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Assessing mesh convergence in discrete-fracture simulations that use random meshes

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ABSTRACT

A pervasive fracturing process is one in which a multitude of cracks are dynamically active, propagating in arbitrary directions, coalescing, and branching. Pervasive fracturing is a highly nonlinear process involving complex material constitutive behavior, postpeak material softening, localization, new surface generation, and ubiquitous contact. A popular computational method for modeling pervasive fracture processes is to only allow fractures to propagate along interelement edges within a predefined finite-element mesh. With this approach, to avoid nonobjectivity in the simulation results, it is necessary to use a random mesh that has no preferred orientation. To define mesh convergence, simulation results are viewed in a weak or probabilistic sense rather than at the level of a single realization. For random variables, there are a number of different modes in which convergence may be understood. These are almost sure convergence, convergence in probability, and convergence in distribution. Each mode of convergence may be stronger or weaker than another. Herein, the fracture convergence assessment is based on demonstrating empirically the mode of convergence in distribution. Specifically, a sequence of cumulative distribution functions is verified to converge in the L^∞ norm. The effect of finite sample sizes is quantified using confidence levels from the Kolmogorov–Smirnov statistic. This statistical method and convergence assessment is independent of the underlying distribution.