

Feature detection and matching

- Edges

Objectives

- Learn the concept of edge, edge detection
- Techniques used in edge detection
- Understand the concept of Edge linking
- What are application of edge detection?

What is edge in image?

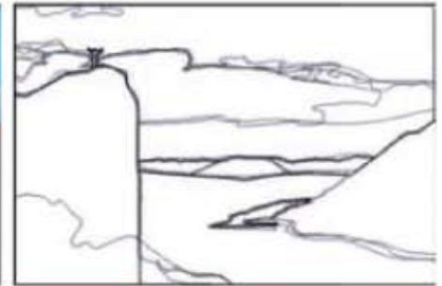
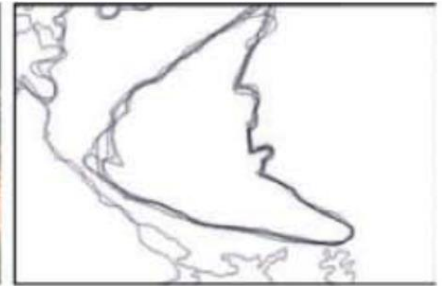
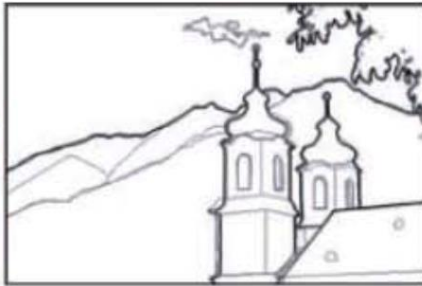
- Edges are significant local changes of intensity in a digital image.
- An edge can be defined as a set of connected pixels that forms a boundary between two disjoint regions.
- Three types of edges:
 - Horizontal edges
 - Vertical edges
 - Diagonal edges



What is edge detection?

- Edge detection is a technique of image processing used to identify points in a digital image with discontinuities ~ sharp changes in the image brightness.
- Edge Detection is a method of segmenting an image into regions of discontinuity.
- Edge detection allows users to observe the features of an image for a significant change in the gray level.
- It reduces the amount of data in an image and preserves the structural properties of an image.

What is edge detection?



- The gradient is a measure of change in a function, and an image can be considered to be an array of samples of some continuous function of image intensity:

$$\nabla f = \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

- Where $\frac{\partial f}{\partial x}$ is the derivative with respect to x (gradient in the x direction); $\frac{\partial f}{\partial y}$ is the derivative with respect to y (gradient in the y direction).

- Two important properties associated with the gradient:

- The gradient direction: $\theta = \tan^{-1} \left[\frac{g_y}{g_x} \right]$

- The magnitude:

$$\sqrt{g_y^2 + g_x^2}$$

- Filtering: filtering is commonly used to improve the performance of an edge detector with respect to noise-noise reduction
- Enhancement: Enhancement emphasizes pixels where there is a significant change in local intensity value-edge sharpening
- Detection: determine which points are edge points-Thresholding
- Localization: The location of the edge- determine the exact location of an edge- use edge thinning and edge linking
- → The errors in edge detection are errors of misclassification: false edges and missing edges.

- Two types of Edge Detection:
 - Gradient – based operator which computes first-order derivations in a digital image like, Sobel operator, Prewitt operator, Robert operator
 - Gaussian – based operator which computes second-order derivations in a digital image like, Canny edge detector, Laplacian of Gaussian
- Edge Detection applications:
 - medical imaging, study of anatomical structure
 - locate an object in satellite images
 - automatic traffic controlling systems
 - face recognition, and fingerprint recognition

- It computes the gradient approximation of image intensity function for image edge detection. At the pixels of an image, the Sobel operator produces either the normal to a vector or the corresponding gradient vector.
- It uses two 3 x 3 kernels or masks which are convolved with the input image to calculate the vertical and horizontal derivative approximations respectively.
- Advantages:
 - Simple and time-efficient computation
 - Very easy at searching for smooth edges
- Limitations:
 - Highly sensitive to noise
 - Not very accurate in edge detection

