OATools Guide (for ArcGIS version 10.2 and 10.3)

1. Why to use Orientation Analysis Tools (OATools) in ArcGIS?

Orientation Analysis Tools described here offer practical method of processing tectonic data in relation to their location and attributes. Use them in combination with GIS tools to work and understand your set of tectonic data. In ArcGIS, **Selection Tools** are available, which you can use to select tectonic orientations in the map according to their location or attributes, such as type of structure, orientation or relation to geological units.

These tools enable to plot orientations into diagram (**azimuthal projection** –equal-area net) as points or great circles, count the **density distribution** diagrams, **map of spatial averages**, map of **fold axes** or a **rose histogram**). **Link Tool** connects data in the diagram and the map. **Profile Tool** was added to create profile line of cross section from DEM. Several additional functions are available (**eigenvectors, vector calculator**).

As a result you can get an overview of main structures in the map, to accompany your map with diagrams and enjoy working in a single environment with no need of data transfer.

2. Data format

Shapefile as a layer in the ArcMap is an input for the tools. Tools dialog boxes offer layers from an Active Data Frame as an input. Table: attribute table should contain fields for **dip direction and dip** (double or integer type of field). The fields' order or names do not matter. Additional fields - station ID and type of structure - can be also useful.

2.1 Coordinate Systems

!!Your data should be in the **projected coordinate system** in linear units (not geographic coordinate system in angular units).

How to project your shapefile in WGS 1985 (degrees) to Projected Coordinate System?
Use Project Tool located in ArcToolbox (in ArcMap or ArcCatalog). Open ArcToolbox window, click on Data Management Tools – Projections and Transformations – Feature. Here is the Project Tool. Double click, fill parameters, new shapefile with desired coordinate system is created.

3. How to get the tools into my computer?

Installation is easy; double click at Esri Add-In File. Confirm installation. In ArcMap display the toolbar "Orientation Analysis Tools for ArcGIS 10_2 or 10_3". For detailed guide see the "OATools_for_10_2_and_10_3_installation.pdf".

4. Attention!

Please, if ever happen to stop working with some error message, give me a notice! I would be grateful to you.

If you have any idea what to improve or what is missing tell me about it!

Recommendation: **files and folders names** should not contain any spaces or marks like %˅´?! etc. Use underscore instead of spaces.

5. Individual tools' guide

5.0 New Projection

This button should be used before the orientations of geological structures are plotted. New Data Frame is added. Navigate to diagram_outline.shp to add to the projection. Diagram outline is a shapefile delivered with this add-in.

Outputs of Plot in Azimuthal Projection tool, Density Distribution Diagram and Rose Histogram tools are to be observed in this projection. It is azimuthal lower hemisphere equal-area projection as indicated in the new Data Frame name.

The Data Frame does not have coordinate system as well as the diagram outline. Radius of the diagram is 200 units and the tools calculate with this number.

Drag the layer with structural data to this Data Frame and make sure it is active before you use the Plot in Azimuthal Projection, Density Distribution Diagram, or Rose Histogram tools. You can switch to Layout view to see both the projection and the map.

5.1 Plot in Azimuthal Projection tool

This tool plots selected orientations from the input layer to azimuthal equal-area projection (lower hemisphere). Create New Projection by the "New Projection" button first. Make it active and drag the layer with structural data here.

- ✓ In the dialog box, choose the input layer in the first box. Only layers from the active Data Frame are in the menu.
- ✓ Then choose field for the control point ID and field for the type of planar structure. These fields are optional.
- ✓ If you want to plot planes, select fields for dip direction and dip. (Convert strikes to dip directions first, if your data contain that). Planes can be plotted as normals to planes or as great circles. Great circles are convenient for small datasets - a few orientations, otherwise the diagram is unclear and the tool takes too much time to execute.
- ✓ If you want to plot lines, select fields for trend and plunge, optionally for type of L structure.

Selected fields are present in the output shapefile.

