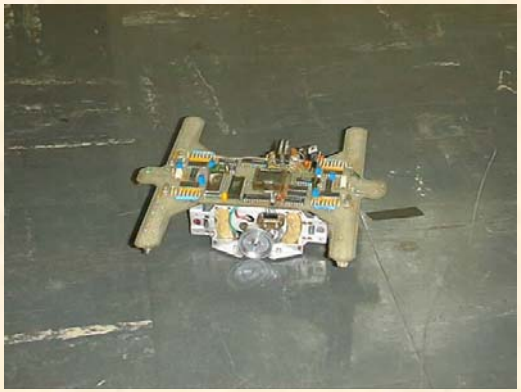
Image Analysis



Extracting Information From Images

Image Analysis

- The first step in image analysis is generally to segment the image.
- The level of segmentation depends on the problem to hand.
- For example, in an autonomous air-to-ground missile system we may segment the road from the image and then segment the road into objects that may correspond to vehicles. There is no point in segmenting below this scale or in looking at objects outside the boundary of the road.

Image Segmentation

- In general, autonomous segmentation is one of the most difficult tasks in image processing.
- Unfortunately, the performance of this difficult first step generally determines the overall success of the whole system.
- In fact, effective segmentation rarely fails to lead to a successful system.
- In industrial inspection applications, we often have some control over the environment which can greatly simplify the task of segmentation.

Vehicle Segmentation Example

Hand drawn. How do we do this with a computer?

Controlling the Environment

- If we can control some aspects of the imaging environment, we can often greatly simplify the task of segmentation. An experienced image analyst will never miss an opportunity to exploit this.
- Examples.
  - Control of lighting intensity, position of lights, colour of light.
  - Control of background field.
  - Control of camera type, focal length, position and aspect/orientation of object.
  - Use of segmentation aids such as staining of cell images.
  - Use of prior knowledge of expected objects under analysis.
  - Use of additional sensors (microwave).
  - Use of motion cues – temporal filtering.

Segmentation Techniques

- Segmentation techniques for monochrome images generally are based on two basic properties of grayscale values
  - Discontinuity and Similarity
- Discontinuity based methods
  - detection of points, lines, and edges in an image
- Similarity Based Methods
  - Thresholding, region growing, region splitting and merging
- If we are examining dynamic (time-varying) images, then motion can give powerful cues to improve segmentation

Detection of Discontinuities

- These point, edge, and line detectors are generally based on running a mask through an image as a 2-D convolution (conv2d in MATLAB)
- Typical 3x3 mask and result calculation

$$R = w_1 z_1 + w_2 z_2 + \cdots + w_9 z_9$$

$$= \sum_{i=1}^{9} w_i z_i$$

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

Isolated Point Detection

- We say that a point is detected if
  $|R|>T$
  where T is a nonnegative threshold
- The idea is that the gray level of an isolated point will be quite different from its neighbours.

-1	-1	-1
-1	8	-1
-1	-1	-1

Line Detection

- This principle can be extended, but the problem with lines is that they can have many different orientations

-1	-1	-1
2	2	2
-1	-1	-1

Horizontal

-1	-1	2
-1	2	-1
2	-1	-1

+45 degrees

-1	2	-1
-1	2	-1
-1	2	-1

Vertical

2	-1	-1
-1	2	-1
-1	-1	2

-45 degrees

Edge Detection

- Points and lines don’t really occur very often in real images, but edges are very common.
- An edge is a boundary between two regions with relatively distinct gray-level properties.
- The idea underlying most edge detection techniques is the computation of the local derivative operator.

