MSc project description (AM, CS-DST)

Spatial Entropy Measures for Classifying Rocks

Earth scientists study rock composition and structure to understand how rocks are formed. Geological processes determine the types of minerals and their spatial configuration in rocks during their formation. Understanding rock history is essential in searching for geothermal resources and raw materials and reconstructing Earth history.

Examples of different rock structures are shown in Figs. 1 and 2. The spatial distribution, size, and shape of rock particles in Fig. 1 vary as a function of the dynamics in the environment in which the particles were deposited and the rock was formed. The same applies to the particles' orientation in Fig. 2, where the particle orientation varies as a function of the rock-forming environment.

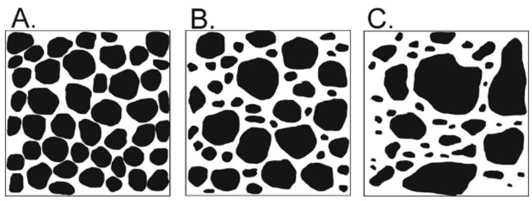

Fig. 1: Homogeneity of particle size and shape, decreasing from A. to C. Image width ~ 1cm.

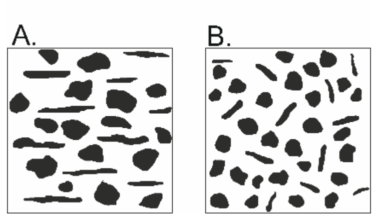

Fig. 2: Preferred A) and random B) orientation of particles in rock. Image width ~ 1cm.

By measuring the degree of order in the geometry and spatial attributes of rock particles and one can obtain information on how the rocks were formed. Entropy-based measures may provide estimates of the degree of order in rock structure data. Starting from [1] a wide range of papers on applications of spatial entropy as well as methodological work exists.

The goal of this research topic is to develop entropy-based measures for characterizing the structure of rocks.

There are several interesting challenges, a subset of which could be addressed in a final project:

1. Marked processes: Existing literature seems to focus on entropy measures for location data. In this case we also have size, shape and orientation of particles. The challenge is to extend existing theory to include the geometric properties.
2. Clustering: Develop an entropy-based measure that can be used for clustering.
3. Boundary effects: The observed samples are relatively small. It is expected that this leads to significant boundary effects with many particles being only partly visible. The challenge is to account for and correct these boundary effects.
4. Starting from a model of a spatial point process analyze the properties of the resulting entropy estimator (consistency, bias, variance, …).
5. Analyze which geometric properties (size, shape, orientation, …) are most relevant for the clustering task.

Multidisciplinary:
Most of the above tasks can be addressed by a student in mathematics or data science, focusing on modelling, followed by analysis or experimental work. Some tasks, however, require in-depth knowledge from the Earth science domain and infrared imaging of rocks. If you want to work on these tasks you will be matched with an ITC student and jointly work on these tasks.

Prerequisites:
This project is combining expertise from information theory as well as spatial statistics. Having completed one of these courses is a prerequisite for starting this project.

Contact information / daily supervisors:

- Jasper Goseling (Mathematics of Operations Research, EEMCS)
- Frank van Ruitenbeek (Department of Earth Systems Analysis, ITC)

References:
[1] Batty, Michael. "Spatial entropy." Geographical analysis 6.1 (1974): 1-31.