ 0 -1  0;
      -1  4 -1;
       0 -1  0];              % The 4-neighbour Laplacian, Marques p. 219


g2_8 = [-1 -1 -1;
        -1  8 -1;
        -1 -1 -1];              % The 8-neighbour Laplacian, Marques p. 219
```

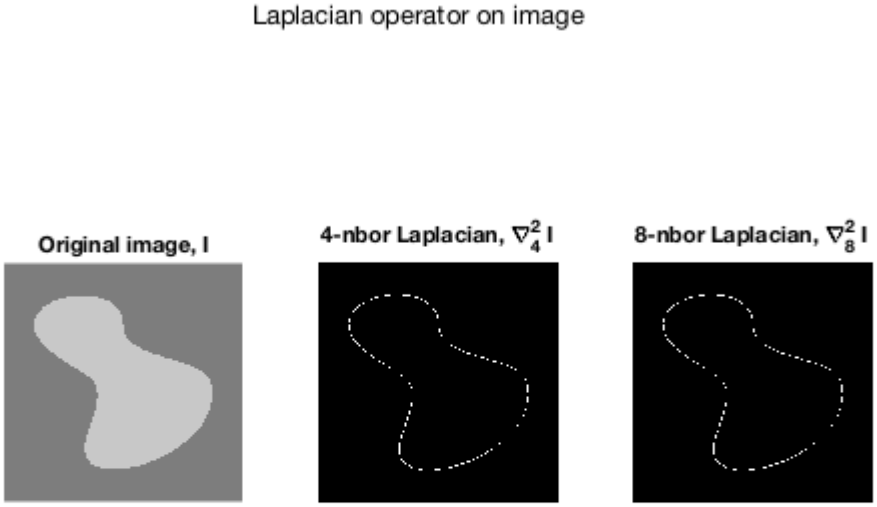
```
g2I = imfilter(I, g2, 'conv');      % filter with 4-nbor Laplacian
g2_8I = imfilter(I, g2_8, 'conv');  % filter with 8-nbor Laplacian

figure;
subplot(131)
imshow(I);
title('Original image, I')

subplot(132)
imshow(imbinarize(abs(g2I)));               % Absolute value of Laplacian (avoid underf
title('4-nbor Laplacian, \nabla^2_4 I')

subplot(133)
imshow(imbinarize(abs(g2_8I)));               % Absolute value of Laplacian (avoid unde
title('8-nbor Laplacian, \nabla^2_8 I')

sgtitle('Laplacian operator on image')
```



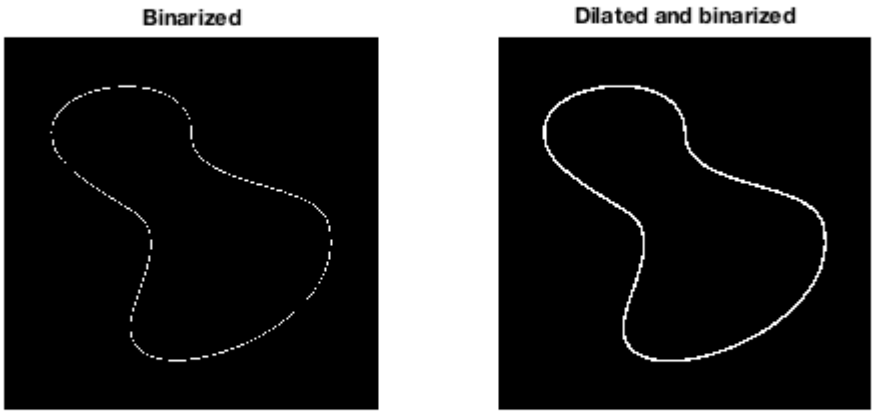
The Laplacian detects edges and transitions. This could be a viable way to partition the image.

We can try to fatten the edge to get a fuller contour by dilating and binarizing again.

