Faulted geological contacts: constraining uncertainty of discontinuities orientation using triangulation and combinatorial algorithm

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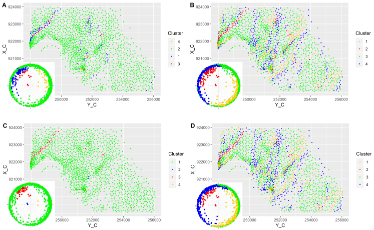
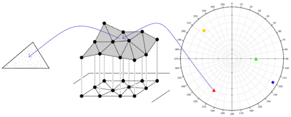
Problem

We'd like to create a simple geological model on a faulted contact using three-point method and triangulation. But we don't know the extent to which this combination of methods is capable of representing faults...





Related approach

In fact we are developing an approach that has been already described: `https://doi.org/10.1016/j.cageo.2019.104322`

Computers & Geosciences 133 (2019) 104322

Contents lists available at ScienceDirect

Computers and Geosciences

journal homepage: www.elsevier.com/locate/cageo

Using Delaunay triangulation and cluster analysis to determine the orientation of a sub-horizontal and noise including contact in Kraków-Silesian Homocline, Poland

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Brief introduction to results

To address this issue, we created two synthetic models of faulted contacts: 1) vertical and 2) dipping at 60° to west.

Due to limited space of this presentation, we will focus on the second model.

We mainly ask:

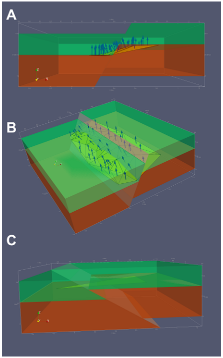
1) can we accurately calculate the orientation of a discontinuity using three-point method and triangulation?

2) can combinatorial algorithm be useful in better constraining the discontinuity orientation?

3) can the distributions be modeled using circular von Mises distribution?

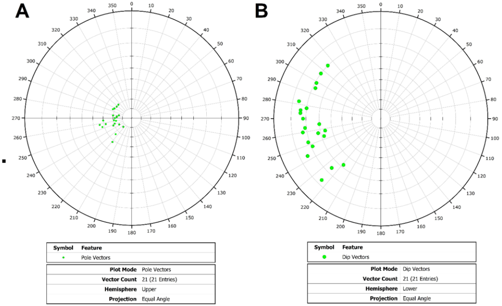
Variability of dip direction

This is a faulted contact dipping at 60° to west. Therefore, its expected dip direction is 270°.



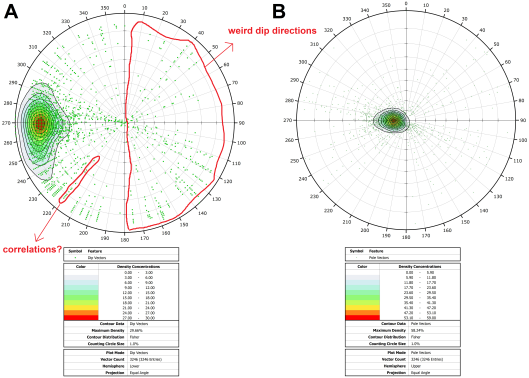
Variability of dip direction

This is a distribution of orientations associated with the previously presented triangulated model (B). It seems that the concentration around the expected orientation (270°) is quite low...



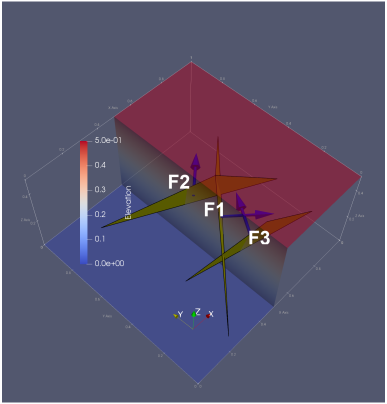
Employing combinatorial algorithm

What about creating all possible triangles from the vertices given?
This is the result:



Surprising orientations

Weird but true...



Basic statistics

Mean direction for the triangulated model: 264.8151

Median direction fot the triangulated model: 262.875

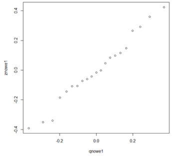
Mean direction for the combinatorial model: 264.8618

Median direction fot the combinatorial model: 267.7852

We are not delighted but...

Statistics

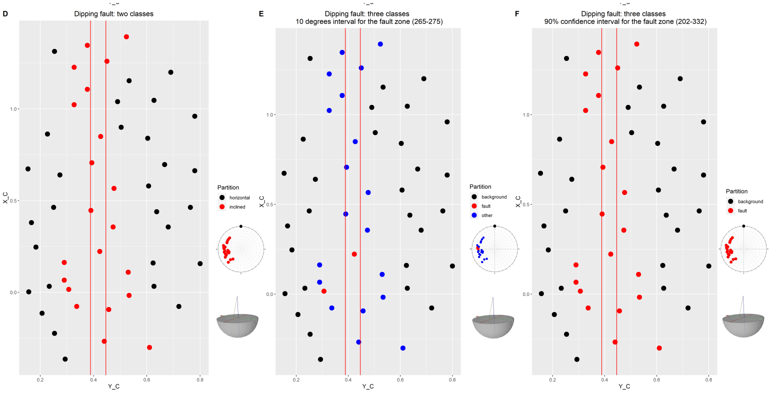
- QQ-plots for the observations taken and statistical tests seem not to invalidate the hypotheses: 1) of 270° mean and 2) that orientations from triangulated models may be modeled using circular von Mises distributions



- statistical tests conducted for combinatorial approach do invalidate both the hypotheses: 1) of 270° mean and 2) that orientations from combinatorial approach may be modeled using circular von Mises distributions

Conducting spatial clustering

Let's conduct spatial clustering using three different approaches:



Conclusion

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- While intrinsically incapable of calculating the fault dip angle, the three-point approach can also be adjusted to constrain the variability of the fault strike. It does not have the potential however of indicating the dip direction but only the relative positions of hangingwall and footwall.

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- While intrinsically incapable of calculating the fault dip angle, the three-point approach can also be adjusted to constrain the variability of the fault strike. It does not have the potential however of indicating the dip direction but only the relative positions of hangingwall and footwall.
- The combinatorial algorithm of generating all three-element subsets from an n-element set may be used to better assess (at least visually) the confidence interval for the fault strike that can be further used for conducting spatial clustering.

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- statistical tests conducted for the combinatorial approach pose a challenge. It could be possibly solved by selecting only triangles below a given collinearity limit
- The patterns obtained through the proposed maps are clearly sensitive to the selection of the points representing a triangle. Taking more points from its interior or making a regularized (grid) version could be a solution to this problem.

Thanks for your attention!