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Using Graph Neural Networks for 3-D Structural Geological Modelling

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A new approach for constrained 3-D structural geological modelling using Graph Neural Networks (GNN) has been developed that is driven by a learning through training paradigm. Graph neural networks are an emerging deep learning model for graph structured data which can produce vector embeddings of graph elements including nodes, edges, and graphs themselves, useful for various learning objectives. In this work our graphs represent unstructured volumetric meshes. Our developed GNN architecture can generate spatially interpolated implicit scalar fields and discrete geological unit predictions on graph nodes (e.g. mesh vertices) to construct 3-D structural models. Interpolations are constrained by scattered point data sampling geological units, interfaces, as well as linear and planar orientation measurements. Interpolation constraints are incorporated into the neural architecture using loss functions associated with each constraint type that measure the error between the network's predictions and data observations. This presentation will describe key concepts involved within this approach including vector embeddings, spatial-based convolutions on graphs, and loss functions for structural geological features. In addition, several modelling results will be given that demonstrate the capabilities and potential of GNNs for representing geological structures.