Image Segmentation

Segmentation: Dividing into the regions/segments of similar properties
• Discontinuity -- boundary
• Similarity -- region
Discontinuity Detection: Point, Line and Edge

Mask Operation (Review)

\[ \begin{array}{ccc}
  w_1 & w_2 & w_3 \\
  w_4 & w_5 & w_6 \\
  w_7 & w_8 & w_9 \\
\end{array} \]
Image Segmentation

Edge Detection

**Model of an ideal digital edge**

**Model of a ramp digital edge**

**Gray-level profile of a horizontal line through the image**

**Gray-level profile of a horizontal line through the image**

**FIGURE 10.5**
(a) Model of an ideal digital edge.
(b) Model of a ramp edge. The slope of the ramp is proportional to the degree of blurring in the edge.
Image Segmentation

Edge Detection

**FIGURE 10.6**
(a) Two regions separated by a vertical edge.
(b) Detail near the edge, showing a gray-level profile, and the first and second derivatives of the profile.
Image Segmentation

Edge Detection

**Figure 10.10**
(a) Original image. (b) $|G_x|$, component of the gradient in the $x$-direction.
(c) $|G_y|$, component in the $y$-direction.
(d) Gradient image, $|G_x| + |G_y|$.
Image Segmentation

Edge Detection

FIGURE 10.11
Same sequence as in Fig. 10.10, but with the original image smoothed with a $5 \times 5$ averaging filter.
Image Segmentation

Hough Transform

Lines

FIGURE 10.17
(a) $xy$-plane.
(b) Parameter space.
Image Segmentation

Hough Transform

Lines

**FIGURE 10.18**
Subdivision of the parameter plane for use in the Hough transform.
Image Segmentation

Hough Transform

Lines

FIGURE 10.19
(a) Normal representation of a line.
(b) Subdivision of the $\rho\theta$-plane into cells.
Image Segmentation

Hough Transform
Lines

Apply edge operator to image \( f(x,y) \), and compute gradient magnitude \( M(x,y) \) at each pixel.

Build the accumulator array \( A \):
for each edge pixel \( M(x,y) \)
  if ( \( M(x,y) > \text{threshold} \) )
    for each quantized value of \( \theta \)
      compute: \( \rho = x \cos \theta + y \sin \theta \)

      increment: \( A[\rho][\theta]++ \)

Search accumulator array for maxima, corresponding to lines in the image.
Image Segmentation

Hough Transform
Lines

FIGURE 10.20
Illustration of the Hough transform.
(Courtesy of Mr. D. R. Cafe, Texas Instruments, Inc.)
Image Segmentation

Hough Transform
Circles
Image Segmentation

Hough Transform
Circles

Apply edge operator to image $f(x,y)$, and compute gradient magnitude $M(x,y)$ at each pixel.

Build the accumulator array $A$:
for each edge pixel $M(x,y)$
  if ( $M(x,y) > \text{threshold}$ )
    for each quantized value of $\theta$
      compute: $xc = x - R \cdot \cos \theta$
      $yc = y - R \cdot \sin \theta$
      increment: $A[xc][yc]++$

Search accumulator array for maxima, corresponding to circle centers in the image.
Image Segmentation

Hough Transform
Circles
Image Segmentation

Thresholding

\[ \text{FIGURE 10.26} \ (a) \text{ Gray-level histograms that can be partitioned by (a) a single threshold, and (b) multiple thresholds.} \]
Image Segmentation

Thresholding

FIGURE 10.28
(a) Original image. (b) Image histogram. (c) Result of global thresholding with $T$ midway between the maximum and minimum gray levels.
Image Segmentation

Thresholding

FIGURE 10.29
(a) Original image. (b) Image histogram. (c) Result of segmentation with the threshold estimated by iteration. (Original courtesy of the National Institute of Standards and Technology.)
Image Segmentation

Thresholding

**FIGURE 10.32**
Gray-level probability density functions of two regions in an image.
Image Segmentation

Region Based

FIGURE 10.42
(a) Partitioned image.
(b) Corresponding quadtree.
FIGURE 6.4 Primary and secondary colors of light and pigments. (Courtesy of the General Electric Co., Lamp Business Division.)
Color Image Processing

**Figure 6.7**
Schematic of the RGB color cube. Points along the main diagonal have gray values, from black at the origin to white at point \((1,1,1)\).
FIGURE 6.12 Conceptual relationships between the RGB and HSI color models.
FIGURE 6.13  Hue and saturation in the HSI color model. The dot is an arbitrary color point. The angle from the red axis gives the hue, and the length of the vector is the saturation. The intensity of all colors in any of these planes is given by the position of the plane on the vertical intensity axis.
Color Image Processing

**Figure 6.14** The HSI color model based on (a) triangular and (b) circular color planes. The triangles and circles are perpendicular to the vertical intensity axis.
Color Image Processing