'Shape Representation' Techniques for Taxonomic Researches

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Contemporary taxonomists are usually trying to get rid of subjectivity. They combine morphological and molecular data to infer reliable phylogenetic trees, and they measure large amounts of specimens for statistical analysis. In this situation, morphometric tools are attractive to many taxonomists. In general, the tools are designed to analyze geometric location of landmark points, and some important concepts including 'partial warps' have been widely applied to numerical studies associated with taxonomy. However, if landmark points are not enough, 'shape representation' techniques may be more appropriate to analyze biological forms. In brief, 'shape' means a connected set of points, and 'shape representation' can be defined as the characterization of shape in terms of a set of features by which reconstruction of the shape is possible. For example, the formula $x^2+y^2+z^2=1$ explains unit-radius sphere exactly. Similarly, in my research, smooth curves such as head shape of aphids could be represented by trigonometric approximations, which is also available to describe complicate two-dimensional objects including 'gonocoxa' of female planthoppers. Once shapes are represented by numerical parameters, it is possible to extract additional information such as 'extrinsic curvature' of shapes. Various kinds of subjects are waiting for taxonomist to accept mathematical methodology. Although peoples usually encounter numerous real representations of biological objects in computer animations, three-dimensional description remains in the realm of art instead of science. Till now, it is not in the center of insect taxonomy that the discussions about shape changes related to insect development, morphogenesis and evolution. If there are available mathematical tools to describe, to analyze and to reconstruct them, behavioral aspects such as locomotion and spatial distribution should be accepted as taxonomic characters.