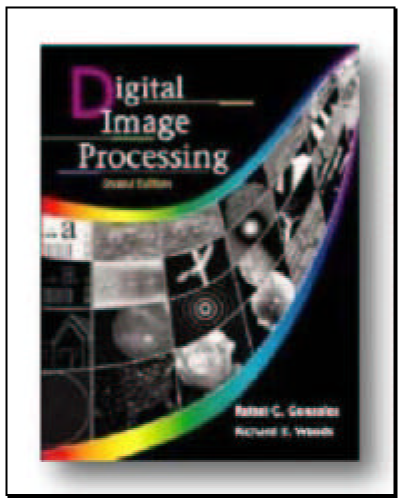

Digital **I**mage **P**rocessing
Chapter 11
“Representation and Description”

Last Updated: July 20, 2003

Preview

11.1 Representation

11.1.1 Chain Codes

- **Chain codes** are used to represent a boundary by a connected sequence of straight-line segments of specified length and direction. Typically, this representation is based on 4- or 8-connectivity of segments. The direction of each segment is coded by using a numbering system.

11.1.2 Polygonal Approximations

Minimum perimeter polygons

Merging techniques

Splitting techniques

11.1.3 Signatures

11.1.4 Boundary Segments

11.1.5 Skeletons

- What is **skeletonization**?

The process of **skeletonization** is reducing the objects in an image to a point where they are as thin as possible, but also retain their original shape. Thereby, they have the following properties: as thin as possible, connected, and centered.

An important aspect of **skeletonization** is to keep the structures "connected". The thinning process tries to achieve a line that is 1 pixel wide, and then we may risk the problem of thinning too much for lines of varied thickness.

- When would you use **skeletonization**?

Skeletonization is used when we wish to represent the structural shape of a plane by using a graph.

■ What is the **Medial Axis Transformation**?

The MAT algorithm …

■

11.2 Boundary Descriptors

11.2.1 Some Simple Descriptors

11.2.2 Shape Numbers

11.2.3 Fourier Descriptors

■ What are **Fourier descriptors** used for?

Fourier descriptors can be used for many purposes. A Fourier descriptor

11.2.4 Statistical Moments

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11.3 Regional Descriptors

■ This section (section 11) describes methods for describing image regions. It is important to note that, in common practice, both boundary and regional descriptors are combined.

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11.3.1 Some Simple Descriptors

11.3.2 Topological Descriptors

■ **Topology** is the study of properties of a figure that are unaffected by any deformation, as long as there is no tearing or joining of the figure (sometimes these are called *rubber-sheet* distortions).

■ **Euler's number** E is defined as the difference between the number of holes H and the number of connected components C of an image.

$$\mathbf{E = C - H}$$

■ **Polygonal Networks**:

11.3.3 Texture

Statistical approaches

- ***Average Entropy*** is defined as

$$e = -\sum_{i=0}^{L-1} p(z_i)\log_2 p(z_i)$$

Structural approaches

Spectral approaches

11.3.4 Moments of Two-dimensional Functions

11.4 Use of Principal Components for Description

- The material discussed in this section is applicable to boundaries and regions.
- What does the **covariance** matrix describe?

The covariance matrix of the vector population as

$$C_x = E\{(x - m_x)(x - m_x)^T\}$$

Because x is n dimensional, C_x and $(x - m_x)(x - m_x)^T$ are matrices of order n x n.

The mean vector is often referred to as the *centroid* and the variance-covariance matrix as the *dispersion* or dispersion matrix. Also, the terms variance-covariance matrix and covariance matrix are used interchangeably.

■ Qualify the following statement: "*Because Cx is real and symmetric, finding a set of n orthonormal eigenvectors is possible*." (Noble and Daniel [1988])

We say that two vectors are **orthogonal** if the product of these two vectors equals 0. We say a vector is **orthonormal** if it is orthogonal and its length is 1.

■ What is the **Hotelling** transform?

The Hotelling Transform, also known as the principal components transform, is

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■ What are the **Eigen axes**?

11.5 Relational Descriptors

Summary

Further Reading

My Questions

1. What is an **eigenvalue**?

The *eigenvalues* of a real matrix **M** are the real numbers l for which there is a nonzero vector **e** such that **Me**= l **e**.

2. What are **eigenvectors**?

The *eigenvectors* of **M** are the nonzero vectors **e** for which there is a real number l such that M**e**= l **e**.

3. What is a **covariance matrix**?

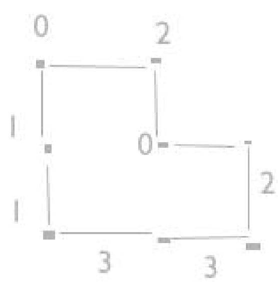
End of Chapter Questions

11.1 (a) Show that redefining the starting point of a chain code so that the resulting sequence of numbers forms an integer of minimum magnitude makes the code independent of the initial starting point on the boundary.

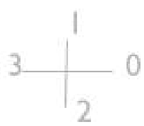
- First, we must define what a chain code is:

- **Chain codes** are used to represent a boundary by a connected sequence of straight-line segments of specified length and direction. Typically, this representation is based on 4- or 8-connectivity of segments. The direction of each segment is coded by using a numbering system.

- How do redefine the starting point of a chain code so that the resulting sequence of numbers forms an integer of minimum magnitude?



In this graph, we have 8 possible starting points.



(b) Find the normalized starting point of the code 11076765543322.

- What does it mean to "normalize" the starting point?

11.12 Give the smallest number of statistical moment descriptors needed to differentiate between the signatures of the figures shown in fig 11.5.

11.20 Under what conditions would you expect the major axes of a boundary, defined in section 11.2.1 to be equal to the eigen axes of that boundary?

- First, try to define the meaning of “eigen axes”?

Eigen axes are the y-axis of a

11.24 Having heard about your success with the bottling problem, you are contacted by a fluids company that wishes to automate bubble-counting in certain processes for quality control. The company has solved the imaging problem and can obtain 8-bit images of resolution 700x700 pixels, such as the ones show. Each image represents an area of 7 cm^2. The company wishes to do two things with each image: (1) Determine the ratio of the area occupied by bubbles to the total area of the image, and (2) count the number of distinct bubbles. Based on the material you have learned up to this point, propose a solution to this problem. In your solution, make sure to state the physical dimensions of the smallest bubble your solution can detect. State clearly all assumptions that you make and that are likely to impact the solution you propose.

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References

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