Handout 07 Image Segmentation

1. Basic Concepts

(1) Segmentation attempts to partition the pixels of an image into groups that strongly correlate with the objects in an image.

(2) The detection of isolated points embedded in areas of constant or nearly constant intensity in an image can be fulfilled by using Laplacian operator.

(3) Edges are pixels where the image function changes abruptly.

(4) Neurological and psychophysical research suggests that locations in the image in which the function value changes abruptly are important for image perception.

(5) Main causes of edges include depth discontinuity, surface orientation discontinuity, reflectance discontinuity, and illumination discontinuity.

(6) There are 3 fundamental steps for edge detection, image smoothing for noise reduction, detection of edge points, and edge localization.

(7) Edges can be regarded as the extrema points of the first-order derivative.

\[
\text{image intensity function (along horizontal scanline)}
\]

\[
\text{first derivative}
\]

(8) Gradient \( \nabla f = \left( \frac{\partial f}{\partial x}, \frac{\partial f}{\partial y} \right) \), gradient magnitude \( \| \nabla f \| = \sqrt{\left( \frac{\partial f}{\partial x} \right)^2 + \left( \frac{\partial f}{\partial y} \right)^2} \) and gradient direction \( \theta = \arctan \left( \frac{\partial f}{\partial y} : \frac{\partial f}{\partial x} \right) \)

(9) Sobel operator and Prewitt operator are two typical operators that can be used to compute gradients for the 2D image.

(10) When there is strong noise in the input image, smoothing can help the edge detection.

(11) Edges can be regarded as the zero-crossing points of the second-order derivative.

(12) Laplacian of Gaussian operator is defined as

\[
\nabla^2 G_\sigma(x, y) = \left( \frac{x^2 + y^2 - 2\sigma^2}{\sigma^4} \right) \exp \left( -\frac{x^2 + y^2}{2\sigma^2} \right)
\]
(13) The LoG function can be approximated by a difference of Gaussian (DoG).
(14) Canny method is an effective method for edge detection.
(15) The success of intensity thresholding based segmentation is related to the width and depth of the valley(s) separating the histogram modes.
(16) Global thresholding will partition the image histogram using a single global threshold.
(17) Otsu’s method can choose the optimum threshold in the sense that it maximizes the between-class variance.
(18) In some cases (even seems very simple) due to noise and nonuniform illumination, a global threshold does not work well; that’s why we want to have a variable thresholding scheme.
(19) Moving average based segmentation is especially useful in document processing; moving average at the pixel $k$ is formed by averaging the intensities of that pixel and its $n-1$ preceding neighbors.

2. Related Matlab routines

- graythresh, im2bw, imfilter, fspecial

3. Matlab Programming

(1) Run the demo “Point detection”.
(2) Run the demo “Gradient computation”.
(3) Run the demo “Basic global thresholding”.
(4) Run the demo “moving average thresholding”.
(5) Restate the basic global thresholding algorithm mentioned in our lectures so that it uses the histogram of an image instead of the image itself.
(6) Implement Otsu's optimum thresholding algorithm. Of course, you cannot simply call the routine “graythresh”.
