

Morphometrics 101

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1. Geometric Morphometrics (GM). GM methods are methods for shape analysis that pay particular attention to the geometry of the structures used to capture the shape of an object of interest. Traditional approaches to shape analysis usually focus on the analysis of distances between points and the angles formed by them, but collecting sufficient numbers of such variables to capture the geometry can be impractical. The most common approach to GM addresses this by focusing on landmark coordinates that encode all linear distances and angles one could collect from the same points (Fig. 1). However, the coordinates also encode location, orientation, and scale that must be controlled for in the analysis of shape.

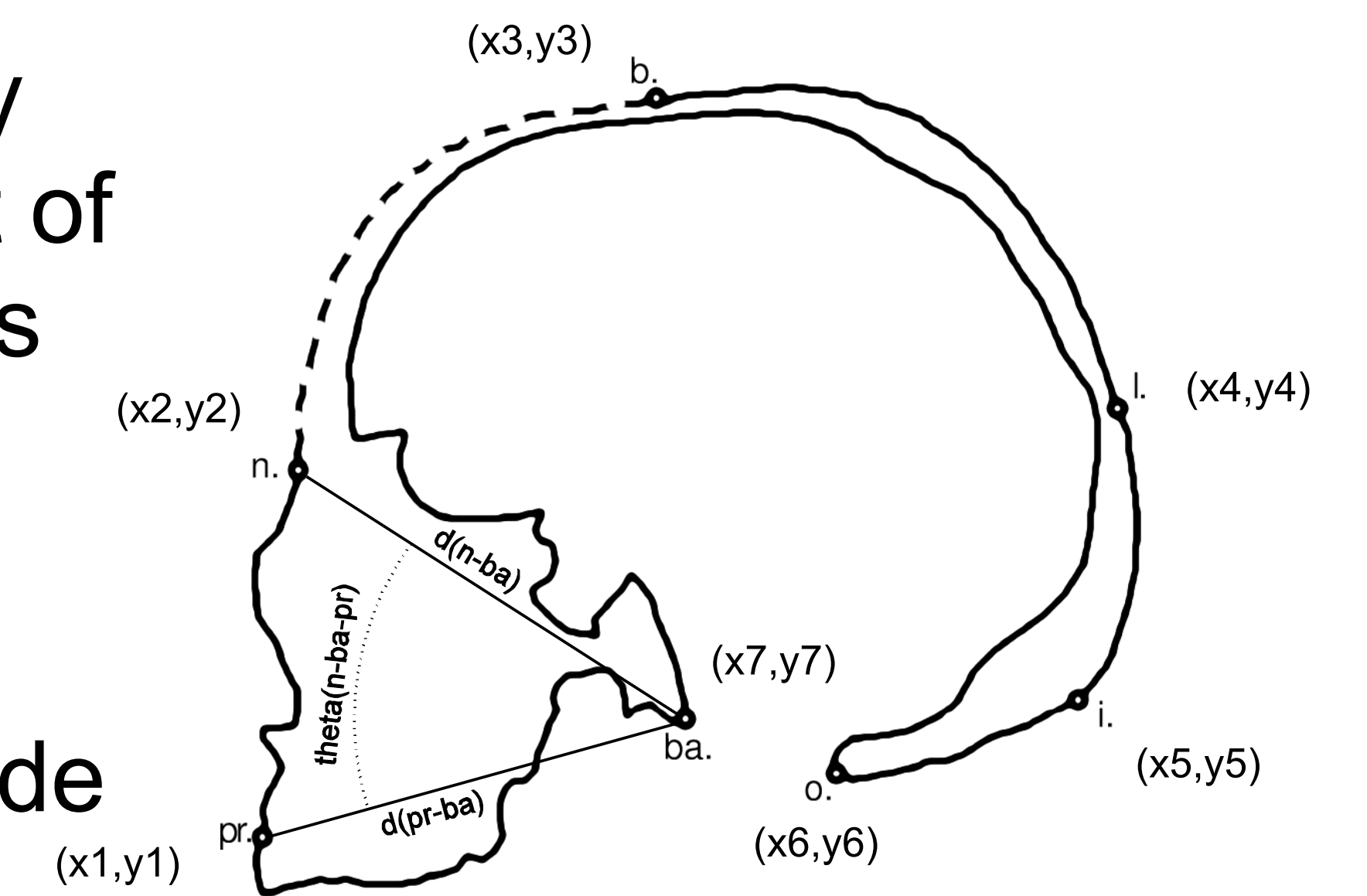


Figure 1. The data of morphometrics. Traditional distance and angles and the coordinates currently preferred by GM.

2. Generalized Procrustes Analysis (GPA). The usual approach to extract and sequester variation in coordinate data due to location, orientation, and scale is GPA. GPA centers all configurations of