```
s = strel('square', 3);

Ib = imbinarize(abs(g2I));                      % Only binarize
Ibd = imbinarize(imdilate(abs(g2I), s));        % dilated and binarized

figure;
subplot(121);
imshow(Ib);
title('Binarized')
subplot(122);
imshow(Ibd);
title('Dilated and binarized')
```



Morphological boundary extraction

Attempt to extract the boundary with $B(A) = A - (A \ominus B)$

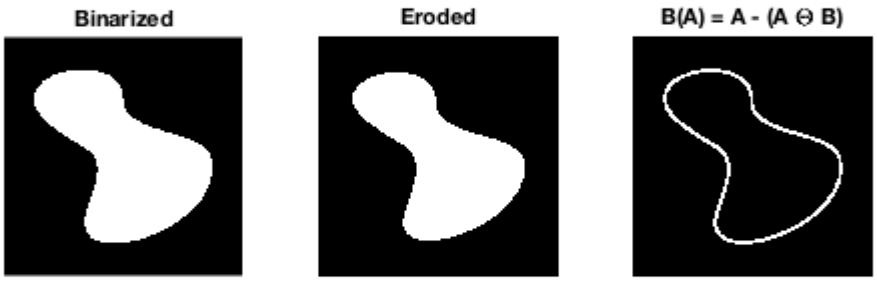
First, erosion of A by B, using a square structuring element, and the subtract the eroded image from the original.

```
A = imbinarize(I);          % Work on binary image
                            % This is like a threshold segmentation
B = strel('square', 15);        % Structuring element

AeB = imerode(A, B);        % Erosion
BA = A - AeB;               % Subtract eroded image (some edge eroded away) from origir

figure;
subplot(131)
imshow(A);
title('Binarized');
subplot(132)
imshow(AeB);
title('Eroded');
subplot(133)
imshow(BA);
title('B(A) = A - (A \Theta B)');
sgtitle('Boundary extraction using morphological processing')
```

Boundary extraction using morphological processing



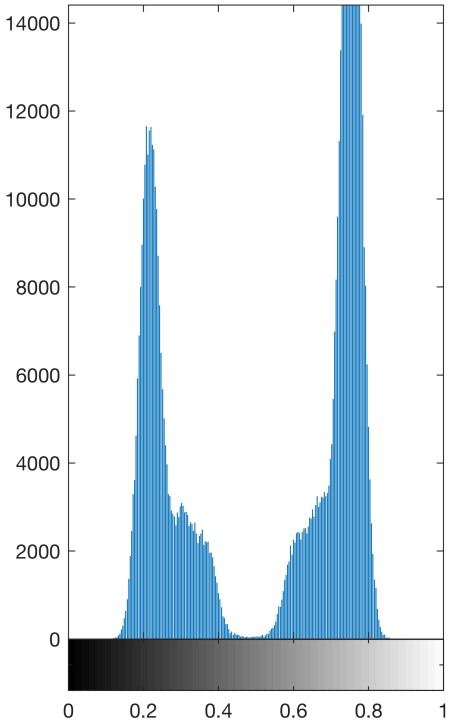
This method allows varying the amount of erosion, which can then make a wider boundary.

Part 2. Segmentation based on thresholding

```
clc; close all; clear all;
```

1. Load the image "noisy_fingerprint_bw.tif" and show it.
2. Show the histogram of the image, and choose a suitable threshold value for segmenting the image into foreground (the object) and background. The result should be a binary image with 1 as foreground and 0 as background.

```
I = im2double(imread('img/noisy_fingerprint_bw.tif')); % read in as double values
figure;
subplot(121)
imshow(I);
subplot(122)
imhist(I);
```



The image is a noisy fingerprint.

The histogram shows a bimodal distribution.

To biarize, a manual choice for the threshold will be a value inbetween the two modes.

We want to retain the foreground (the black part) as the 1s in the binary image, so thresholding has to be the logical operation $I < T$.

