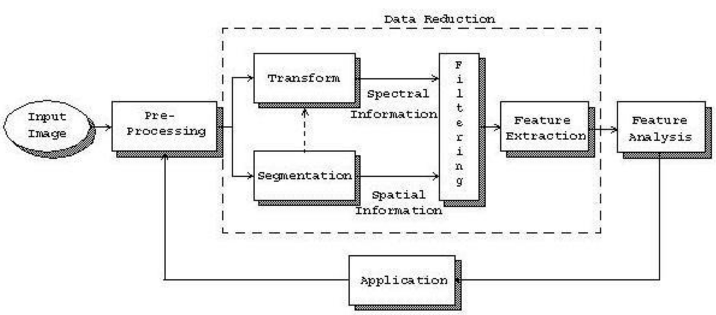
Chapter 4
Edge, Line and Shape Detection

➢Introduction and Overview

✓Image analysis requires data reduction and segmentation is the primary method in the spatial domain to accomplish it



- ✓The goal of image <u>segmentation is to find regions that represent objects or meaningful parts of objects</u>

- ✓Division of the image into regions corresponding to objects of interest is necessary before any processing can be done at a level higher than that of the pixel

- ✓Identification of real objects, pseudo objects, shadows, or actually finding anything of interest within the image, requires some form of segmentation

- ✓Image segmentation methods will look for objects that either have some measure of ***homogeneity*** within themselves, or have some measure of ***contrast*** with the objects on their border

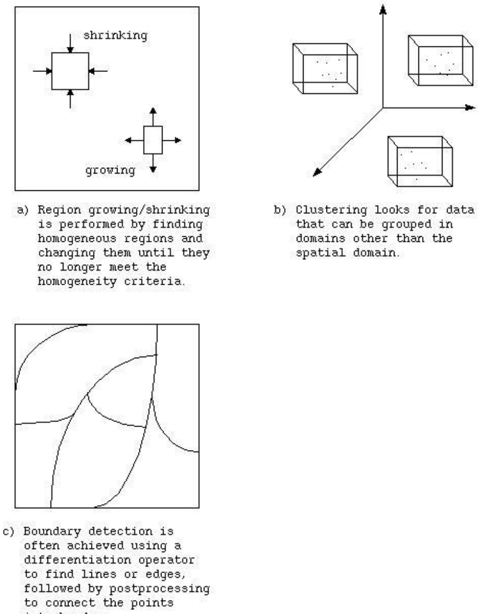
- ✓The ***homogeneity*** and ***contrast*** measures can include features such as gray level, color, and texture

- ✓ Image segmentation techniques can be divided into three main categories:

   1. *Region growing and shrinking*
   2. *Clustering methods*
   3. *Boundary detection*

- ✓ Region growing and shrinking category can be considered a subset of the clustering methods, but is limited to the spatial domain

Figure 4.1-1: IMAGE SEGMENTATION CATEGORIES



a) Region growing/shrinking is performed by finding homogeneous regions and changing them until they no longer meet the homogeneity criteria.

b) Clustering looks for data that can be grouped in domains other than the spatial domain.

c) Boundary detection is often achieved using a differentiation operator to find lines or edges, followed by postprocessing to connect the points into borders.

➢Edge/Line Detection

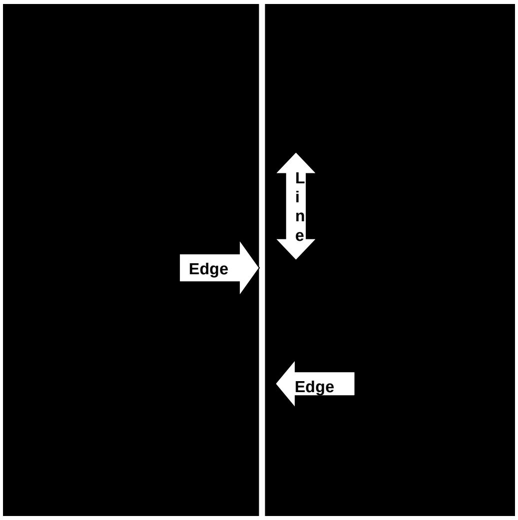
- ✓Edge detection operators are often implemented with convolution masks and most are based on discrete approximations to differential operators
- ✓Differential operations measure the rate of change in a function, in this case, the image brightness function

- ✓A large change in image brightness over a short spatial distance indicates the presence of an edge
- ✓Some edge detection operators return orientation information (information about the direction of the edge), while others only return information about the existence of an edge at each point

- ✓Edge detection methods are used as a first step in the line detection process
- ✓Edge detection is also used to find complex object boundaries by marking potential edge points corresponding to places in an image where rapid changes in brightness occur

- ✓After the edge points have been marked, they can be merged to form lines and object outlines
- ✓The edge is where the sudden change occurs, and a line or curve is a continuous collection of edge points along a certain direction
- ✓Hough transform is used for line finding, but can be extended to find arbitrary shapes

Figure 4.2-1: Edges and lines are perpendicular



The line shown here is vertical and the edge direction is horizontal. In this case the transition from black to white occurs along a row, this is the edge direction, but the line is vertical along a column.