landmarks at the origin and scales them to unit centroid size (the root sum of squared distances of all landmarks to their centroid). Configurations are rotated to minimize the sum of squared distances between each configuration and a reference. For samples, the reference is an iteratively computed mean (Fig. 2).

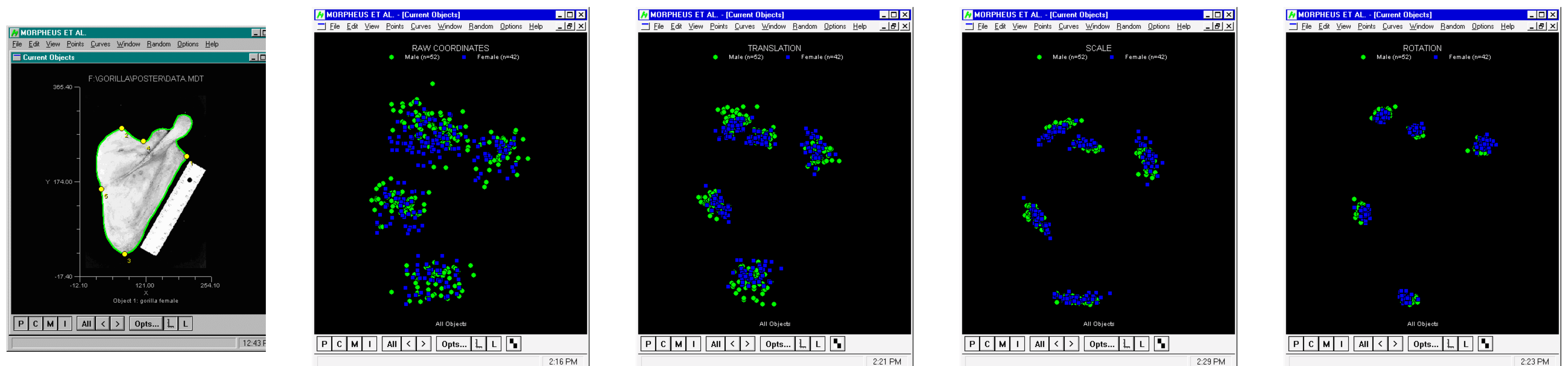


Figure 2. GPA. From left to right: a specimen (gorilla scapula), the raw data (52 male gorilla scapula in green, 42 female in blue), translation to origin, scaling to unit centroid size, least-squares rotation to minimize differences.

3. Multivariate Analysis.

Once aligned, the configuration coordinates can be converted into a multivariate vector and and subjected to familiar multivariate analyses such as principal components analysis, tests for group differences, regressions, discriminant analysis, etc.

4. Visualization – Thin-plate Splines (TPS).

Because the methods of GM have retained the geometric integrity, visualizations and reconstructions of statistical results are possible. The TPS is a very effective means for this, especially for two-dimensional data (Fig. 3).