Plotting options include graphical points or plot in a shapefile. The shapefile can be used by the "Link Map and Projection" tool to link selected data in the map and the projection. Great circles cannot be plotted as graphics; new shapefile must be created.
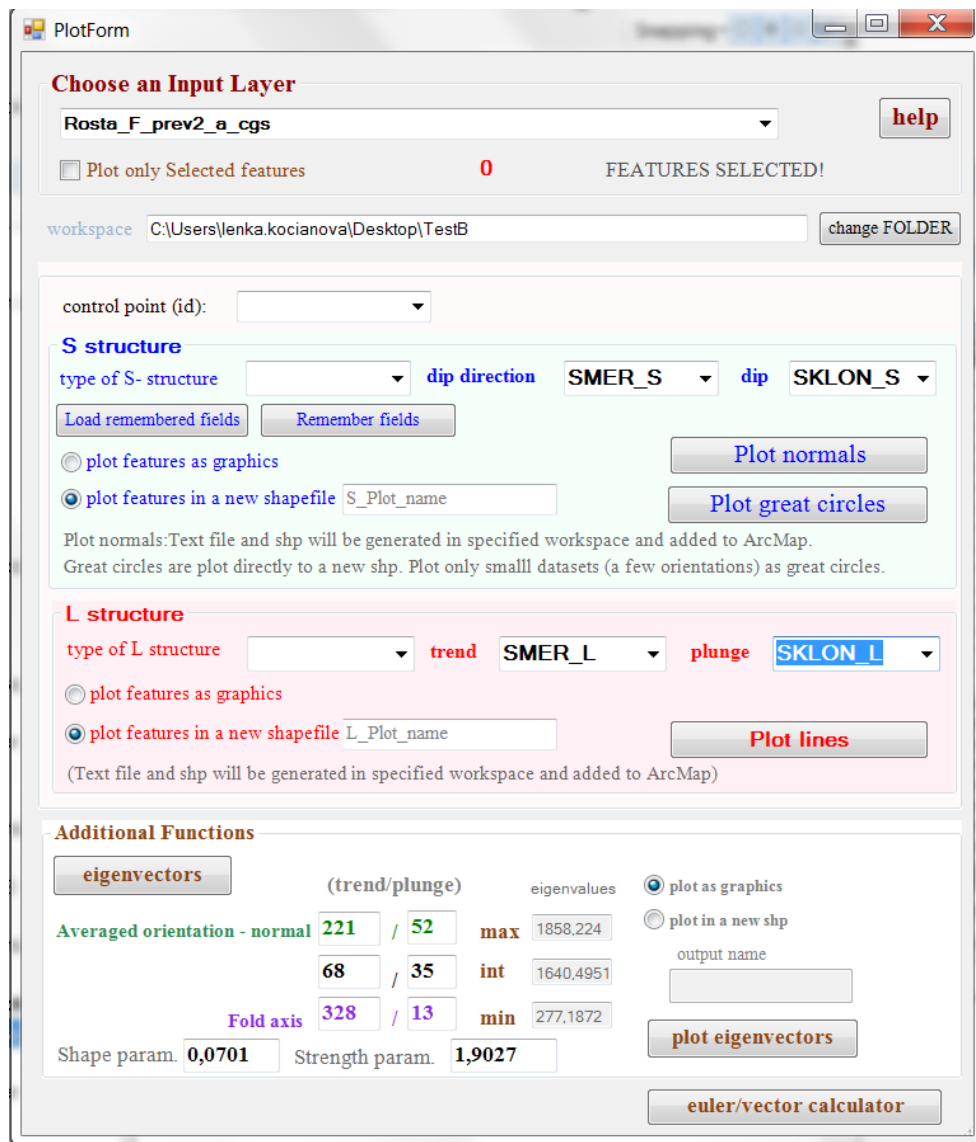
5.1.1 Additional functions

The Tool offers calculation of the fold axis, the averaged orientation, and the shape and strength parameters, which are parameters useful in discriminating girdle-type distributions from clustered distributions (Fisher et al., 1987). These statistical functions use the orientation matrix, whose components are the sums of the direction cosines of selected orientations. Computed eigenvalues and eigenvectors are used. The maximum eigenvector corresponds to the mean axis of the data; the minimum eigenvector is the direction of the fold axis, the π-pole. The calculated orientation of the fold axis can be plotted in the projection.

There is also "Euler/Vector calculator" to convert angles to vector components and vice versa, compute pole to plane, cross product and dot product of two lines.

Tip: Any orientation written manually into the text boxes of eigenvectors can be plotted into the projection by the Plot Eigenvector button.

