



GemPy: Model based machine learning in implicit geological modelling

Miguel de la Varga, Alexander Schaaf, and Florian Wellmann

Computational Geoscience and Reservoir Engineering, RWTH Aachen University, Germany

The representation of subsurface structures is an essential aspect of a wide variety of geoscientific investigations and applications: ranging from geofluid reservoir studies, over raw material investigations, to geo-sequestration, as well as many branches of geoscientific research studies and applications in geological surveys. A wide range of methods exists to generate geological models. However, especially the powerful methods are locked away in expensive commercial packages. We present GemPy a full open-source geomodeling package, based on an implicit potential-field interpolation approach.

The interpolation algorithm (based on Lajaunie et al., 1997 potential field method) is comparable to implementations in commercial packages and capable of constructing complex full 3-D geological models, including fault networks, fault-surface interactions, unconformities, and dome structures. GemPy is implemented in the programming language Python, making use of a highly efficient underlying library – theano (Theano Development team, 2016) – for efficient code generation that enables a direct execution on GPU's as well as performs automatic differentiation. This property allows the computation of gradients cheaply what enables many of the latest optimization and inference algorithms.

GemPy's functionality can be separated into the core aspects required to generate 3-D geological models and additional assets for advanced scientific investigations. These assets provide the full power behind our approach, as they enable the link to Machine Learning and Bayesian inference frameworks and thus a path to stochastic geological modeling and inference. In addition, we provide methods to analyse model topology and to compute gravity fields on the basis of the geological models and assigned density values. Regarding visualization, we make use of many of the different options available in the Python eco-system such as Matplotlib, Visual Tool Kit (vtk) or even Blender.

In summary, we provide a basis for open scientific research using geological models, with the aim to foster reproducible research in the field of geomodeling.