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Grid-Free Surface-Based Geological Modelling using Subdivisions Surfaces and NURBS – Advantages for Geothermal Applications

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Pragmatic and cost-effective representations of geological structures and features (e.g., heterogeneities, faults and folds) in full 3-D geological models are challenging. Implementations are highly dependent on the flexibility of the representation method. We investigate the use of parametric surface-based geological modelling methods for the purpose of low-dimensional model representations. Specifically, we focus on two grid-free and controllable parametric surfaced-based modelling methods: NURBS and subdivision surfaces. NURBS are the standard method in Computer-Aided Design (CAD) and have been used in geological reservoir modelling before. Subdivision surfaces are a common representation in the gaming and animation industry. They are very interesting as they can support watertight modelling and arbitrary topology (preserving the relationship between different parts of the model). However, this method is, to date, rarely used in geological modelling.

Unlike implicit modelling, parametric surfaced-based modelling is a grid-free representation and exploits the boundary surfaces of the model. Also, the geological features (e.g., heterogeneities, faults, folds) can be represented by there bounding surfaces instead of grid-cells. Therefore, they do not suffer from the limitation of grid cells (e.g., Stair-stepping), which are often present in implicit representations.

We discuss the advantages and shortcomings of both NURBS and subdivision surfaces for geological modelling. Furthermore, we investigate the approximation of geological structures by subdivision surfaces in this presentation. The approximated models are watertight (closed), controllable with few control points, smooth, and have less than 5% of the number of the vertices of the original model. Reducing the number of vertices of the model while preserving the topology can decrease the cost of both modelling and simulations. As the final step, we present the advantages of grid-free surface-based geological modelling for thermal finite element analyses by using a state-of-the-art finite-element solver, namely the MOOSE framework