Every time you plot the orientations in a new shapefile, new field „N" is added into the output shapefile table. This field contains FIDs of the original data, which is the way, how the orientations in the new shapefile can be linked to the original data.

Fisher, N. I. – Lewis, T. – Embleton, B. J. J. (1987): Statistical Analysis of Spherical Data. – Cambridge University Press, Cambridge, 329pp.

5.2 Link Map and Projection tool
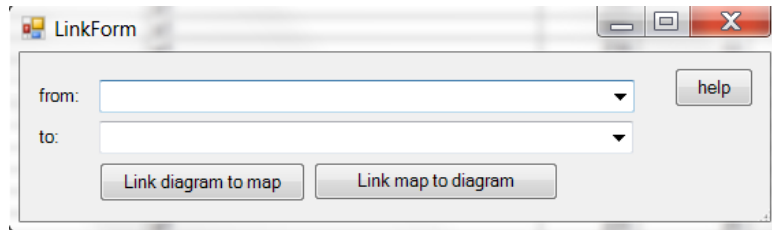
This tool links data in the projection with corresponding orientations in the map, and vice versa.

Select points in the diagram or in the map by Selection tool first. These points will be linked. The result of the Link tool is selection in the layer that is linked to. Both layers must be in the active Data Frame.

- ✓ Use the "Link Map and Projection" button and in the first box of the dialog box choose the layer with selected points (FROM layer).
- ✓ In the second box choose the layer, you want to link to (TO layer).
- ✓ Click on the button representing the link direction ("diagram to map" or "map to diagram"). Equivalent points are selected in the "TO layer".

5.3 Density distribution diagram

This tool calculates the density distribution diagram. Create the new projection by the "New Projection" button first. Make it active and drag the layer with structural data here.
Use the "Density Distribution Diagram" button.
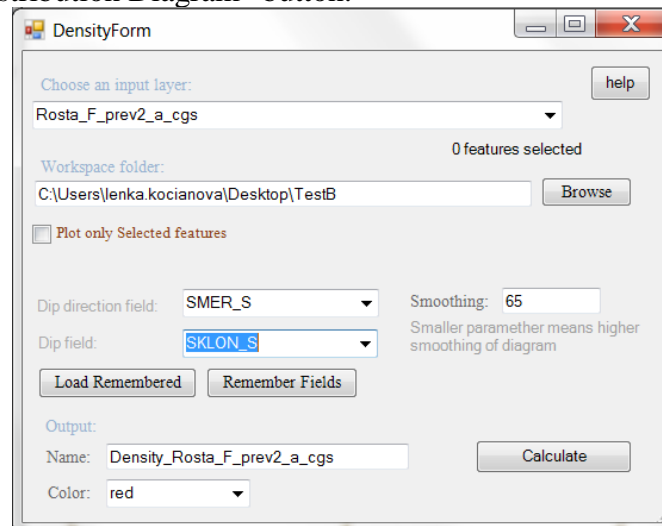
- ✓ In the dialog box, choose the input layer in the first box. Only layers from the active Data Frame are in the menu.
- ✓ You can change the workspace.
- ✓ Untick the option "Plot only selected features" if you want to work with all (not only selected) features.
- ✓ Select fields for dip direction and dip.
- ✓ Type a name for the output raster and select colour of the output raster.
- ✓ Smoothing parameter: for less data, smaller number is adequate, produces more smoothed diagrams. Smoothing parameter is set in default, but try to change, higher number produces more detailed diagrams. Maximum is 100.

✓ Watson density is calculated.

5.4 Spatial Averaging tool and Map of Fold Axes tool

This tool calculates spatial averages (resp. fold axes) in a net of stations. The interval is set by user as well as the radius of influence (this radius determines the space around the station within the tectonic orientations have influence on the calculation). Orientation matrix is used. Influence of each orientation is determined by the distance from the averaging station. Eigenvalues and eigenvectors are computed. The highest eigenvalue is used to compute the spatial average and the lowest to compute the fold axis.

If there is a selection in the input layer, the tool works with this selection. If no selection, the tool works with all features.

✓ Choose the input layer in the first box, then fields for dip and dip direction.
✓ Type the interval of the net of stations and radius of influence.
✓ Type the name of the output. You can change the workspace.
✓ There are informative values in the text boxes below: numbers of stations in X and Y directions and the extent of the data in meters.
✓ Use "Calculate" button.
✓ Text file with x, y and computed orientation (dip direction and dip, resp. trend and plunge) is generated in the selected workspace and shapefile is created from that. This shapefile is added to the active Data Frame of the ArcMap and rotated symbols are set.

