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Digital Image Processing Fundamentals

Chapter 7

Shape Description

Answers to the Chapter Questions

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Chapter 7:

Shape description

7.1 Introduction

Questions/Answers

1. Why is invariance to geometrical transformations useful for object recognition?

Generally, in object recognition the images (and the object that we try to recognize) have been translated, rotated, scaled or mirrored. Therefore, it is important to have a representation that is not altered by geometrical transformations.

2. What is the difference between internal and external object representation?

- The external object representation describes the 2-D objects using the objects contour and its features (e.g. boundary length, curvature, signature, Fourier descriptors). This method is directly connected to edge and line detection. They are quite popular because they produce compact shape representations.
- The external representation describes the region occupied by the object on the image plane. This method is linked to the region segmentation techniques. The resulting representation schemes are called ***internal*** representations. Some segmentation techniques (e.g. region splitting) lead directly to object representation schemes (quadtrees). Region features (e.g. area, moments, skeletons) have been used extensively in object recognition applications.

7.2 Chain codes

Questions/Answers

1. Which are the advantages of the difference chain code?

The difference chain code represents direction differences. Therefore, it is rotation invariant (at least for angles that are multiples of ð/*2* for 4-connected chains) as opposed to chain code that is translation invariant only.

2. Does the use of chain code compress the description information of an object contour?

Chain codes provide a good compression of boundary description, because each chain code element can be coded with *2* bits only (for a 4-connected chain code), instead of the 2 bytes required for the storage of the coordinates (*x*, *y*) of each boundary pixel.

3. Can Papert's turtle produce a chain code?

Papert's turtle can be easily modified to produce a 4-connected chain code of a contour of an object.

7.3 Polygonal approximations

Questions/Answers

1. Which are the advantages and disadvantages of the splitting and merge methods?

- Splitting algorithm can detect bend points (those pixels that the curve changes orientation) in a curve and use them in its representation. Sometimes, this algorithm may have heavy computational complexity.
- The primary disadvantage of the merge techniques is that polygon vertices do not coincide with curve inflection points. This disadvantage is a serious problem when the curves to be represented are close to linear piecewise models.

2. How is the splitting method modified in the case of a closed curve?

In case of a closed curve, the start and end points x_1, x_N are chosen to lie on two opposite remote parts of the curve. These points split the curve into two parts. The splitting algorithm can be applied to the two parts independently.

7.4 Fourier descriptors

Questions/Answers

1. What happens to the Fourier descriptors if the object boundary is rotated?

A rotation of the curve coordinates by angle *è* results in a phase shift of the transform coefficients by an equal amount.

2. What happens to the Fourier descriptors if the image is translated?

A translation in curve coordinates affects only the term *Z(0)* of the representation.

3. What problems are caused by the orthogonal sampling and the 8-connected chain code to the Fourier descriptors?

The above-mentioned properties are valid for uniformly sampled curves. This is not the case if the 8-connected neighborhood is used for curve following, because the sampling intervals may be *1* or $\sqrt{2}$. Phase information is affected particularly by non-uniform curve sampling. Thus, if 8-connected curve traversing is used on a rectangular grid, only the transform magnitude possesses reliable information.

7.5 Quadtrees

Questions/Answers

1. What is the relation between image segmentation and quadtrees?

Apart from the binary region representation, the quadtrees have been used for region segmentation (Chapter 6) in region splitting algorithms.

2. What are the advantages of the quadtrees?

Image representation through quadtrees demands (generally) less memory for its representation and storage.

7.6 Pyramids

Questions/Answers

1. Why do we lose details at the higher pyramid levels?

The mapping function from each level to the next is a low-pass operator. Additionally subsampling occurs from each level to the next. Therefore, high frequencies (and image details) are gradually suppressed.

2. Where are the pyramids used in image processing?

We use pyramids when we want to start image analysis from rough object characteristics and to move gradually to object details. Pyramidal techniques are quite popular for image analysis and compression applications, because they offer abstraction from image details. Binary image pyramids can be used in multiresolution edge detection and region segmentation.

3. What are the advantages of the contour following in multiple resolution levels?

In the contour following we may have edges that are broken and regions that are disjoint at the bottom of the pyramid but may join at intermediate pyramid levels. Therefore, edge following can benefit from a multiresolution approach.

7.7 Shape features

Questions/Answers

1. What is the meaning of the curvature magnitude?

Curvature magnitude is a curve feature that denotes its corners. In the corners the curvature magnitude becomes quite large or infinite.

2. What are the major and minor axes of an object?

The major axis is the straight line joining the two object points lying furthest apart from each other. The minor axis is perpendicular to the maximal axis.

3. What is the meaning of the Euler number?

The *Euler number* is an important topological descriptor. It is defined as $E=C-H$ where C is the number of connected components of object X and H is the number of its holes.

7.8 Moment descriptors

Questions/Answers

1. What is the orientation of a circle?

Object orientation è is the angle between the major axis of the object and axis x. However, the major axis of a circle can not be uniquely defined because any diameter of the circle can be considered as major axis. Thus, the circle doesn't have orientation.

2. What is the centre of gravity of a square?
The centre of gravity of square is the intersection of its diagonals.

7.9 Thinning algorithms

Questions/Answers
1. What demands do we have from a thinning algorithm?
Thinning algorithms satisfy the following two constraints:

- They maintain connectivity at each iteration. They do not remove border pixels that may cause discontinuities.
- They do not shorten the end of thinned shape limbs. Therefore, they do not remove border pixels.

7.10 Mathematical morphology

Questions/Answers
1. What are the properties of erosion?
Erosion increases the black regions and decreases the white ones.

2. What are the properties of dilation?
Erosion increases the white regions and decreases the black ones.

3. What are the properties of opening?
Opening cuts the narrow isthmuses, compresses the small islands and smoothes the contours.

4. What are the properties of closing?
Closing blocks the narrow canals, the small holes and the thin bays of the object.

7.12 Skeletons

Questions/Answers
1. Can we use a skeleton for object recognition?
Skeletons have found extensive applications in biological shape description, pattern recognition, industrial inspection, quantitative metallography and image coding.

2. Is the skeleton sensitive to noise?
Skeleton is very sensitive to boundary noise and inside the object.

7.13 Shape decomposition

Questions/Answers

1. Which are the disadvantages of shape decomposition?

One disadvantage of morphological shape decomposition is that it is susceptible to boundary noise. Another disadvantage is that the representation produced is not close to human shape perception if the object consists of unions, intersections and differences of various geometrical primitives. Combining morphological techniques with constructive solid geometry (CSG) can alleviate this disadvantage. The resulting representation scheme is called *morphological shape representation*.

2. When shape decomposition remains unalterable in rotation?

In order for the shape decomposition to remain unaffected by rotation, the structure element should also be unaffected by rotation. Thus, the structure element should be a circle.