



Figure 1: An irregular object

techniques as calculus and differential equations, that cannot be used when data has been acquired using only counting techniques. To apply these sophisticated techniques, more advanced image analysis techniques need to be employed. Additionally, these advanced techniques will result in data more closely approximating the empirical results of human image evaluation.

Future analysis techniques will do more than count pixels. Upgraded image analysis will start with a set of (x,y) coordinate points on image boundaries. From this, the precise functional forms of the image boundaries will be determined. These can then be analyzed using many techniques of modern mathematics and reveal image characteristics that classical image analysis can never show.

Basic Principals of Image Analysis

Four criteria must be met by any advanced image analysis technique in order to be considered effective and of significant value. These criteria are: invariance, information reduction, lack of distortion, and the resulting data must relate to human perception.

- Invariance. To extract useful information from the image descriptors, it is usually necessary to convert it into an invariant form, that is, no variables can exist in the data that can modify the image when mathematically processed.

- Information Reduction. It is vitally important that the process of extracting information from the image will condense the information into a usable and understandable form.
- Lack of Distortion. The process of converting the coordinate points of any boundary or image highlight to invariant descriptors should occur without distorting any data or image feature.
- Relate to Human Perception. The anticipated power of advanced image analysis is that it will include not only common geometric and mathematical data, such as areas, lengths and means, but human observers should be able to relate to the extracted information using verbal descriptors, such as triangular, oval-shaped, etc.

Shape Analysis is Image Analysis

Once the shape (or morphology) of a closed curve is fully characterized, the resulting data will contain not only classical geometric image descriptors but shape and symmetrical information as well. These improved methods of morphological analysis are required to determine the boundary function of an object. Once this function is determined, appropriate equations of mathematical physics can be integrated over the surface (i.e., over the boundary). These geometric boundary values can be used as the boundary conditions of the differential equations useful in analyzing the object.

Using Figure 1 as an example, we can describe this figure as an irregular curvilinear figure. In terms of morphological image analysis terms, the figure is described as having an irregular function. The manipulation of this boundary function by various mathematical techniques allows us to articulate key morphic features of the image that are scientifically rigorous and at the same time are in line with our human experience.

The key to effective description of an object using morphological analysis is to have standards to which the image can be compared. One such standard involves various rules of symmetry. Another standard relates to possible shapes for comparing various samples. These standards will be covered in the next two parts of this series.

This series of articles is extract from a soon-to-be-published *Image Analysis Source Book* written by Dr. Beddow and is featured as part of a one-day short course being offered in September and October, 1995. ■

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Cleaning Osmium Black from Glass Bottles

Michael S. Forbes, Ph.D.

In issue #94-9 of *Microscopy Today*, Angela Welford offers a protocol for cleaning lead citrate-derived precipitate (lead carbonate?) from glass containers and asks for a method for restoring osmium storage bottles to cleanliness.

A number of techniques in neurobiology depend upon some form of silver staining to reveal elements such as degenerating neurons; the glassware for such involved regimens typically goes through a scrupulous cleaning process which ends with immersion for several days in diluted nitric acid (say, a 1:3 dilution of 90% "fuming" nitric acid in water). This nitric acid step was suggested to me by a more neuroanatomically inclined colleague for use on osmium-stained glass containers as well, and I have found it to work nicely (even on the bottle caps, if one is using Wheaton-type bottles). ■

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