Further Edge Detection

Canny

1 optimal.
2 single response
3 edges in right place.

Approximation

i). Gaussian
ii). Sobel
iii). non max suppression – peak detection
iv) hysteresis thresholding

more complex but worth it

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ii). second order edge detection

differentiate twice , find the zero crossing

$$f'(x) = f_{x,y} - f_{x+1,y}$$

$$f''(x) = \underbrace{f'_{x,y}} - \underbrace{f'_{x+1,y}}$$

$$\overline{f_{x,y} - f_{x+1,y} - (f_{x+1,y} - f_{x+2,y})}$$

1	-2	1

3x3

0	1	0
1	-4	1
0	1	0

sensitive to noise

iii). Include smoothing.

use Gaussian

$$\nabla^2 = \nabla\left(\frac{df}{dx} U_x + \frac{\partial f}{\partial y} U_y\right)$$

second order

unit vectors

$$\frac{\partial g}{\partial x} = \frac{\partial}{\partial x} e^{-(x^2+y^2)/2\sigma^2}$$

$$= \frac{-\cancel{2}x}{\cancel{2}\sigma^2} e^{-(x^2+y^2)/2\sigma^2}$$

$$\frac{\partial^2 f}{\partial x^2} = \left(+\frac{\cancel{2}x^2}{\cancel{2}\sigma^2} - 1\right)\frac{e^{-(x^2+y^2)/2\sigma^2}}{\sigma^2}$$

$$\frac{\partial^2 f}{\partial y^2} = \left(\frac{y^2}{\sigma^2} - 1\right)\frac{e^{-(x^2+y^2)/2\sigma^2}}{\sigma^2}$$

Zero crossing by averaging in 4 quadrants & then look for a sign change.

ii) Better way?

Taylor series

A $\quad f(x+\Delta x) = f(x) + \Delta x f'(x) + \frac{\Delta x^2}{2!} f''(x) + \dots$

$$f'(x) = \frac{f(x+\Delta x) - f(x)}{\Delta x} + O(\Delta x)$$

$$\boxed{-1 \mid +1} \quad \times$$

B $\quad f(x-\Delta x) = f(x) - \Delta x f'(x) + \frac{\Delta x^2}{2!} f''(x) - O(\Delta x^3)$

A $\cancel{+}$ − B

$$f(x+\Delta x) - f(x-\Delta x) = 2\Delta x f'(x) + O(\Delta x^3)$$

$$f'(x) = \frac{f(x+\Delta x) - f(x-\Delta x)}{2\Delta x} - O(\Delta x^2)$$

$$\boxed{-1 \mid 0 \mid +1} \quad \checkmark$$

if $\Delta x < 1 \quad O(\Delta x^2) \ll O(\Delta x)$