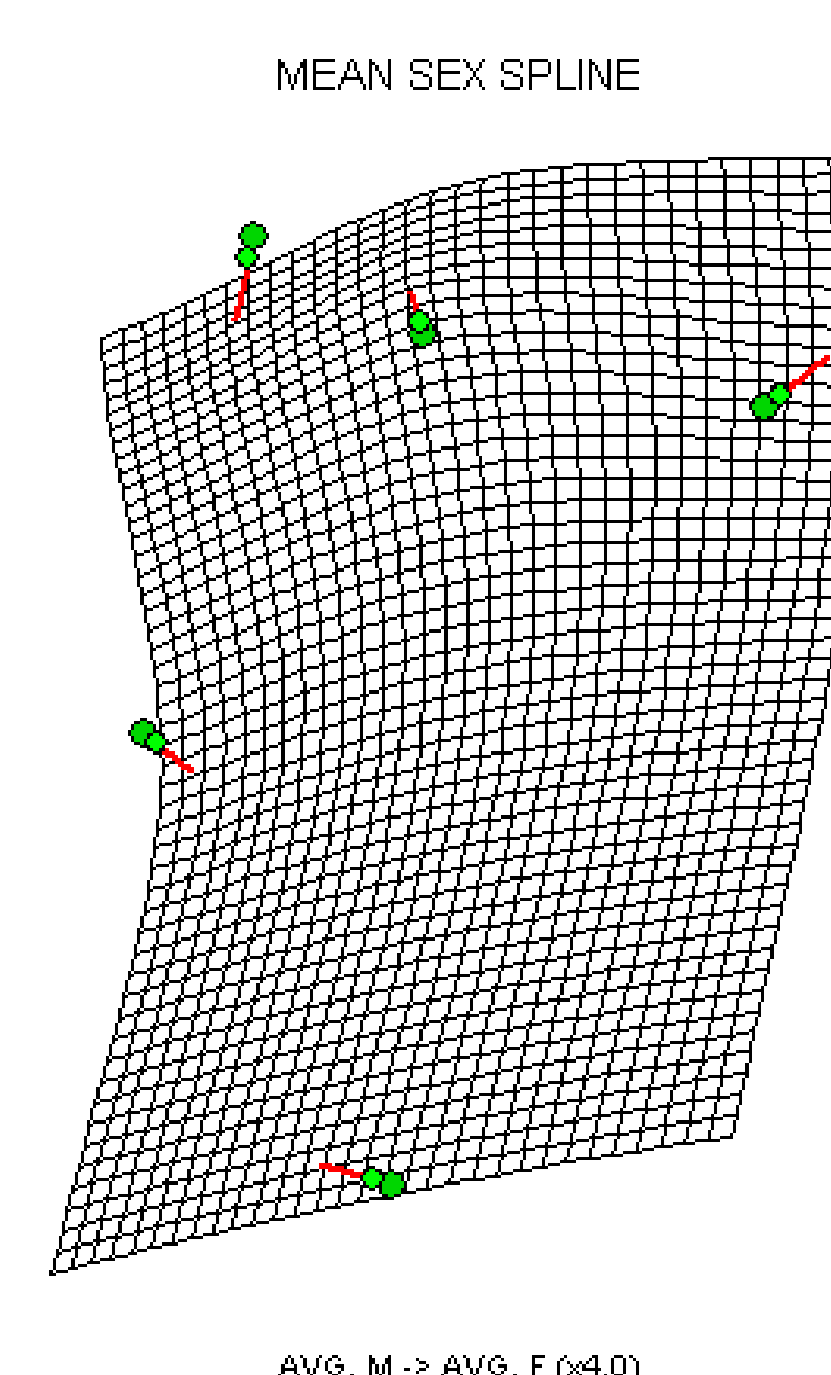


Figure 3. Visualization using thin-plate splines. Grid shows spline from average male gorilla scapula to average female exaggerated by a factor of four.

5. Summary. The basic procedures outlined here have become standard in GM applications. They have also been enhanced by numerous techniques such as sliding landmarks, asymmetry analysis, etc. This symposium is intended to exhibit the state of the art in GM analysis and suggest new directions for future research and development..