5.6 Rose histogram

The "Rose Histogram" tool creates diagram that represents the frequency of orientations of geological structures.

Orientations are read from the point geometry data (orientations are in the attribute table) or are calculated from the geometry of polylines.

Orientations are matched to one of the 10 degrees classes. The class with the highest frequency is 100% of the diagram radius; other classes are relative to it.

Point Input: Dip directions from the attribute table of the point shapefile are converted to strikes. Select the field containing the dip directions.

Line Input: Orientation for each line is calculated. Options are: mean vector of the polyline segments or orientation of the straight line connecting the start and the end point of the polyline.

Optionally use the button "Line Azimuths" and calculate orientations of the input polyline data. Orientations are added to the attribute table. Both methods of calculation are used (mean vector of segments and start-end point orientation).

Optionally the length of the polyline can be considered, when you tick the option "Weight the line influence by the line length". The influence of the line is multiplied by its length. (Short lines will have less influence than the long lines).

Fields in the output polygon shapefile: "class_no": class number (1-18), "count": number of orientations that fall in this class, "tot_length": total length of lines in this class in kilometres (when weighted by length), "rel_length": relative length of classes (from 0 to 1)
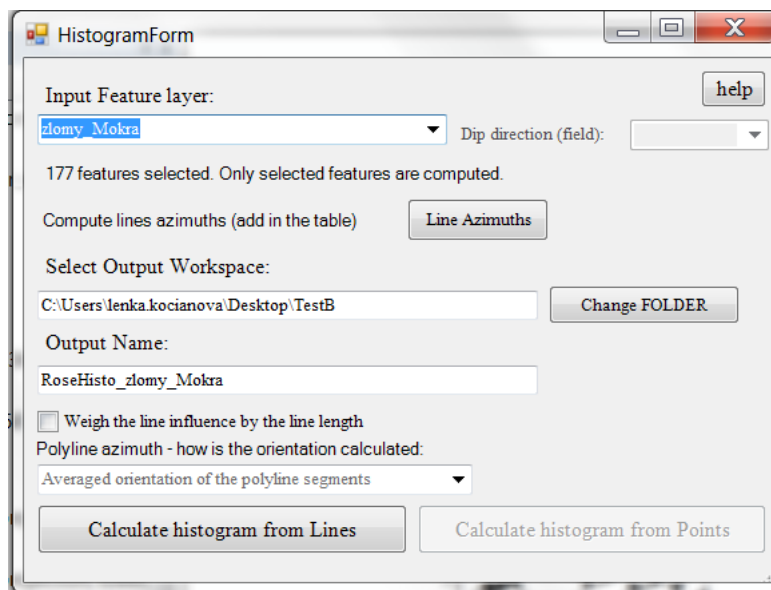
Using tool - steps
✓ Use the „Rose histogram" button
Dialog box appears.
✓ In the first box „Input Feature layer", choose the input layer- line or point shapefile.
✓ Number of selected features is displayed, if there is any selection. The tool works with selection. If there is no selection, the tool works with all features.
✓ Lines input: Optionally use the "Line Azimuths" button to add line orientations in the input attribute table.
✓ Points input: Select the dip direction field.
✓ You can change the workspace. Type a name of the output polygon shapefile.
✓ Lines input: Tick "Weigh the line influence by the line length" if you want to weigh by the lines lengths.
✓ Select the option how the line orientation is calculated.
✓ Click on „Calculate histogram from Lines" or "..from points".

5.7 CSProfile tool

This tool creates profile line of cross section from Digital Elevation Model (DEM).
✓ Input is the line shapefile with one line selected (line of cross section in the map).
✓ Input is DEM, pixel value=elevation.
✓ Both inputs must be in the projected coordinate system.

✓ Optional input is a point shapefile with intersections of line of cross section with water lines or other points that you want to have on the profile line.

✓ Optionally you can tick the option "Create txt file with Map points (points along the line of cross section in the map with elevations), Profile points (points that form the profile line) and Beziers points (approximation calculated from profile points).

✓ Output is a line shapefile with profile line and a point shapefile with intersections.