```
T = 0.5                         % Manual choice of threshold halfway inbetween modes
```

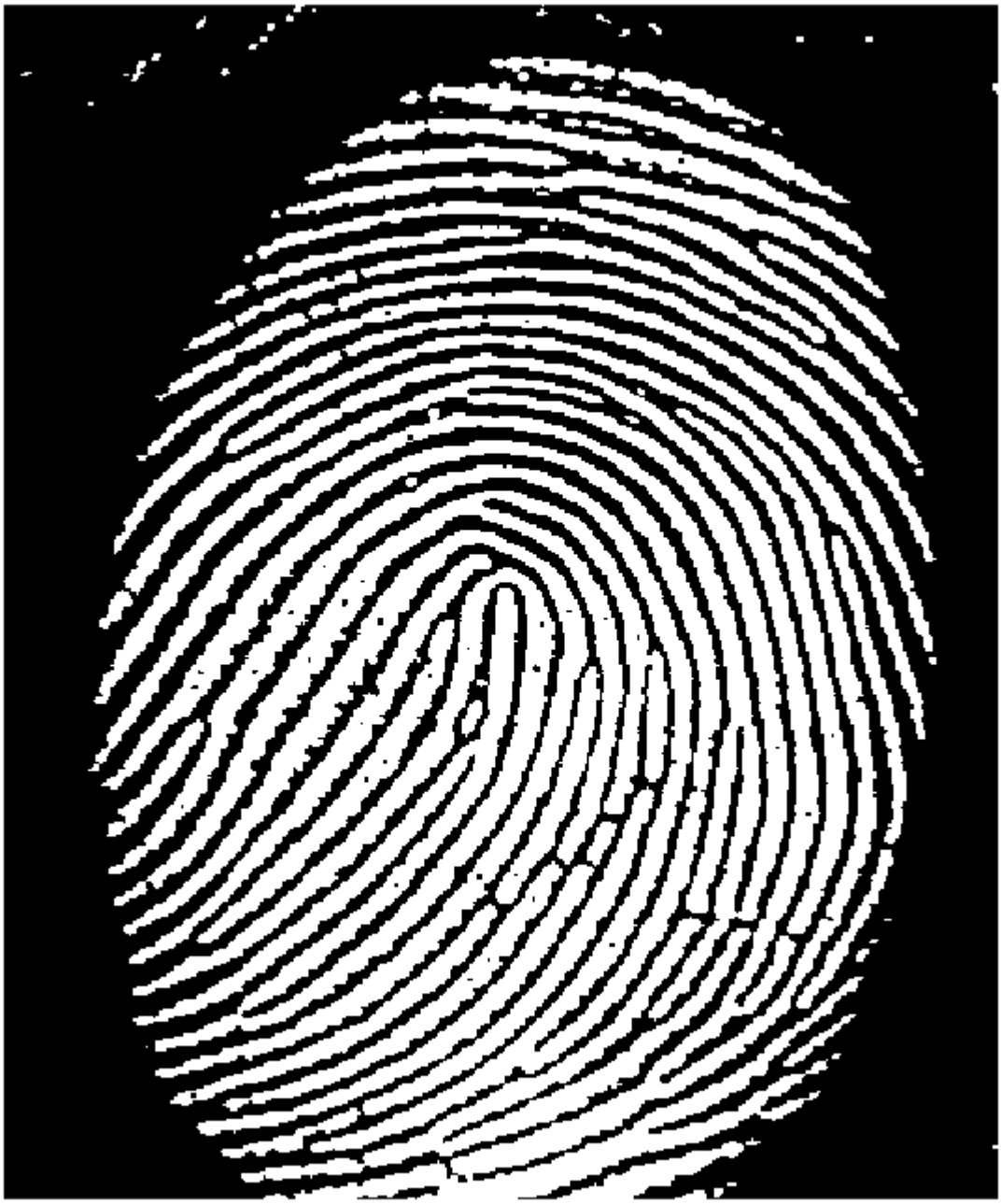
```
T = 0.5000
```

