22437 - Industrial Vision
Lab 8: Morphological Image Processing

Jaume Taberner Ferrer

Universitat de les Illes Balears

Useful functions: *strel*, *imerode*, *imdilate*, *imopen*, *imclose*, *bwmorph*, *bwlabel*, *bwhitmiss*, *imfill*

Once segmentation is completed, morphological operations can be used to remove imperfections in the segmented image and to provide information about forms and structures present in the image. Morphological image processing describes a range of techniques that deal with the shape of features present in an image. Fundamentally, morphological image processing is very like to spatial filtering. An structuring element is moved across every pixel in the original image to get a new value in the output image. This value depends on the operation performed. This structure element can:

- *Fit*: All active pixels in the structuring element cover active pixels in the input image.
- *Hit*: Some active pixel in the structuring element covers an active pixel in the input image.

Erosion and Dilation

In the *erosion* operation, the structuring element s is positioned with its origin at $f(x, y)$ and the new pixel value is determined using the rule:

$$f \ominus s = \begin{cases} 1 & \text{if } s \text{ fits } f \\ 0 & \text{Otherwise} \end{cases}$$

Conversely, in the *dilation* operation, the structuring element s is positioned with its origin at $f(x, y)$ and the new pixel value is determined using the rule:

$$f \oplus s = \begin{cases} 1 & \text{if } s \text{ hits } f \\ 0 & \text{Otherwise} \end{cases}$$

Perform the following tasks:

1. Load the image *morph1.jpg* and binarize it.
2. Erode the binary image using disks of radius 5, 10 and 20, respectively. Display the results and the original image in the same figure. Using these images, explain the effects produced by the erosion operation.
3. Write a code to automatically count the number of circles in the image *circles.jpg*. Display the output image.
4. Load the image *text.jpg* and binarize it.
5. Improve the quality of the text using a dilation operation. Perform the operation using several structuring elements available in the *strel* function and display the results. Using these images, explain the effects produced by the dilation operation.
6. Load the image *licoln.jpg* and binarize it.
7. Obtain the boundaries of the image combining an erosion or dilation operation with the original image.

Opening and Closing

More interesting morphological operations can be performed by combining erosion and dilation operations. The most widely used composed operations are *opening* and *closing*. The opening of image f by the structuring element s, denoted $f \circ s$ is simply an erosion followed by a dilation, while the closing of image f by the structuring element s, denoted $f \bullet s$ is a dilation followed by an erosion.

Perform the following tasks:

1. Load the image *shapes.jpg* and apply a threshold in order to obtain a binary image.
2. Perform opening operations using squares of different sizes as structuring elements. Display the results and observe the effects produced by the opening operation.
3. Perform closing operations using squares of different sizes as structuring elements. Display the results and observe the effects produced by the closing operation.
4. Load the image *fingerprint.jpg* and apply a threshold in order to obtain a binary image.
5. Improve the quality of the fingerprint using a combination of opening and closing operations and display the final results.

Exercises

Perform the following tasks related to morphological image processing:

1. Load the image *letters.jpg*. Apply a threshold in order to obtain a binary image.
2. Apply erosion, dilation, opening and closing transformations to the image using the following structuring elements:

$$G1 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & \bullet 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \qquad G2 = \begin{bmatrix} 1 & \bullet 0 & 1 \end{bmatrix} \qquad G3 = \begin{bmatrix} 0 & 1 & 0 \\ 1 & \bullet 1 & 1 \\ 0 & 1 & 0 \end{bmatrix} \qquad G4 = \begin{bmatrix} 1 & 0 & 1 \\ 0 & \bullet 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}$$

   You should display 4 figures, one for each operation. Each figure must include the original image and the results of applying each structuring element to the image using the correspondent operation.
3. Compute the skeleton **only for the letters** present in the image and display, in the same figure, the original image and the results.
4. Use the *Hit and Miss* transform to obtain the end points and the triple junctions of the skeleton. Show, in the same figure: the original skeleton, the end points, the triple junctions and the combination of end points and triple junctions.