POLITECNICO DI TORINO

DISMA Dipartimento di Scienze Matematiche G. L. Lagrange
ECCELLENZA 2018 · 2022

Wednesday the 13 June 2018 at 10:00
Politecnico di Torino, DISMA, Aula Buzano (third floor)

Jeffrey HYMAN
Computational Earth Science Group (EES-16) – Earth & Environmental Sciences Division
Los Alamos National Laboratory

Applications of Graph Theory and Machine Learning to Discrete Fracture Networks

Prof. Stefano Berrone moderates the discussion

Abstract

Characterizing flow and transport through low-permeability fractured media is important for many industrial engineering applications including carbon-dioxide sequestration, aquifer storage and management, environmental restoration of contaminated fractured media, hydrocarbon extraction from unconventional shale aquifers, and the long-term storage of spent nuclear fuel. Discrete fracture networks (DFN) are one common modelling tool for the simulation of flow and transport through these fractured subsurface systems. In the DFN methodology fracture networks are represented as an interconnected set of planar N-1 dimensional objects embedded within an N-dimensional space, e.g., lines in two dimensions or planar polygons in three dimensions. The structure of a DFN naturally lends itself to the use of graphs as a coarse-scale representation that retains the multiscale nature of flow and transport through fractured media.

In this talk, Dr Hyman will introduce a bipartite graph representation that integrates fracture network topology, fracture geometry, and hydraulic properties and demonstrate how that the two most common graph-representations of DFNs, vertices representing intersections and vertices representing fractures, are projections of this bipartite graph thereby providing a generalisation of previous DFN-graph frameworks. The utility of the bipartite representation is demonstrated through the application of two efficient graph-based methods to identify backbones in a DFN, which are sub-networks that carry the majority of the flow. The first method is a heuristic graph theoretical approach that identifies the shortest paths through a weighted projection of the graph and the second is a supervised machine learning approach that classifies a fracture's inclusion in the backbone on the bases of geometric, hydrological, and topological features.

Biografy

Dr Hyman is a research scientist in the Computational Earth Science Group (EES-16) at Los Alamos National Laboratory. He obtained a PhD in Applied Mathematics and a PhD Minor in Hydrology and Water resources from the University of Arizona in 2014. His research focuses on advancing our understanding of complex subsurface hydrological systems across multiple scales through detailed simulations of flow and transport through large, kilometre-scale, fracture networks to small, micrometre-scale, explicit pore microstructures using high-performance computing.

Save the date for the next event: Wednesday the 20th of June 2018