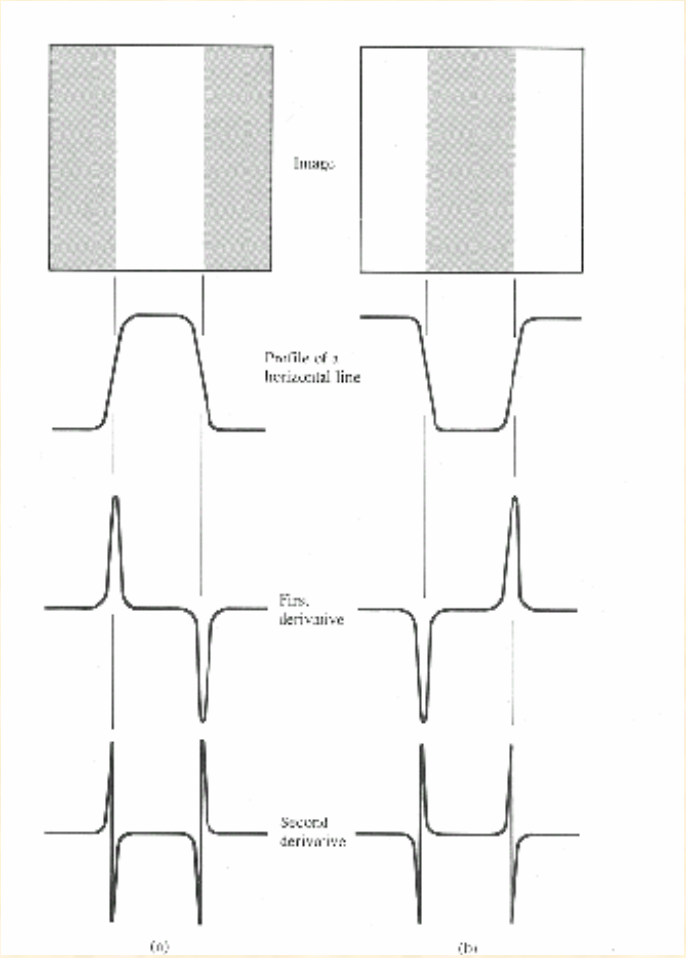
Behaviour of Derivatives

Edge images

Profile of a horizontal line

First derivative

Second Derivative



Derivatives

- First derivative is positive at the leading edge of a transition, negative at the trailing edge, and zero in areas of constant gray level.
- Second derivative is positive for that part of the transition associated with the dark side of the edge and negative for the part associated with the light.
- Hence magnitude of the fist derivative indicates presence of an edge and the sign of the second derivative indicates the dark and light sides of the edge.
- Clearly we need to orient the edge detectors appropriately to maximise the response to edges as was the case for the line detectors.

Gradient Operators

- Gradient of an image f(x,y) at location (x,y) is the vector

$$\nabla \mathbf{f} = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \dfrac{\partial f}{\partial x} \\ \dfrac{\partial f}{\partial y} \end{bmatrix}$$

- It is well known that the gradient vector points in the direction of maximum rate of change
- In edge detection we are mainly concerned with the *scalar* magnitude of the gradient denoted

$$\nabla f = \mathrm{mag}(\nabla f) = [G_x^2 + G_y^2]^{1/2}$$

Gradient Operators

- Common practice is to approximate the gradient with absolute values so

$$\nabla f \approx |G_x| + |G_y|$$

- This is much simpler to implement particularly in hardware

Sobel Operators

- Sobel operators are a digital implementation of the first derivative gradient operators.

$$G_x = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$

$$G_y = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)$$

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

Calculates G_x at centrepoint

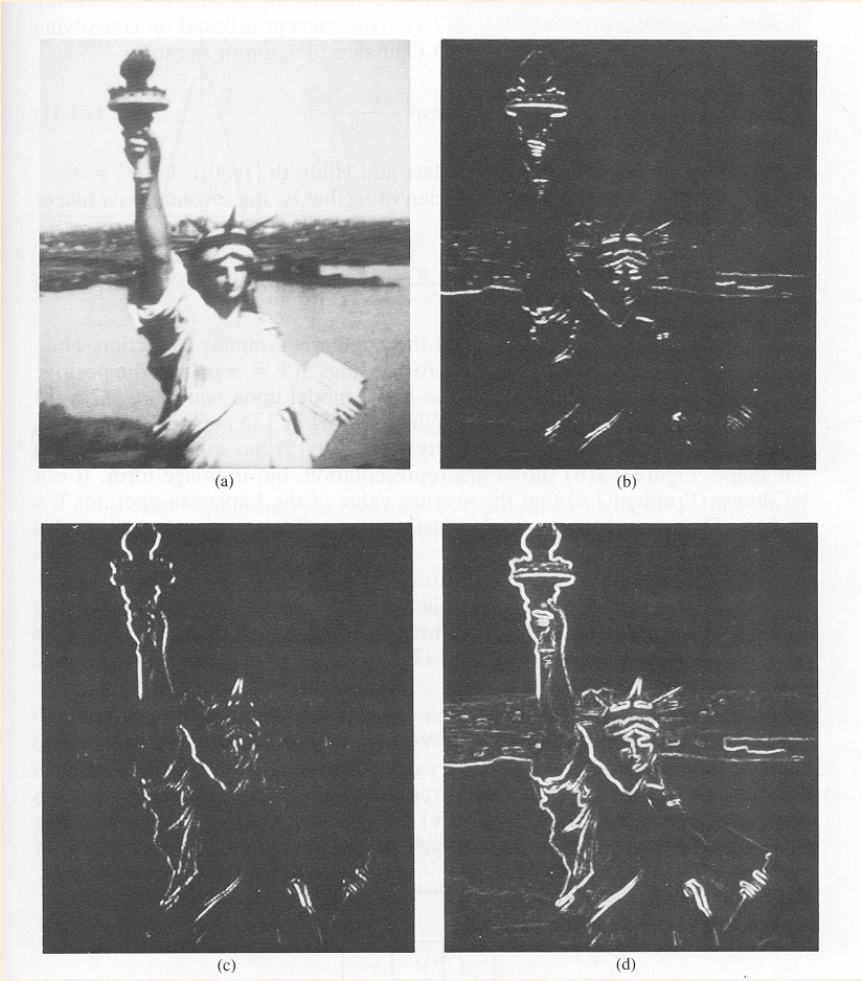
-1	0	1
-2	0	2
-1	0	1

Calculates G_y at centrepoint

Sobel Edge Detection

Original

Gx



Gy

Combined