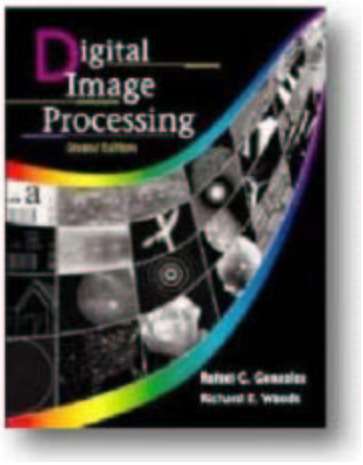


Chapter 10
"Image Segmentation"
Digital Image Processing

Preview

Segmentation subdivides an image into it constituent regions or objects. Segmentation accuracy determines the eventual success or failure of computerized analysis procedures.
Image segmentation algorithms generally are based on one of two basic properties of intensity values: **discontinuity** and **similarity**.

10.1 Detection of Discontinuities

- What are **discontinuities**?

Discontinuities are points, lines, and edges in an image.

- What is the most common way to find a discontinuity in an image?
  Run a mask through the image.

Eq 10.1-1: $$R = w_1 z_1 + w_2 z_2 + w_3 z_3 + w_4 z_4 + w_5 z_5 + w_6 z_6 + w_7 z_7 + w_8 z_8 + w_9 z_9 = \sum_{i=1}^{9} w_i z_i$$

where z_i is the gray level of the pixel associated with the mask coefficient w_i.

10.1.1 Point Detection

- How does one detect a point in an image?

The simple algorithm and mask discussed in chapter 10 is based on the fact that the pixel itself is distinguishable from surrounding pixels and that the surrounding pixels are homogeneous, or nearly homogeneous, in intensity. A pixel of this type is usually described as **isolated**.
Using the mask listed in 10.1, we say that a point has been detected at the location on which the mask is centered if $|R| \geq T$, where T is a nonnegative threshold and Eq. 10.1-1 gives R. Typically T can be set to a percentage of the brightest pixel in the image.

10.1.2 Line Detection

- Line detection is the process of detecting a line, or lines, in an image by applying a mask to the image itself. The product of applying 10.1-1 results in an image where the lines that were detected are a positive intensity value while surrounding pixels are the value of 0, **given that the background is constant**.

10.1.3 Edge Detection

- What is an **edge**?

An edge is a set of connected pixels that lie on the boundary between two regions.

What is the difference between an **edge** and a **boundary**?

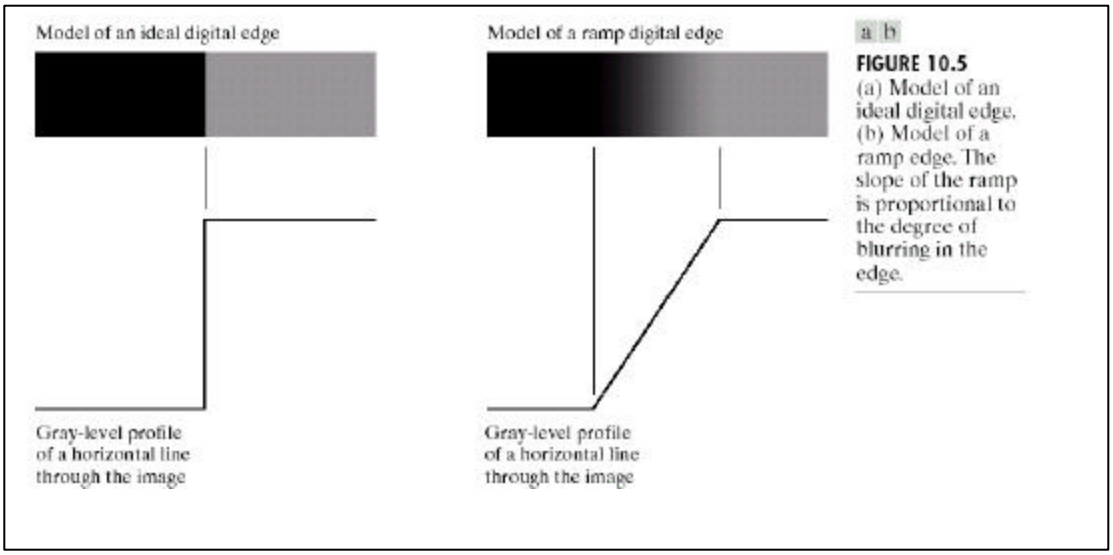
In general terms, an edge is a more “local” concept based on a measure of gray-level discontinuity at a point, whereas a region boundary is a “global” idea, which, in a finite region, may form a closed path.

- What is **edge detection**?

It is the process of identifying edges in an image, which provides an outline to objects in the image. These outlines become useful for pattern and object recognition and possible image segmentation.

