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# A parallel program for numerical simulation of discrete fracture network and groundwater flow

Ting-Wei Huang (1), Tai-Sheng Liou (2), Roohollah Kalatehjari (2,3)

(1) National Chung Cheng Unerversity, Institute of Applied Geophysics and Environmental Sciences, Taiwan , (2) National Chung Cheng Unerversity, Department of Earth and Environmental Sciences, Taiwan (tslioutw@gmail.com), (3) Auckland University of Technology, New Zealand

The ability of modeling fluid flow in Discrete Fracture Network (DFN) is critical to various applications such as exploration of reserves in geothermal and petroleum reservoirs, geological sequestration of carbon dioxide and final disposal of spent nuclear fuels. Although several commerical or acdametic DFN flow simulators are already available (e.g., FracMan and DFNWORKS), challenges in terms of computational efficiency and three-dimensional visualization still remain, which therefore motivates this study for developing a new DFN and flow simulator. A new DFN and flow simulator, DFNbox, was written in C++ under a cross-platform software development framework provided by Qt. DFNBox integrates the following capabilities into a user-friendly drop-down menu interface: DFN simulation and clipping, 3D mesh generation, fracture data analysis, connectivity analysis, flow path analysis and steady-state grounwater flow simulation. All three-dimensional visualization graphics were developed using the free OpenGL API. Similar to other DFN simulators, fractures are conceptualized as random point process in space, with stochastic characteristics represented by orientation, size, transmissivity and aperture. Fracture meshing was implemented by Delaunay triangulation for visualization but not flow simulation purposes. Boundary element method was used for flow simulations such that only unknown head or flux along exterior and interection bounaries are needed for solving the flow field in the DFN. Parallel compuation concept was taken into account in developing DFNbox for calculations that such concept is possible. For example, the time-consuming seqential code for fracture clipping calculations has been completely replaced by a highly efficient parallel one. This can greatly enhance compuational efficiency especially on multi-thread platforms. Furthermore, DFNbox have been successfully tested in Windows and Linux systems with equally-well performance.