AI Lab Pratical4 : Edge Detection and Image Sementation

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Introduction

In this section, we will explore the fundamental concepts of edge detection by applying several techniques, including Gradient-based methods, the Laplacian operator, the Canny edge detector, and corner detection. For the practical component, you are provided with a blurred image file, **"blur.tif"**, located in the **"blur_image"** folder. The objective of this laboratory exercise is to enhance the given image so that it appears clearer and visually improved.

Fig: blur.tif

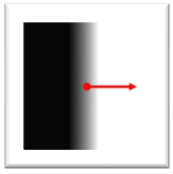
1.Edge detection using Gradient (∇)

Method1: Gradient Magnitude

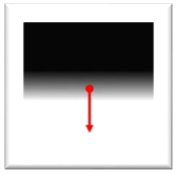
- The gradient of an image:

$$\nabla I = \begin{bmatrix} \frac{\partial I}{\partial x} & \frac{\partial I}{\partial y} \end{bmatrix}$$

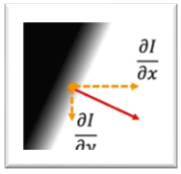
- The gradient points in the direction of fastest intensity change:



$$\nabla I = \begin{bmatrix} \frac{\partial I}{\partial x} & 0 \end{bmatrix}$$



$$\nabla I = \begin{bmatrix} 0 & \frac{\partial I}{\partial y} \end{bmatrix}$$



$$\nabla I = \begin{bmatrix} \frac{\partial I}{\partial x} & \frac{\partial I}{\partial y} \end{bmatrix}$$

- The gradient direction (orientation of edge normal) is given by:

$$\theta = \tan^{-1}\left(\frac{\partial I}{\partial y} / \frac{\partial I}{\partial x}\right)$$

- The edge strength is given by the gradient magnitude:

$$\| \nabla I(x,y) \| = \sqrt{\left(\frac{\partial I}{\partial x}\right)^2 + \left(\frac{\partial I}{\partial y}\right)^2}$$

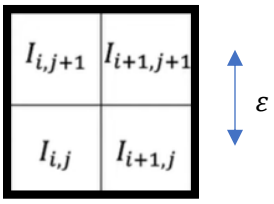
Method2: Edge Thresholding:

- Standard (single threshold T)
  - $\| \nabla I(x,y) \| < T$: definitely not an edge
  - $\| \nabla I(x,y) \| \geq T$: definitely an edge
- Hysteresis bases (two thresholds $T_0 \leq T_1$)
  - $\| \nabla I(x,y) \| < T_0$: definitely not an edge
  - $\| \nabla I(x,y) \| > T_1$: definitely an edge
  - $T_0 \leq \| \nabla I(x,y) \| < T_1$: is an edge if a neighboring pixel is definitely an edge

Method3: Finite difference approximation:

$$\frac{\partial I}{\partial x} \approx \frac{1}{2\varepsilon}\left[\left(I_{i+1,j+1} - I_{i,j+1}\right) - \left(I_{i+1,j} - I_{i,j}\right)\right]$$

$$\frac{\partial I}{\partial y} \approx \frac{1}{2\varepsilon}\left[\left(I_{i+1,j+1} - I_{i+1,j}\right) - \left(I_{i,j+1} - I_{i,j}\right)\right]$$



Some kernels gradient (∇) operators:

Gradient	Roberts	Prewitt	Sobel (3x3)	Sobel (5x5)
$\frac{\partial I}{\partial x}$	$\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$	$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} -1 & -2 & 0 & 2 & 1 \\ -2 & -3 & 0 & 3 & 2 \\ -3 & -5 & 0 & 5 & 3 \\ -2 & -3 & 0 & 3 & 2 \\ -1 & -2 & 0 & 2 & 1 \end{bmatrix}$
$\frac{\partial I}{\partial y}$	$\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$	$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$	$\begin{bmatrix} 1 & 2 & 3 & 2 & 1 \\ 2 & 3 & 5 & 3 & 2 \\ 0 & 0 & 0 & 0 & 0 \\ -2 & -3 & -5 & -3 & -2 \\ -1 & -2 & -3 & -2 & -1 \end{bmatrix}$

2.Edge detection using Laplacian (∇^2)

Laplacian sum of second derivatives

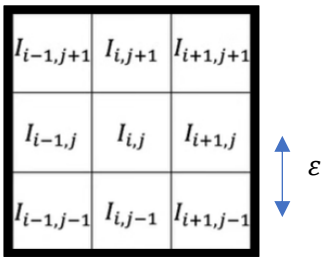
$$\nabla^2 I(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

- Edges are “zero-crossin” in Laplacian of image.
- Laplacian doesn’t not provide directions of edges.

Finite difference approximations:

$$\frac{\partial^2 I}{\partial x^2} \approx \frac{1}{\varepsilon^2}\left(I_{i-1,j} - 2I_{i,j} + I_{i+1,j}\right)$$

$$\frac{\partial^2 I}{\partial y^2} \approx \frac{1}{\varepsilon^2}\left(I_{i,j-1} - 2I_{i,j} + I_{i,j-1}\right)$$



Example the result of calculation Laplacian ($\nabla^2 I(x,y)$)

$$\nabla^2 I(x,y) \approx \frac{1}{\varepsilon^2}\begin{bmatrix} 1 & 4 & 1 \\ 4 & -20 & 4 \\ 1 & 4 & 1 \end{bmatrix}$$

The kernel for Laplacian (∇^2) defined by:

$$\begin{bmatrix} 1 & 4 & 1 \\ 4 & -20 & 4 \\ 1 & 4 & 1 \end{bmatrix}$$

Task: Experiment Gradient and Laplacian then give remark.

3.Canny Edge Detector:

Imformation detail: https://www.youtube.com/watch?v=hUC1uoigH6s&t=227s

Experiment this technic for impove image quality of image given **"blur.tif".**

4.Corner Edge Detector

Imformation detail: https://www.youtube.com/watch?v=Z_HwkG90Yvw

Experiment this technic for impove image quality of image given **"blur.tif".**