Book review

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An Invariant Approach to Statistical Analysis of Shapes

By Subhash R. Lele and Joan T. Richtsmeier (2001). Chapman & Hall/CRC. 308 pp. $69.95 hardback. ISBN 0-8493-0319-2.

Recent approaches to the analysis of shape (the geometric properties of an object invariant to size, location, and orientation) and form (shape+size) have focused on the analysis of landmark coordinates. Such data provide a compact and exhaustive archive of the geometric relationships between the landmarks that might only be sampled by more traditional collections of linear distances, ratios, and/or angles. However, a coordinate-based approach to morphometric analysis brings to the fore the necessity of handling the ''nuisance'' variation in the data due to the location and orientation of the specimen at the time of data collection.

Lele and Richtsmeier provide in this volume an exposition of their approach to the analysis of coordinate data, Euclidean Distance Matrix Analysis (EDMA), and a summary of their work extending the EDMA approach to specific research problems. The rather simple and appealing foundation of EDMA is the form matrix FM(A), a symmetric matrix of all pairwise, Euclidean distances computed from the Cartesian coordinates of landmarks on an organism. The construction of the form matrix at once addresses the problems of location and orientation invariance and admits further modification for scale-adjustment to allow analysis of shape.

The book is organized into seven chapters including the more-or-less requisite historical overview of morphometrics, descriptions of sample data sets, and characterizations of morphometric data types. One helpful and distinguishing feature of the organization is that Chapters 3, 4, and 5, entitled ''Morphometric Data'', ''Statistical Models for Landmark Coordinate Data'', and ''Statistical Methods for Comparison of Forms'', are presented in two parts. The first part of each is intended for all but the most mathematically-averse reader, while the second part dives headlong into invariances, moments, and computational algorithms. Later chapters focus on the application of EDMA-based methods to the analysis of growth and the problems of clustering and classification. The final chapter, contributed by long-time collaborator Tim Cole, considers ongoing work on the study of asymmetry, molecular structure, and phylogenetics.

The text provides a good overview of the EDMA methods and their use by the authors to address a variety of research questions. Unfortunately, the approach is not without its problems. Studies have shown that the statistical geometry of the EDMA-based methods is extremely complicated and can introduce structure, such as correlation, into data for which none exists (Rohlf, 2000*a*). Furthermore, for simple datasets the statistical power of these procedures has a complex dependence upon the shape differences being tested (Rohlf, 2000*b*). The authors address these results directly, though somewhat derisively, on pages 164 and 165, where they argue against the relevance of the simple simulation model

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(triangles with isotropic errors) to general biological investigation. Here, and throughout the text, they also de-emphasize the importance of overall significance testing despite results reported in Lele & Cole (1996) and challenged by Rohlf (2000*b*).

Such arguments aside, one might hope that some aspects of such an apparently reasonable method would provide useful tools for morphometric research. I think one possible candidate for this might be the univariate testing of individual lengths and subsequent display of significant differences superimposed onto average specimens or representative images (e.g., Figure 4.10, p. 189). Such displays could effectively identify local landmark displacements and, perhaps, larger-scale shape differences like bending or regional expansions. More complex patterns might be more difficult, or even impossible, to discern. For situations where this approach would work, it could be a useful addition to the morphometrics toolkit.

In summary, the book provides a comprehensive and accessible exposition of EDMA-based morphometric procedures that could prove useful to those seeking a broad understanding of field of morphometrics. However, the underlying structure and performance of the methods, despite their intuitive appeal, argue against using the techniques presented within the book as a foundation for most morphometric-based research.

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