Morphological Image Algorithms

Examples
Example 1

- Use thresholding and morphological operations to segment coins from background

Matlab’s “eight.tif” image
clear all
close all

I = imread('eight.tif');
imshow(I,[]);

B = im2bw(I, graythresh(I));  % threshold
B = imcomplement(B);         % we want black regions

S = strel('disk',1);         % define a small structuring element
B1 = imopen(B, S);          % get rid of small white regions

S = strel('disk', 5, 0);     % Need structuring element bigger than gaps
B2 = imclose(B1, S);        % Fill in gaps
figure, imshow(B2);
Example 2

- Get boundary of the coin regions

\[ \beta(A) = A - (A \theta B) \]
Example 3

- Get a list of boundary pixels

Array "contours", size (Nx2):

\[
x_1, y_1 \\
x_2, y_2 \\
x_3, y_3 \\
:\:\:
\]

\[
x_N, y_N
\]
Example 3 (continued)

```
B = bwtraceboundary(BW, P,fstep)
```

traces the outline of an object in binary image `bw`. Nonzero pixels belong to an object and 0 pixels constitute the background. `P` is a two-element vector specifying the row and column coordinates of the point on the object boundary where you want the tracing to begin.

`fstep` is a string specifying the initial search direction for the next object pixel connected to `P`. You use strings such as 'N' for north, 'NE' for northeast, to specify the direction.

`bwtraceboundary` returns `B`, a Q-by-2 matrix, where Q is the number of boundary pixels for the region.
Example 4

• Extract all boundaries

B = bwboundaries(BW)

traces the exterior boundaries of objects, as well as boundaries of holes inside these objects, in the binary image BW.

bwboundaries returns B, a P-by-1 cell array, where P is the number of objects and holes. Each cell in the cell array contains a Q-by-2 matrix. Each row in the matrix contains the row and column coordinates of a boundary pixel. Q is the number of boundary pixels for the corresponding region.

A cell array is a data type with indexed data containers called cells. Each cell can contain any type of data. Cell arrays commonly contain lists of text strings, combinations of text and numbers, or numeric arrays of different sizes.

You access one of the members of the cell array using curly brackets, {}
Example 4 (continued)

% Get all contours from the binary image B2.
contours = bwboundaries(B2);
figure, imshow(B2);
hold on
for k = 1:length(contours)
    boundary = contours{k}; % Get the kth contour
    plot(boundary(:,2), boundary(:,1), 'r', 'LineWidth', 2)
end
Example 5 - skeletonization

BW2 = bwmorph(BW, 'skel', n)

With $n = \infty$, removes pixels on the boundaries of objects but does not allow objects to break apart. The pixels remaining make up the image skeleton. This option preserves the Euler number.

Image from http://www.heikohoffmann.de/htmlthesis/node144.html
Matlab function “bwmorph”

bwmorph Morphological operations on binary image.  
BW2 = bwmorph(BW1,OPERATION) applies a specific morphological operation to the binary image BW1.

BW2 = bwmorph(BW1,OPERATION,N) applies the operation N times. N can be Inf, in which case the operation is repeated until the image no longer changes.

OPERATION is a string that can have one of these values:
- 'bothat' Subtract the input image from its closing
- 'branchpoints' Find branch points of skeleton
- 'bridge' Bridge previously unconnected pixels
- 'clean' Remove isolated pixels (1's surrounded by 0's)
- 'close' Perform binary closure (dilation followed by erosion)
- 'diag' Diagonal fill to eliminate 8-connectivity of background
- 'dilate' Perform dilation using the structuring element ones(3)
- 'endpoints' Find end points of skeleton
- 'erode' Perform erosion using the structuring element ones(3)
- 'fill' Fill isolated interior pixels (0's surrounded by 1's)
- 'hbreak' Remove H-connected pixels
- 'majority' Set a pixel to 1 if five or more pixels in its 3-by-3 neighborhood are 1's
- 'open' Perform binary opening (erosion followed by dilation)
- 'remove' Set a pixel to 0 if its 4-connected neighbors are all 1's, thus leaving only boundary pixels
- 'shrink' With N = Inf, shrink objects to points; shrink objects with holes to connected rings
- 'skel' With N = Inf, remove pixels on the boundaries of objects without allowing objects to break apart
- 'spur' Remove end points of lines without removing small objects completely
- 'thicken' With N = Inf, thicken objects by adding pixels to the exterior of objects without connected previously unconnected objects
- 'thin' With N = Inf, remove pixels so that an object without holes shrinks to a minimally connected stroke, and an object with holes shrinks to a ring halfway between the hole and outer boundary
- 'tophat' Subtract the opening from the input image
Example 6 – Segment the defects

• The defects appear as dark patches in the cloth. Simply thresholding the image will not segment the defects, since the normal texture of the cloth also has dark pixels.

• However, the normal texture of the cloth is finer-grained than the defects. Morphological operations can be used to enhance the appearance of the defects.

1. Estimate the radius of a defect. Create a disk structuring element of that size.
2. Use that structuring element to enhance the defects. Which operation should be used, “imopen” or “imclose”?
3. After enhancing, threshold the image (you can pick the threshold by hand) to segment the defects, find connected components, and draw a bounding box around each defect.