Edge detection

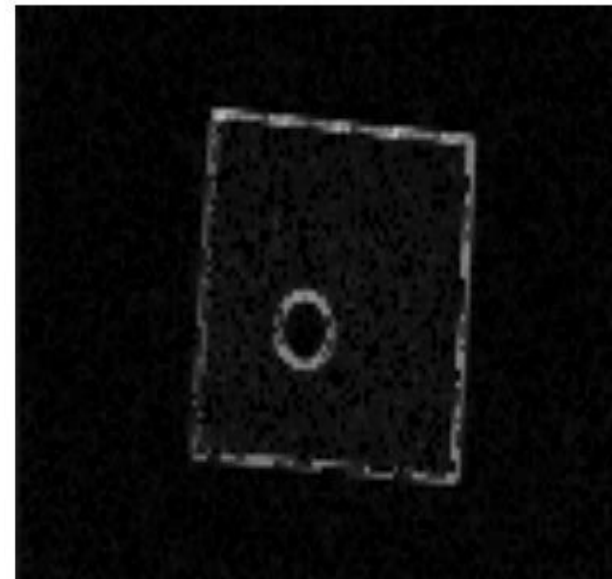
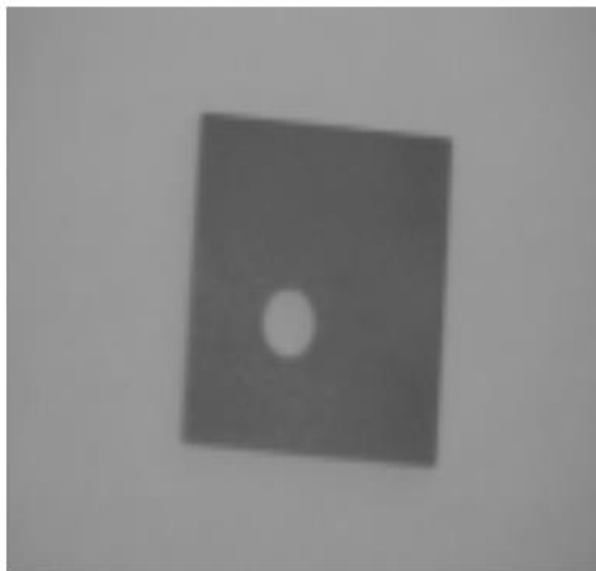
- Sobel operator

Gx

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

Gy

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



- It also detects vertical and horizontal edges of an image.
- It is one of the best ways to detect the orientation and magnitude of an image.
- Advantages:
 - Good performance on detecting vertical and horizontal edges
 - Best operator to detect the orientation of an image
- Limitations:
 - The magnitude of coefficient is fixed and cannot be changed
 - Diagonal direction points are not preserved always

Edge detection - Prewitt operator

Gx

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

Gy

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



- This gradient-based operator computes the sum of squares of the differences between diagonally adjacent pixels in an image through discrete differentiation. Then the gradient approximation is made.
- Advantages:
 - Detection of edges and orientation are very easy
 - Diagonal direction points are preserved
- Limitations:
 - Very sensitive to noise
 - Not very accurate in edge detection

Edge detection - Robert operator

Gx

+1	0
0	-1

Gy

0	1
-1	0



- It is a gaussian-based operator which uses the Laplacian to take the second derivative of an image.
- This really works well when the transition of the grey level seems to be abrupt. It works on the zero-crossing method i.e when the second-order derivative crosses zero, then that particular location corresponds to a maximum level.
- The Gaussian operator reduces the noise and the Laplacian operator detects the sharp edges.