Basic Formulation

- What is an **ideal edge**?



a b

FIGURE 10.5 (a) Model of an ideal digital edge. (b) Model of a ramp edge. The slope of the ramp is proportional to the degree of blurring in the edge.

Gradient Operators

10.2 Edge Linking and Boundary Detection

- What is **edge linking**?

10.2.1 Local Processing

10.2.2 Global Processing via the Hough Transform

- For edge linking, a process based on the Hough transform is as follows:

(1) Compute the gradient of an image and threshold it to obtain a binary image.
(2) Specify subdivisions in the pè –plane.
(3) Examine the counts of the accumulator cells for high pixel concentrations
(4) Examine the relationship (principally for continuity) between pixels in a chosen cell.

10.2.3 Global Processing via Graph-Theoretic Techniques

10.3 Thresholding

- What is Thresholding?

Thresholding is the process of including or excluding values based on a given range. Typically, you would use thresholding after applying an edge detection filter and applying binarization to an image. In that case, you would

10.3.1 Foundation

10.3.2 The Role of Illumination

10.3.3 Basic Global Thresholding

10.3.4 Basic Adaptive Thresholding

10.3.5 Optimal Global and Adaptive Thresholding

10.3.6 Use of Boundary Characteristics for Histogram Improvement and Local Thresholding

10.3.7 Thresholds Based on Several Variables

- What is multi-spectral thresholding?

10.4 Region-Based Segmentation

10.4.2 Region Growing

- What is region growing?

10.4.3 Region Splitting and Merging

10.5 Segmentation by Morphological Watersheds

- What is the *concept* of a watershed?

The concept of watersheds is based on visualizing an image in three dimensions: two spatial coordinates versus gray levels.

- How is the **watershed algorithm** implemented?

Perform dilation until two structures “overlap”, then mark those as a “dam”. A “dam”, in the concept of an area of concentrated water, would be used to prevent water from flowing from one area to another. The same idea is used in image processing. This is explained more in section 10.5.2.

- When would you use the watershed algorithm?

- Why wouldn't you use the watershed algorithm?

10.5.1 Basic Concepts

10.5.2 Dam Construction

10.5.3 Watershed Segmentation Algorithm

10.5.4 The Use of Markers

- What is a **marker**?

A marker is a connected component belonging to an image. There are two types of markers:

(1) Internal Markers.
(2) External Markers

- Why would we use **markers**?

10.6 The Use of Motion in Segmentation

- How

10.6.1 Spatial Techniques

Basic Approach

Accumulative Differences

Establishing a Reference Image

10.6.2 Frequency Domain Techniques

This section describes methods of determining motion estimates via a Fourier transform formulation.

- What is the frequency-velocity relationship? What is it used for?

It is the relationship between frequency and velocity which

Summary

Further Reading

Chapter Questions

- What is **thresholding**?

Thresholding is the process of comparing the intensity value of a pixel to a fixed value, a threshold, and determining the outcome of that test by its comparison results. For example, a threshold value of 200 is compared to a pixel intensity (grayscale) of 210. Because 210 >= 200, we decide to keep that value. Any values below 200 are thrown away and the outcome is the value of 0

.

- What is the **Watershed Segmentation Algorithm**?

- What is the difference between an edge and a boundary?

- If you have a simple boundary problem where the edge detection algorithm failed to discover discontinuities that existed because of thresholding or intensity/brightness, what algorithms would you use to perform edge linking to create a closed region?

Actual Questions from the Back of Chapter 10

1. A binary image contains straight lines oriented horizontally, vertically, at 45 degrees, and at –45 degrees. Give a set of 3x3 masks that can be used to detect 1-pixel long breaks in these lines. Assume that the gray level of the lines is 1 and that the gray level of the background is 0.

    a) First, ask yourself, what does it imply that the gray level of the lines is 1 and background is 0?

        i. Gray levels are typically represented from 0 to 255 (or 1-256).
        ii. Since this is a binary image, we can only have values of either 0 or 1, thus it is implying that the intensity of the line is 1 and the intensity of the background is 0. Obviously, it is necessary to have a difference in

values when trying to discover discontinuities.

b) Next, note that the question is not mentioning that the lines pass through any distinct point (e.g., the origin). They are all uncorrelated and independent. This isn't important for answering the question, but does stress the importance of looking at all aspects of the problem before trying to answer it.

2. Propose a technique for detecting gaps of length ranging between 1 and L pixels in line segments of a binary image. Assume that the lines are 1 pixel thick. Base your technique on 8-neighbor connectivity analysis, rather than attempting to construct masks for detecting the gaps.

3. Refer to figure 10.4 in answering the following questions:
   a) Some of the lines joining the pads and center element in Fig. 10.4(b) are single lines, while some others are double lines. Explain why.
   b) How would you go about eliminating the components in figure 10.4© that are not part of the line oriented at –45 degrees?

References

Woods, Richard, Gonzalez, Rafael, “Digital Image Processing”, Second Edition, Prentice Hall