Booth 20

61st Annual Meeting
Southeastern Section, GSA

Morphometric Analysis of Fossils Using Heads-Up Digitizing and Geographic Information System (GIS) Software

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Abstract

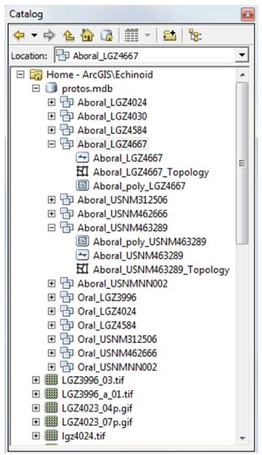
Typical biometric studies of organisms are based on measurements made on reference points or landmarks. A great deal of effort can go into defining and measuring landmarks, with the hope that they represent the essential morphological characters of the organism. I describe a detailed methodology using heads-up digitizing from photographs and ArcGIS® software for capturing significantly more information with only minor increased effort. The method is demonstrated by morphometric analysis of sand dollar echinoids. Rather than collect the coordinates of individual landmarks, the sutures between all skeletal plates are digitized, constrained by standard topological rules, and converted into polygons. Although the data are digitized from 2-dimensional photographs, full 3-dimensional models can be generated based on a few key measurements and straight-forward geometric transformations. The data are stored in geodatabase format (which can include the photography as embedded raster datasets, if desired) and can be exported in a variety of common formats, including GIS shapefiles and Excel® tables. Plate number, centroid, perimeter, area, and juxtaposition are automatically calculated. The method can also be used to capture data regarding ornamentation (tubercle size and location) and associated characters. Examples taken from an ontogenetic series of the Common Sand Dollar, *Echinarachnius parma*, reveal important and quantifiable aspects of the phenotypic expression of growth that are not apparent from usual morphometric analysis. These new principles can be compared with similar analyses of an extinct clade of sand dollars which includes the well-known Gulf Coast Eocene species *Periarchus lyelli*.

Workflow

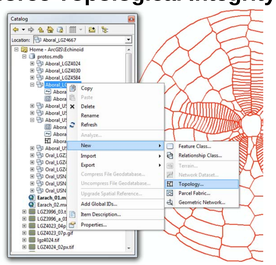
Creation of GIS feature datasets and classes is straight-forward and readily documented

Geodatabase design promotes standardized archival storage of imagery and features together

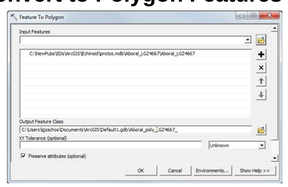
Consolidated Data Management



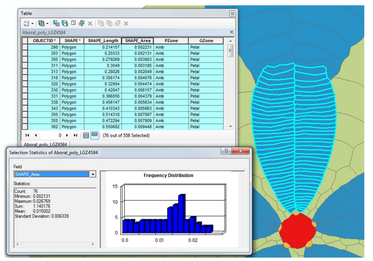
Enforce Topological Integrity



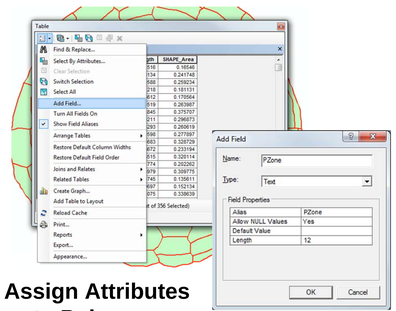
Convert to Polygon Features



Analyze Geometric Relationships

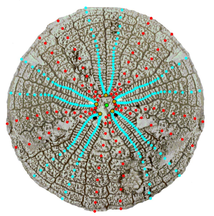


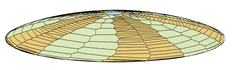
Assign Attributes to Polygons



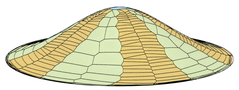
Digitize Points

Digitize polygon centroids
Export X-Y coordinates





Model plate polygons
(Delaunay Triangulation)

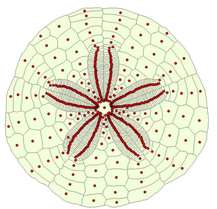


Model height variation

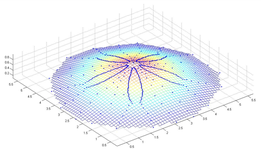
GIS can be used to generate coordinate information for input to other applications

Extract Points

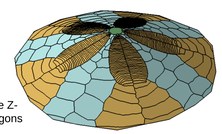
Generate polygon centroids
Export X-Y coordinates



Use surface to interpolate Z-values for individual polygons

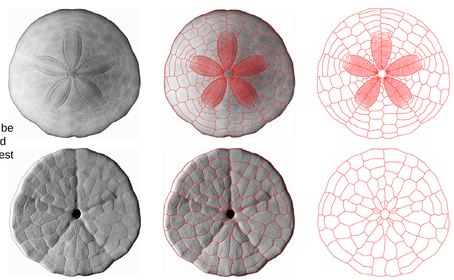


Define a surface based on curve-fitting to height information for small set of points

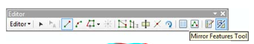


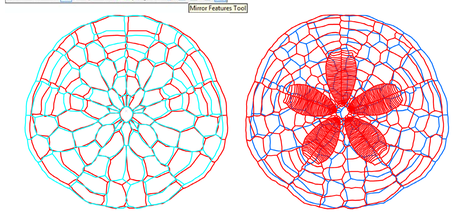
Digitize Directly from Scaled Photography

Images should be co-centered and co-scaled for best results

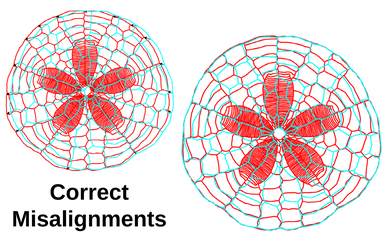


Photographs are taken from opposing viewpoints - proper overlays require mirroring of some layers





Mirror for Surface Correspondence



Correct Misalignments

Features can be aligned by affine or nonlinear transformations

Convert from Lines to Polygons

Each plate (or any other feature) can have multiple attributes

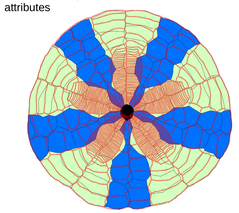
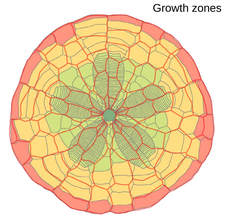


Plate-types

Growth zones



Assign Attributes to Polygons

Surface layers, whether corrected to 3D or not, can be layered to examine feature correspondence

References

Ormsby, T., E. Napoleon, R. Burke, C. Groessl, and L. Feaster. 2010. Getting to Know ArcGIS Desktop: for ArcGIS 10, ESRI Press, Redlands, 584 p.

Yacobucci, M. and L. Manship. 2011. Ammonoid septal formation and suture asymmetry explored with a geographic information systems approach. Palaeontologia Electronica, 14:1:3A, 17 p.

Zuccotti, L., M. Williamson, W. Limp, and P. Ungar. 1998. Modeling primate occlusal topography using geographic information systems technology. American Journal of Physical Anthropology, 107, p. 137-142.