- ✓Preprocessing of image is required to eliminate or at least minimize noise effects
- ✓There is tradeoff between sensitivity (noise) and accuracy in (correct/true) edge detection
- ✓The parameters that we can set so that edge detector is sensitive include the size of the edge detection mask and the value of the gray level threshold

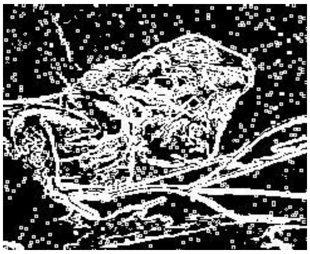
✓A larger mask or a higher gray level threshold will tend to reduce noise effects, but may result in a loss of valid edge points

✓Edge detection operators are based on the idea that edge information in an image is found by looking at the relationship a pixel has with its neighbors

✓If a pixel's gray level value is similar to those around it, there is probably not an edge at that point

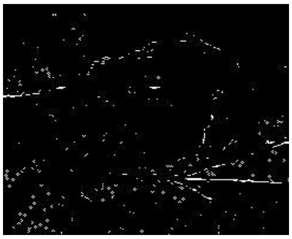
Figure 4.2-2: Noise in images requires tradeoffs between sensitivity and accuracy for edge detectors

a) Noisy image



b) Edge detector too sensitive, many edge points found that are attributable to noise

Figure 4.2-2: Noise in images requires tradeoffs between sensitivity and accuracy for edge detectors(contd)



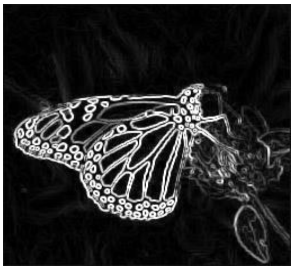
c) Edge detector not sensitive enough, loss of valid edge points

d) Reasonable result obtained by compromise between sensitivity and accuracy, may mitigate noise via postprocessing
(original lizard photo courtesy of Mark Zuke)

- ✓However, if a pixel has neighbors with widely varying gray levels, it may represent an edge point
- ✓An edge can also be defined by a discontinuity in gray level values
- ✓Edges may exist anywhere and be defined by color, texture, shadow, etc., and may not necessarily separate real world objects

Figure 4.2-3: Image objects may be parts of real objects

a) Butterfly image properties (original photo courtesy of Mark Zuke),

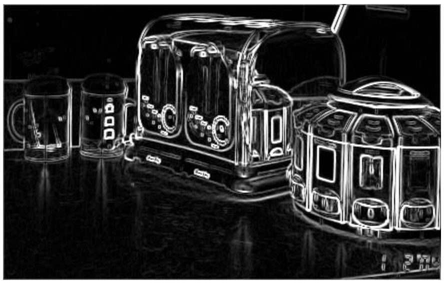


b) Butterfly after edge detection, note that image objects are separated by color, or gray level, changes

Figure 4.2-3: Image objects may be parts of real objects (contd)

c) Image of objects in kitchen corner

Figure 4.2-3: Image objects may be parts of real objects (contd)



d) Image after edge detection,
note that some image objects are created by reflections in the image due to lighting conditions and object properties

- ✓A real edge in an image tends to change slowly, compared to the ideal edge model which is abrupt
- ✓This gradual change in real edges is a minor form of blurring caused by the imaging device, the lenses, or the lighting, and is typical for real-world (as opposed to computer generated) images

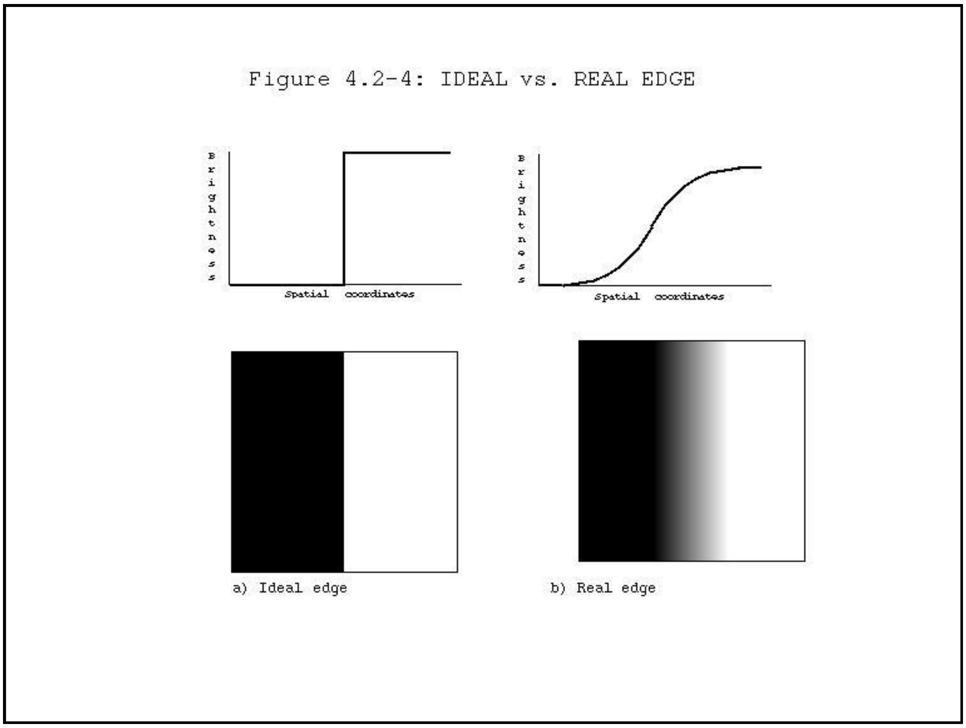


Figure 4.2-4: IDEAL vs. REAL EDGE
Brightness
Spatial coordinates
Brightness
Spatial coordinates
a) Ideal edge
b) Real edge