Edge detection

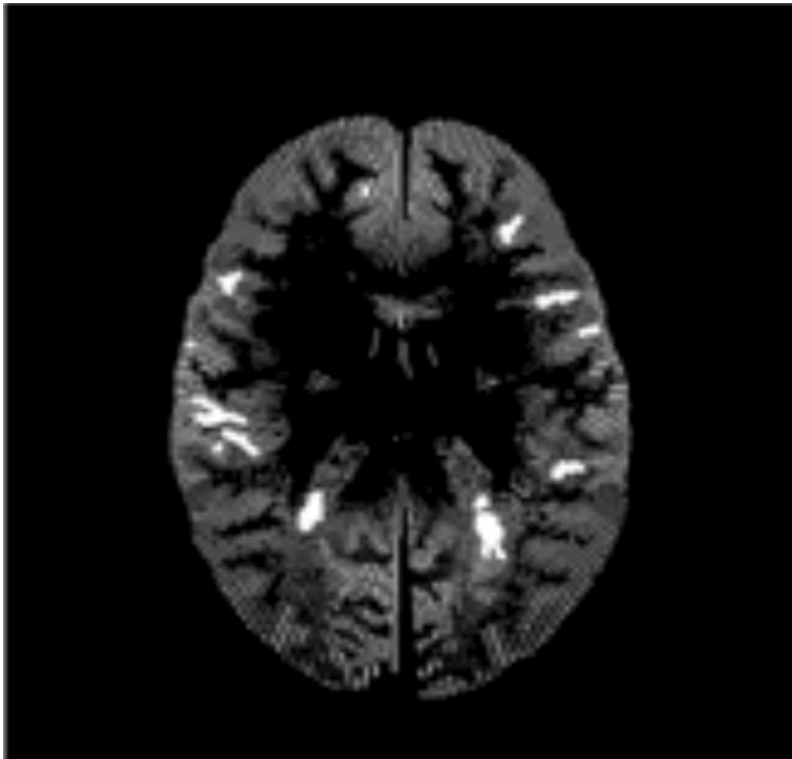
- Laplacian of Gaussian

- Advantages:
 - Easy to detect edges and their various orientations
 - There is fixed characteristics in all directions
- Limitations:
 - Very sensitive to noise
 - The localization error may be severe at curved edges
 - It generates noisy responses that do not correspond to edges

Edge detection

- Laplacian of Gaussian

Sobel edge detection



Mar- Hildreth edge detection



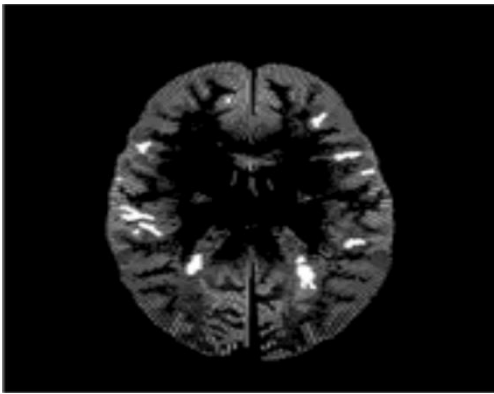
- It is a gaussian-based operator in detecting edges.
- This operator is not susceptible to noise.
- It extracts image features without affecting or altering the feature.
- Canny edge detector have advanced algorithm derived from the previous work of Laplacian of Gaussian operator.
- It is widely used an optimal edge detection technique.

- It detects edges based on three criteria:
 - Low error rate
 - Edge points must be accurately localized
 - There should be just one single edge response
- Advantages:
 - It has good localization
 - It extracts image features without altering the features
 - Less Sensitive to noise
- Limitations:
 - There is false zero crossing
 - Complex computation and time consuming

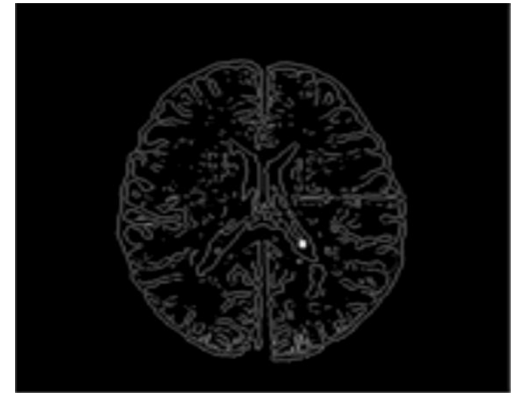
Edge detection

- Canny Operator

Sobel edge detection



Mar- Hildrethedge detection



Candy edge detection



- Edge linking process takes an unordered set of edge pixels produced by an edge detector as an input to form an ordered list of edges.
- Local edge information are utilized by edge linking operation; thus edge detection algorithms typically are followed by linking procedure to assemble edge pixels into meaningful edges.
- edges have been detected using zero crossings of some function, linking them up is straightforward, since adjacent edges share common endpoints.
- Linking the edges into chains involves picking up an unlinked edge and following its neighbors in both directions.

