Geometric Analysis

Polygon Shape Properties

The Polygon Shape Properties process (Geometric / Attributes / Polygon Shape Properties) computes shape metrics for individual polygons in one or more geometric objects (vector, CAD, or shape). The results can be saved in tables added to the input objects or to CSV-formatted text files.

Compactness

The process provides a number of measures of compactness, which is the most widely-used polygon shape property. A compact polygon has a relatively simple boundary with vertices that are relatively equidistant from the centroid. A circle is the shape with maximum compactness. Compactness measures have applications in analyses of ecological habitats, hydrological properties of drainage basins, and in assessing legislative redistricting plans.

Compactness can be quantified in several ways: 1) from physics, the moment of inertia of the polygon; 2) computations using polygon area and perimeter (or maximum length); 3) area comparison with an ideal shape such as a circle or the polygon’s convex hull. Compactness values for the measures described below range from 0 to 1.0. Numbers in square brackets refer to the numbered references on the next page.

By Moment of Inertia [3]: area² / 2 * pi * moment of inertia

The physical measure of an object’s resistance to changes in its rotation is called moment of inertia. It depends on the object’s mass, the distribution of mass (shape), and the point of rotation. For 2D polygons, moment of inertia is measured relative to rotation about an axis at the polygon centroid and perpendicular to the mapping plane. Moment of inertia increases with area and complexity of the shape, so compactness is calculated as the ratio of the moment of inertia of a circle of the same area about its center to that of the polygon about its centroid. This measure is less sensitive to polygon vertex positioning errors (noise) and differences in the level of boundary detail than compactness measures computed from perimeter and area, described below.

Richardson [3,6]: 2 * sqrt(pi * area) / perimeter

This expression is equivalent to the ratio of the perimeter of a circle with area equal to that of the polygon to the polygon’s actual perimeter.

Iso-Perimetric Quotient [3,4]: 4 * pi * area / perimeter² (also called the Polsby-Popper method and Cox’s circularity). This measure is the square of the Richardson compactness.

Gibbs [2]: 4 * area / (pi * length²)

Two measures of compactness are ratios of the polygon area to the area of an ideal shape:

Reock [1,5]: area / (area of minimum spanning circle)

Convex Hull [1]: area / (area of convex hull).

Complexity

Complexity of polygon shape is the opposite of compactness. One measure is provided, with a range from 1 to infinity:

Schwartzberg [1]: perimeter / (2 * sqrt(pi * area)); this is the inverse of the Richardson compactness measure.

Circularity

Circularity is a property similar to compactness, measuring how closely a polygon’s shape matches that of a circle. Two circularity measures are provided:

Max: sqrt(area / pi) / RadiusMax (ratio of the radius of the circle with equivalent area to the maximum radius of the polygon; range is 0 to 1).

Min/Max: sqrt([RadiusMin / RadiusMax] * sign(RadiusMin)) The final factor [sign(RadiusMin)] in the expression is 1 for RadiusMin > 0 and -1 for RadiusMin < 0 (for a polygon centroid outside the polygon boundary). The range is -1 to +1.

Miscellaneous Shape Properties

Grain Shape Index: perimeter / length

Orientation Angle: azimuth of the length direction relative to the map projection.

Elongation: length / width

Aspect Ratio: width / length

(continued)
All of the polygon shape measures take island polygons (holes) into account. The presence of islands reduces compactness and circularity and increases complexity.

Objects georeferenced in geographic (latitude / longitude) coordinates are automatically converted to an orthographic projection centered on the object in order to compute the polygon properties. Coordinate reference systems using planar coordinates do not require any conversion.

**Process Interface**

Press the Select button to select one or more geometric objects with polygons to process. The file and object names of the selected objects are shown in the list at the top of the window. To remove any object, left-click on its list entry to highlight it and press [Remove]. Press the Remove All button to clear the list.

Use the Output menu to choose how to save the computed shape properties: Add table(s) to object or Text file(s). You can choose an ID or name to embed in the statistics table(s) to identify each record. The choices from the ID/Name menu are None, Element Number, Polygon_ID.Current (if the polygons have an ID table) and Choose; the latter option prompts you to select a database table and field to provide the ID. When multiple objects are being processed, the field selections presented in the menu refer to the top object in the list. If other objects do not have a field with the selected table and field name, the element number is automatically used as the ID value. For best results with multiple inputs, make sure that they have consistent tables or use element number as the identifier.

The Properties box shows the list of available shape properties with a checkbox allowing you to select or deselect each. Current property selections are saved when you exit the process.

**References**