GeoStats.jl - IAMG short-course

Overview

In this short-course, I will cover important concepts from geostatistics using the GeoStats.jl framework, a state-of-the-art, open-source package for geostatistics implemented in the Julia programming language. Topics covered: variography, estimation/simulation of spatial variables with variogram-based methods, multiple-point simulation with training images, among other topics of practical interest.

Requirements

No previous exposure to the Julia programming language is required, but is very welcome. A good resource is their official documentation at https://julialang.org.

Although no programming experience is required to follow the course material, attendees will be asked to execute code in the form of Jupyter notebooks.

A computer with internet connection is necessary for those interested in doing the exercises.

Goals

By the end of the course, you should be able to understand the types of problems that can be solved with the framework, and to reproduce the examples with your own data.

Agenda

- PART I - INTRODUCTION TO JULIA
  - Rationale (why another programming language?)
  - Overview of features and the package ecosystem
  - Installation and setup (Julia + Jupyter + packages)
  - Experimenting with the language basics
  - Pros and cons of Julia (to keep in mind)
  - Programming exercises [OPTIONAL]
- PART II - SPATIAL ESTIMATION PROBLEMS
  - January 4, 2018 - A Bay Area Earthquake
  - Problem definition and components
  - Introduction to GeoStats.jl
  - Spatial data and domain types

        - Solving the problem
            - Inverse distance weighting (IDW)
            - Locally weighted regression (LWR)
            - Kriging methods (SK, OK, UK, EDK)
        - Comparing solvers (visually and with cross-validation)
        - Programming exercises [OPTIONAL]
        - Review quiz (multiple choice)
- PART III - SPATIAL SIMULATION PROBLEMS
        - Problem definition and components
        - Solving the problem (specifying a distribution)
            - 2-point methods (Direct Gaussian simulation)
            - Multiple-point methods (Image quilting)
            - Cookie-cutter (hierarchical simulation)
        - Spatial summary statistics (mean, variance, quantiles)
        - Parallel simulation (exploiting computer clusters)
        - Programming exercises [OPTIONAL]
        - Best solution contest (audience's vote)
- PART IV - VARIOGRAPHY
        - Turing patterns (simulation by reaction-diffusion)
        - H-scatter plots and empirical variograms
        - Directional variograms and variogram plane plots
        - Theoretical variogram models (e.g. Gauss, Matérn)
        - Variogram fitting methods
- CONCLUDING REMARKS
        - Useful links and references
        - Upcoming developments

Instructor

Júlio Hoffimann Mendes

Júlio completed his bachelor's degree in Mechanical Engineering at Universidade Federal de Pernambuco (UFPE) (2007-2011) where he was involved with research in finite element methods, and methods for uncertainty propagation in the oil & gas industry. He obtained his masters in Civil Engineering at the same university (2011-2014) with a dissertation on inverse problem theory, and his Ph.D. in Geostatistics immediately after at Stanford University (2014-2018). Currently, he is a research scientist at IBM Research.

With a unique combination of skills in applied machine learning in the Earth sciences and high-performance computing, he is the author of GeoStats.jl, a platform for high-performance geostatistics used by hundreds of users worldwide, as well as other projects listed on his website (https://juliohm.github.io). His career goals include 1) advancing the field of machine learning and artificial intelligence to account for challenges unique to the Earth sciences, and 2)

establishing new methodologies for uncertainty quantification and decision making involving the use of natural resources in the planet.