

Edge-based Segmentation

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Edge-based Segmentation

基于边缘检测的图像分割

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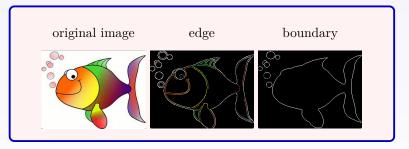






Edge & Boundary

Edge-based Segmentation



The edge of object may be not a boundary, the boundary may also be not edge.



Problems

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Edge Trackin Hough Transform Edge detection is a simple and fast technique used in segmentation methods. However, there also are some problems:

- Noise and background affect the accurate of edge detection.
- Edges are the sign of lack of continuity, and ending.







Steps in Edge Detection

Edge-based Segmenta-

- 1 Filtering: Filtering to reduce noise results in a loss of edge strength.
- **Enhancement:** In order to facilitate the detection of edges, it is essential to determine changes in intensity in the neighborhood of a point.
- 3 Detection: Find the zero crossing and peak value to detect edge.



Problems

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Step in Image Segmentation

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Edge Detection

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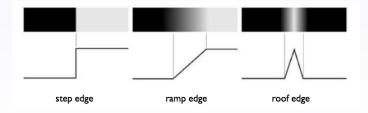
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Three edge types and definitions:

- Step edge
- Ramp edge
- Roof edge





Edge Detection

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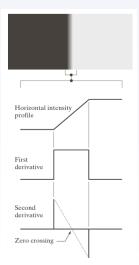
Edge Detection Techniques

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Edge Detection Techniques¹

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■ Roberts Edge Detection

- Sobel Edge Detection
- Prewitt Edge Detection
- Marr-Hildreth Edge Detection (LoG)
- Canny Edge Detection

¹Rafael C. Gonzalez *et al.*, "Digital Image Processing", Publishing House of Electronics Industry, 2011.



Gradient

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The gradient ∇f of a function is:

$$\nabla f = \operatorname{grad}(f) = \left[\begin{array}{c} g_x \\ g_y \end{array} \right] = \left[\begin{array}{c} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{array} \right]$$

The magnitude of the gradient is:

$$M(x, y) = mag(\nabla f) = \sqrt{g_x^2 + g_y^2}$$

The directions of the greatest rate of change is:

$$\alpha(x,y) = \arctan\left[\frac{g_x}{g_y}\right]$$

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z_1	z_2	z ₃
z_4	z_5	z ₆
z ₇	z_8	Z9

■ Roberts Edge Detection

-1	0
0	+1

0	-1
+1	0

$$g_x = \frac{\partial f}{\partial x} = z_9 - z_9$$
$$a_x = \frac{\partial f}{\partial x} = z_8 - z_9$$

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■ Sobel Edge Detection

-1	-2	-1
0	0	0
+1	+2	+1

-1	0	-1
-2	0	+2
-1	0	+1

$$g_x = \frac{\partial f}{\partial x} = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$

$$g_x = \frac{\partial f}{\partial y} = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)$$

■ Prewitt Edge Detection

-1	-1	-1
0	0	0
+1	+1	+1

-1	0	+1
-1	0	+1
-1	0	+1



Marr-Hildreth Edge Detection $(LoG)^2$

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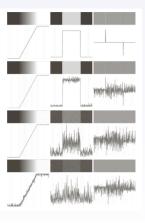
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Linking Edge Trackir Hough This method combines Gaussian filtering with the Laplacian for edge detection.

Idea:

- Gaussian filer is used to swipe away noise from the image
- 2 Laplace operator
- 3 Locate zero crossings



²Marr D, Hildreth E, "Theory of Edge Detection", Proc. of the Royal Society of London, 1980.



Canny Edge Detection³

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Canny Edge Detection

Elifiking Edge Trackin Hough Canny is the best edge detection detector.

Idea:

- 1 Low error rate
- **2** Edge points should be well localized

³Joun F. Canny, "A Computational Approach To Edge Detection", PAMI, 1986.



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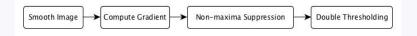
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Canny algorithm:







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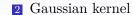
Gauss Filter:

- 1 Gaussian distribution
 - one dimension:

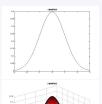
$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}$$

■ two dimension:

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2 + y^2}{2\sigma^2}}$$









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Compute Gradient:

$$S_x = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}, S_y = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$







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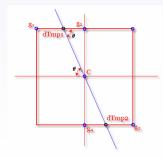
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Non-maxima Suppression (NMS):

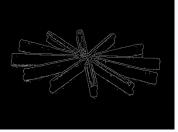
- Problem: Edges generated using gradient typically contain wide ridges around local maxima.
- Use non-maxima suppression to thin those ridges to find thin edges corresponding to local maxima.





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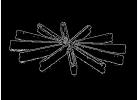
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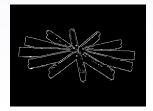
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Double thresholding:

Problem: The received image may still contain false edge points.









Edge Linking

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- Edge Tracking
- Hough Transform
- Curve Fitting
- Dynamic Programming

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Idea:

 Each point is linked to the adjacent if magnitude and direction of the gradient are similar.

e(x,y) is magnitude of the gradient, $\theta(x,y)$ is the direction of the gradient, if two each points meet the following conditions:

$$\begin{cases} | e(x_i, y_i) - e(x_j, y_j) | \leq E \\ | \theta(x_i, y_i) - \theta(x_j, y_j) | \leq A \\ | e(x_i, y_i) |, | e(x_j, y_j) | > E \end{cases}$$

Edge-based Segmentation The Hough Transform can be used to detect lines, circles or other parametric curves.

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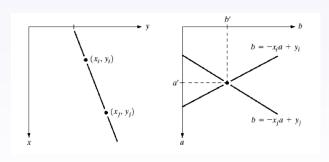
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Idea:



$$y = a'x + b' \qquad \begin{cases} b = -x_i a + y_i \\ b = -x_j a + y_j \end{cases}$$



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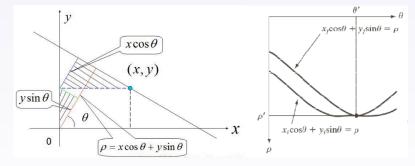
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$$\begin{cases} \rho^{'} = x_{i}cos\theta^{'} + y_{i}sin\theta^{'} \\ \rho^{'} = x_{j}cos\theta^{'} + y_{j}sin\theta^{'} \end{cases} \Longrightarrow \begin{cases} x_{i}cos\theta + y_{i}sin\theta = \rho \\ x_{j}cos\theta + y_{j}sin\theta = \rho \end{cases}$$



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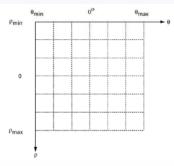
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Hough algorithm:

- Quantize the parameter space (ρ, θ) . This quantized space is referred to as the accumulator cells.
- 2 Count the number of times a line intersects a given cell.
- 3 Lines can be found as peaks in this accumulator space.



$$\rho = x\cos\theta + y\sin\theta$$



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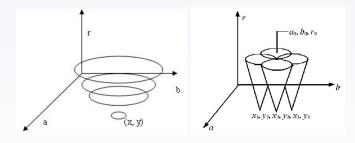
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Circle:

$$(x-a)^2 + (y-b)^2 = r$$



$$(a - x_i)^2 + (b - y_i)^2 = r$$



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Thanks!