```
T_otsu = graythresh(I)          % Using Otsu 1979
```

```
T_otsu = 0.4902
```

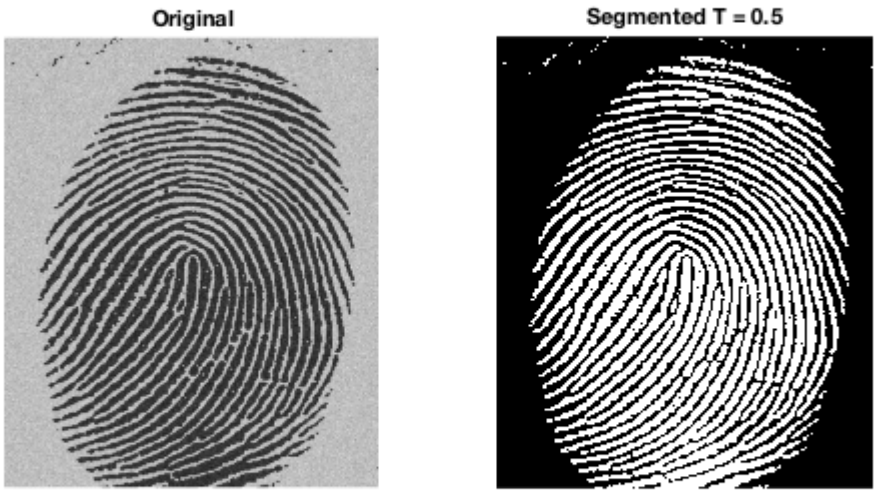
The automatic choice of global threshold yields a value close to the manual.

```
figure; imshow(I<T);
```



```
I_seg = I < T;                % Segmentation to separate fingerprint from bg, as binary i
figure;
subplot(121)
imshow(I);
title('Original')
subplot(122)
imshow(I_seg);
title(['Segmented T = ', num2str(T)])
sgtitle('Manuel segmentation')
```

Manuel segmentation



Can be cleaned up a bit using opening and closing

Process

- A: Segment original image Iinto binary image using $A(x,y) = \begin{cases} 1 & I(x,y) < T \\ 0 & \text{otherwise} \end{cases}$
- I_1: Remove small grained noise with $A \ominus B$
- I_2: Put back useful part eroded away by dilation with B: Total image is $(A \ominus B) \oplus B = A \circ B$ (opening of A by B)
- I_3: Dilate once more by B to make lines clearer: Total image is $(A \circ B) \oplus B$
- I_4: Erode by B: $((A \circ B) \oplus B) \ominus B = (A \circ B) \bullet B$

Recall,

- $A \circ B = (A \ominus B) \oplus B$ is the opening of A by B.
- $A \bullet B = (A \oplus B) \ominus B$ is the closing of A by B.

```
A = I_seg;
B = strel('square', 5);      % structure elem

I1 = imerode(A, B);
I2 = imdilate(I1, B);    % Opening of A by B
I3 = imdilate(I2, B);
```

```
I4 = imerode(I3, B);     % Closing of the opening

figure;

subplot(321)
imshow(I);
title('Original image')

subplot(322)
imshow(A);
title(['Segmented image A, T = ', num2str(T)])

subplot(323)
imshow(I1);
title(['I_1: A \Theta B, B has dim = [', num2str(size(B.Neighborhood)), ']'])

subplot(324)
imshow(I2);
title('I_2: Opening of A by B: (A \Theta B) \oplus B')

subplot(325)
imshow(I3);
title('I_3: Further dilation of the opening')

