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Fourier Descriptors

Properties and Utility for Leaf Classification

In geometry, shapes are classified by a combination of simple properties. Properties such as the number of sides and sum of interior angles can be used to classify any polygonal region into one of many broad groups. A triangle has three sides with interior angles adding to 180 degrees. A quadrilateral has four sides with interior angles adding to 360 degrees.

We can add extra restraints to the shapes to further classify them. Require that all four sides be equal and you get a rhombus. Further require that all angles be equal and you are left with a single shape class, squares. A square is completely characterized by the length of one of its sides. All squares can be described by this single property. If you want to store the shape of a square so that it can be reconstructed exactly you would have to remember two things, its class (square) and its property (length of a side).

The wish to automatically recognize objects of a specific shape is the motivation behind the discrete characterization of shape. A training database of shape classes and their corresponding properties can be used to recognize shapes in future images. I propose the use of Fourier Descriptors (FDs) to create a boundary signature, which completely specifies an objects shape.

Classical geometric shapes don't tend to exist in nature, so a truly useful description needs to effectively catch the intricacies of natural objects. I believe that a Fourier description may be able to capture the fractal nature of tree leaves and reveal their periodic structure. A good description must also classify shapes at different scales. A large square and a small square should both be classified as squares with equal probability. The scaling property is realized by normalizing the Fourier description. After the properties of Fourier Descriptors have been studied. The following method will be used for leaf classification.

1. Pre-processing will be done to extract image border.
   a). Convert color image to grayscale.
   b). Automatically threshold into binary image by analyzing histogram.
   c). Fill interior holes of the leaf by dilation.
   d). Find boundary as difference of region and its erosion.

2. Calculate eccentricity to limit search to "related" shapes and quicken recognition time.

3. Calculate starting point using thinning and nearest neighbor local curvature maximum.

4. Calculate Centroid-Contour Distance Curve (CCDC)
   a). Calculate centroid distances beginning with derived starting point.
   b). Take DFT using FFT.
   c). Approximate curve with first M coefficients.
   d). Normalize to [0,1] to obtain a scale invariant representation.

5. Calculate shapes using Time-Warp Distance (TWD) and/or a weighted combination of CCDC, angle code histogram, and eccentricity.

6. Analyze the results and methods used.

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Research References

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