- Edge is used directly for image editing. It allows users to selectively remove edges corresponding to unwanted features such as specularities, shadows, or distracting visual elements. After reconstructing the image from the remaining edges, the undesirable visual features have been removed



(a)



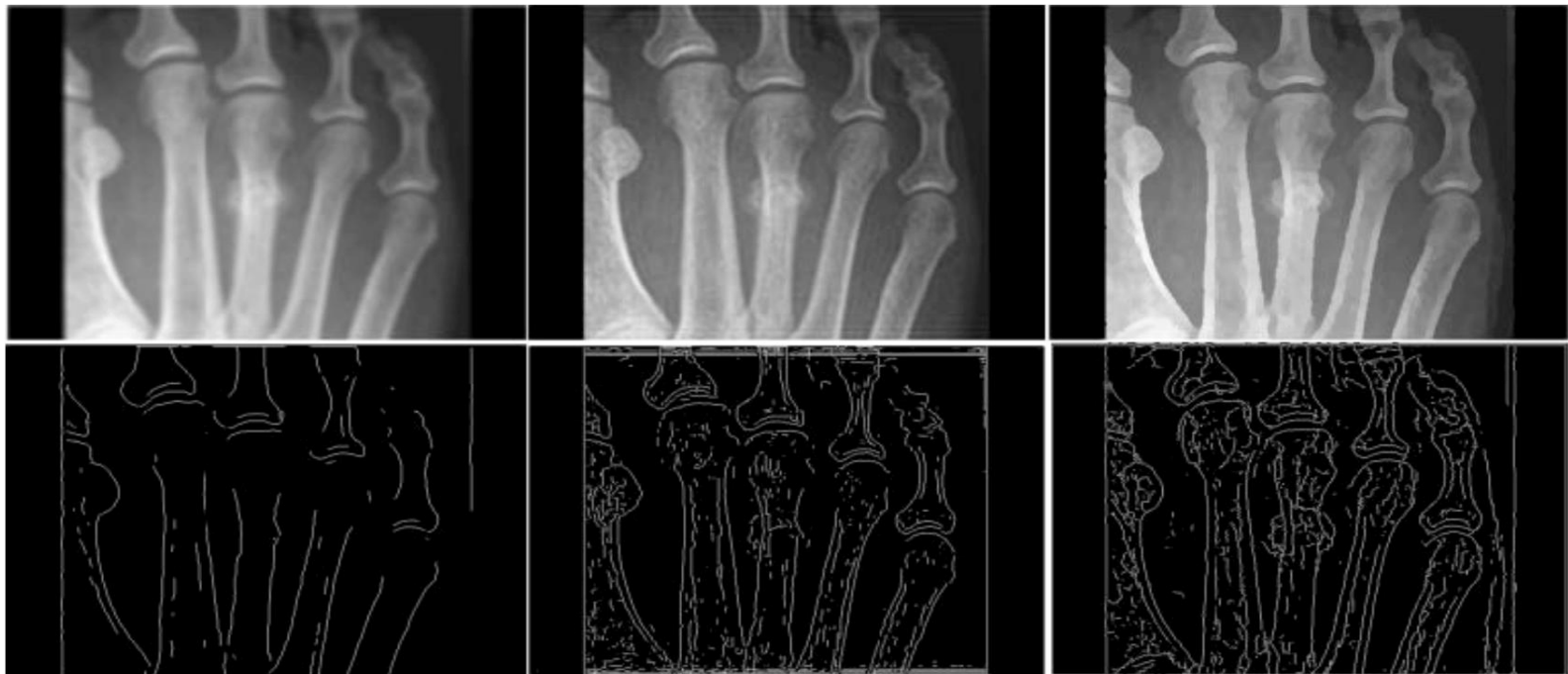
(b)



(c)

Application: Edge enhancement

- Another potential application is to enhance perceptually salient edges while simplifying the underlying image to produce a cartoon-like or “pen-and-ink” stylized image



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