What to do with Edges

Computer Vision
CSE 190-B
Lecture 9

Announcements

• Assignment 2 is posted to the web page.
• The Midterm will be Tuesday, May 6

Finding derivatives

The scale of the smoothing filter affects derivative estimates

Gradient Magnitude

We wish to mark points along the curve where the magnitude is biggest. We can do this by looking for a maximum along a slice normal to the curve (non-maximum suppression). These points should form a curve. There are then two algorithmic issues: at which point is the maximum, and where is the next one?
Non-maximum Suppression from Text

Input: $E_s =$ Edge strength, $E_p =$ Edge orientation
Output: $I_N =$ New image of edge strength

For each pixel $(i,j)$
1. Find normal $d_k$ to edge from $E_o(i, j)$
2. If $E_s(i,j)$ is smaller than at least one of its neighbors along $d_k$,
   THEN $I_N(i,j) \leftarrow 0$ ; suppress edge
   ELSE $I_N(i,j) \leftarrow E_s(i,j)$

Hough Transform: 20 colinear points
- $R, \theta$ representation of line
- Maximum accumulator value is 20

Hough Transform: “Noisy line”
- $R, \theta$ representation of line
- Maximum accumulator value is 6

Hough Transform: Random points
- $R, \theta$ representation of line
- Maximum accumulator value is 4
For 20 points, the maximum value of the accumulator array as a function of noise level.

For N points whose location in the image is chosen randomly with uniform distribution, the maximum number of votes in the accumulator array.

TEM Image of Keyhole Limpet Hemocyanin

3D Maps of KLH

FIG. Three-dimensional maps of KLH at a resolution of 23.5 Å reconstructed using particles extracted either manually or automatically as described in the text. (a), (b) The side- and top- view of a 3D map reconstructed from a set of 1042 manually selected particle images. (c), (d) The side- and top- view of a 3D map from a set of automatically extracted 1243 particle images.

Processing in Stage 1 for KLH

- Canny edge detection.
- A sequence of ordered Hough transforms (HT’s) is applied in order from the computationally simplest one to the most complex one.
- Edges covered by the detected shapes are removed immediately from edge images following the application of the last HT.

Picking KLH Particles in Stage 1

Zhu et al., IEEE Transactions on Medical Imaging, In press, 2003
Line Fitting

Given \( n \) points \((x_i, y_i)\), estimate parameters of line
\[ ax_i + by_i + c = 0 \]
subject to the constraint that
\[ a^2 + b^2 = 1 \]

Problem: minimize
\[ E(a, b, d) = \sum_{i=1}^{n} (ax_i + by_i + d)^2 \]
with respect to \((a, b, d)\).

1. Minimize \( E \) with respect to \( d \):
\[ \frac{\partial E}{\partial d} = 0 \implies d = \frac{\sum_{i=1}^{n} ax_i + by_i}{n} = \bar{x}a + \bar{y}b \]

Line fitting cont.

2. Substitute \( d \) back into \( E \)
\[ E = \sum_{i=1}^{n} [x_i - \bar{x}]^2 + [y_i - \bar{y}]^2 = \|\mathbf{e}\|_2^2 \]

3. Minimize \( E = \mathbf{U}^T \mathbf{U} \mathbf{e} \) with respect to \( a, b \) subject to constraint \( \mathbf{n}^T \mathbf{n} = 1 \)
\[ \mathbf{U}^T \mathbf{U} = \begin{pmatrix} \sum_{i=1}^{n} x_i^2 - n \bar{x}^2 & \sum_{i=1}^{n} x_i (y_i - \bar{y}) \\ \sum_{i=1}^{n} x_i (y_i - \bar{y}) & \sum_{i=1}^{n} y_i^2 - n \bar{y}^2 \end{pmatrix} \]