subplot(326)
imshow(I4);
title('I_4: Eroded again')
```

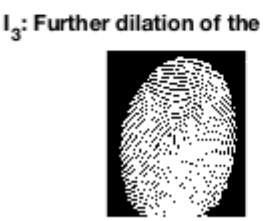


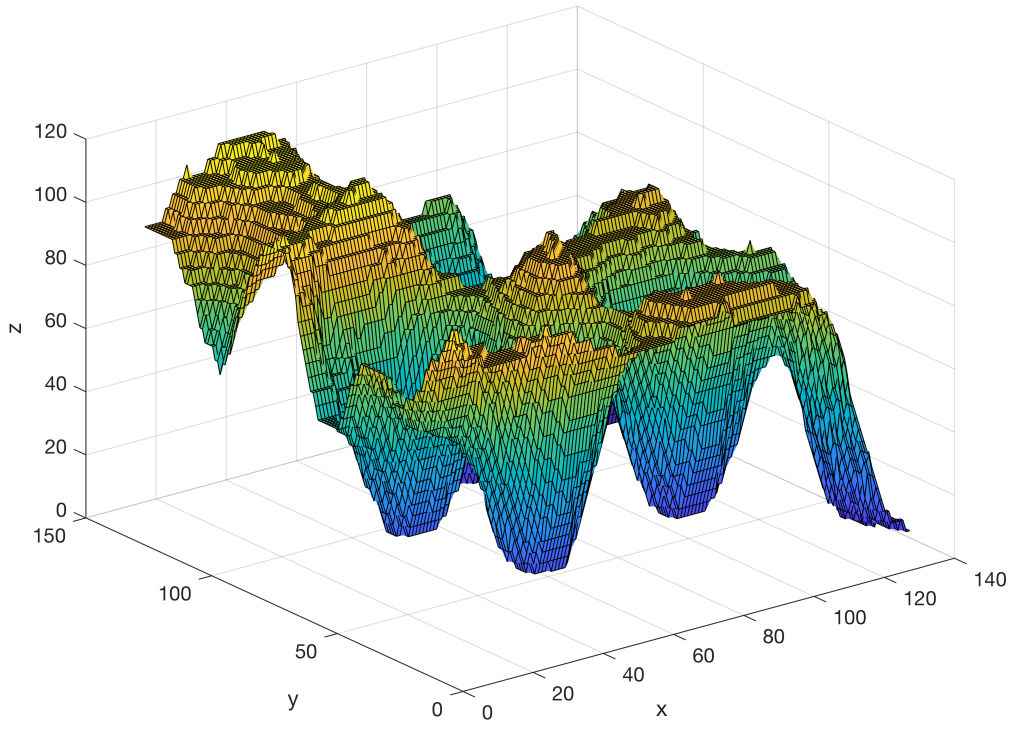
Image 2, the opening of A by B, appears to give the best basis for recognizing a fingerprint.

Part 3. Segmentation by morphological watersheds

```
clc; close all; clear all;
```

Open blob image

```
I = imread('img/blob_original.tif');
figure; surf(I);
xlabel('x'); ylabel('y'); zlabel('z');
```



We want to "fill" the contours with water, and draw segmentation boundaries where the water starts "spilling over" into other regions

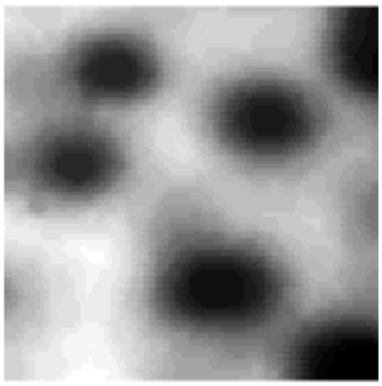
Perform the watershed with 4-connected regions

```
conn = 4;
Iout = watershed(I, conn);
```

See the different regions

```
figure;
subplot(121);
```

```
imshow(I, []);       % force using entire grayscale range with []
subplot(122);
imshow(Iout, []);
```

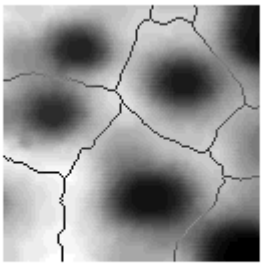


Extract boundaries only:

```
regs = im2double((Iout == 0));
```

Then fuse the two images to have an overlay of the region boundaries ("dams")

```
segm = imfuse(im2double(I), regs, 'diff');
figure; imshow(segm);
```



The image shows how 9 different regions can be picked out, corresponding to nine different topographical areas on a map.