ME 456/556/556XE
Machine Vision

Homework 2 Help

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Question

- Do you need extension for DDL (Mar 17)?

Algorithms to be covered

- LoG
- Canny
- Harris Corner Detection
- Hough transform

LoG

- Core algorithm: LoG operation + find zero crossing
- LoG operator

$$\nabla^2 G(x, y) = \frac{\partial^2 G(x, y)}{\partial x^2} + \frac{\partial^2 G(x, y)}{\partial y^2}$$

$$\nabla^2 G(x, y) = \left[\frac{x^2 + y^2 - 2\sigma^2}{2\pi\sigma^6} \right] \exp\left(-\frac{x^2 + y^2}{2\sigma^2} \right)$$

Step-by-step development

- Step 1: Filter image with LoG
- Step 2: Find zero crossings on filtered image
  - Pixel in operation has "small" value
  - Opposing neighbors have different signs (> 1)
  - Opposing absolute difference > threshold
- Step 3: hysteresis thresholding (if needed)

Canny

- Core algorithm: Gradient of Gaussian + non-maxima suppression
- Gradient of Gaussian

$$\left[\frac{\partial}{\partial x}G(x,y)\right]=\frac{-x}{2\pi\sigma^4}\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right)$$

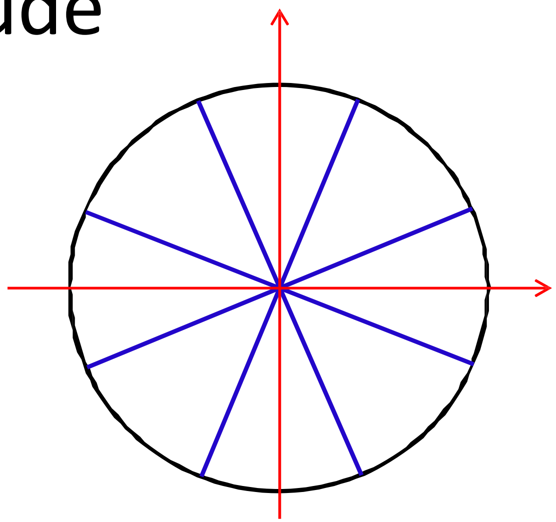
$$M(x,y)=\sqrt{g_x^{\,2}+g_y^{\,2}}$$

$$\left[\frac{\partial}{\partial y}G(x,y)\right]=\frac{-y}{2\pi\sigma^4}\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right)$$

$$\alpha(x,y)=\tan^{-1}\left[\frac{g_y}{g}\right]$$

Step-by-step development

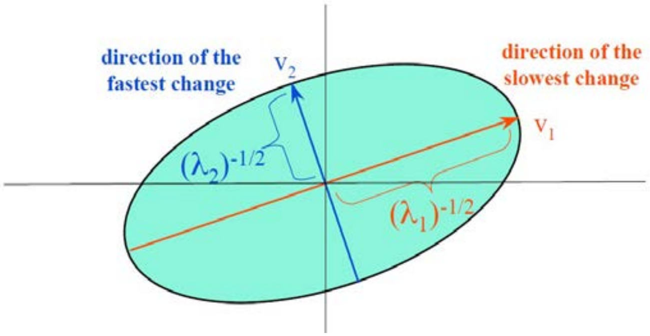
- Step 1: compute gradient magnitude M(x,y) and angle map $\alpha(x,y)$
- Step 2: Apply non maxima suppression to thin the ridges
  - If M(x,y) < one of its two neighbors along d
    - Suppression (make the pixel 0)
  - Else
    - Keep value

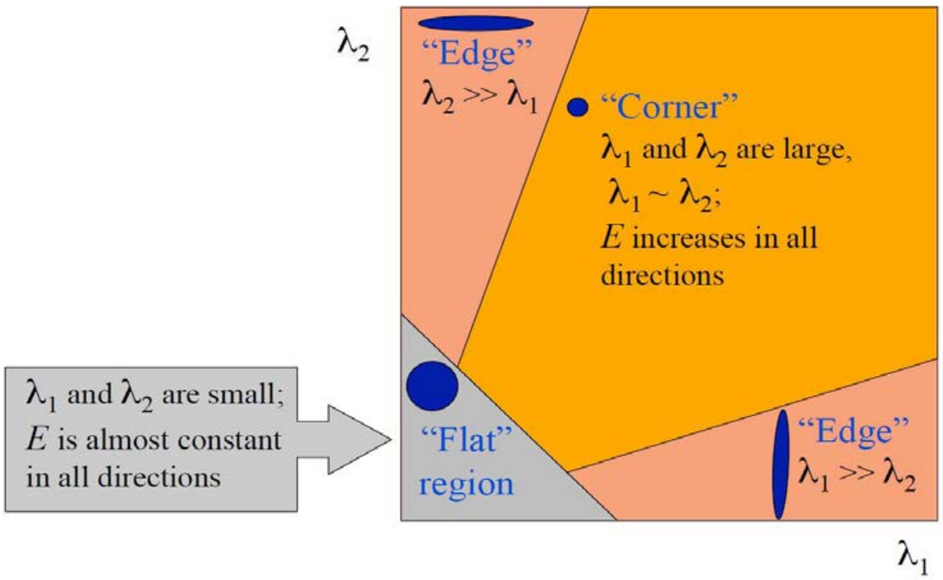


Harris corner detection

- Core algorithm:

$$A = \sum_u \sum_v w(u,v) \begin{bmatrix} I_x^2 & I_x I_y \\ I_y I_x & I_y^2 \end{bmatrix}$$





$$R = \lambda_1 \lambda_2 - k(\lambda_1 + \lambda_2)^2$$

Step by step development

- Determine a window size N for Harris algorithm
- Design a NxN window with Gaussian distribution
- For each pixel, pick its NxN neighborhood, align with your Gaussian window, compute gradients Ix, Iy, construct matrix A

$$A = \sum_u \sum_v w(u,v) \begin{bmatrix} I_x^2 & I_x I_y \\ I_y I_x & I_y^2 \end{bmatrix}$$

Step by step development

- Compute corner responses (k is an empirical number (0.04-0.15) $R = \lambda_1 \lambda_2 - k(\lambda_1 + \lambda_2)^2$
- After thresholding, keep only local maxima of R as corners

Hough transform

- $x_0 = x_i - R\cos\theta$
- $y_0 = y_i - R\sin\theta$

- Step 1: compute edges (LoG or Canny)
- Step 2: compute gradient angle maps θ
- Step 3: Loop through all possible R values, x_i values and y_i values, vote for circle center x_0 and y_0.