Crack propagation in random heterogeneous elastic media

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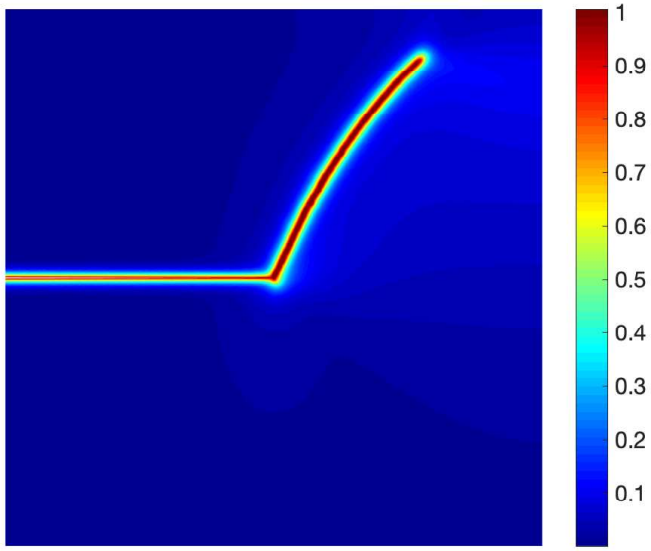
Context and problematic

Phase field fracture (PFF) model for crack propagation

- Topical issue with numerous applications in mechanical and civil engineering, transport (automotive, aeronautic, aerospace, rail)
- Active research field in the last decade [Bourdin, Francfort, and Marigo 2008; Marigo, Maurini, and Pham 2016; Nguyen et al. 2015; Wu et al. 2018]



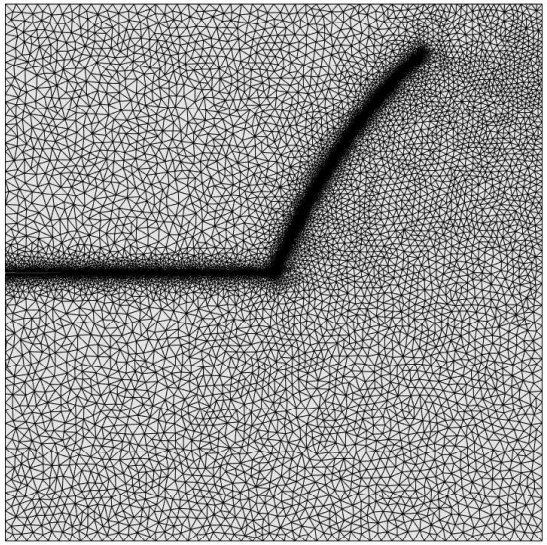


Figure: Quasi-static brittle fracture problem: shear test using a standard isotropic PFF model

- Numerical simulation of crack propagation in highly heterogeneous microstructures with well-defined constitutive phases

Challenge for crack propagation in random heterogeneous media

Stochastic modeling of complex heterogeneous microstructures

- Complex random heterogeneous microstructures that cannot be described by the morphological and mechanical properties of their constituents
- Stochastic model for the apparent (random and heterogeneous) elasticity tensor field at a given mesoscale

Figure: Example of a biological material (cortical bone) at several length scales ranging from macroscale to nanoscale

Identification of stochastic models in crack propagation problems

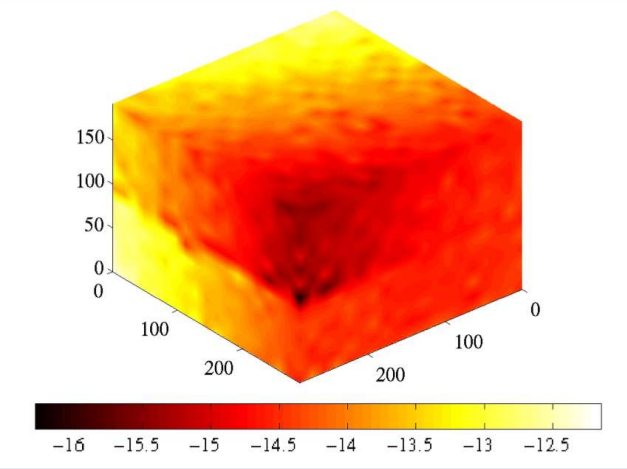
Objectives

Construct a stochastic phase field fracture (SPFF) model for quasi-static fracture of materials with complex microstructures at mesoscale taking into account

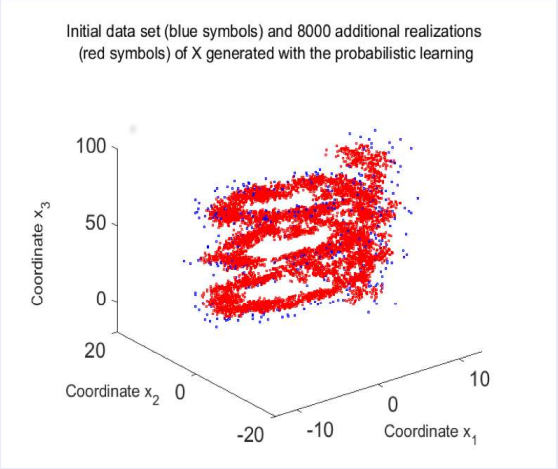
- the random material properties (elasticity field and fracture toughness)
- the topological properties (width of the smeared crack)

Develop an identification methodology of the parameters of the stochastic model for small or big data using

- Genetic Algorithm (GA)
- Artificial Neural Network (ANN)
- Probabilistic Learning (PL) on manifolds
- Bayesian Inference (BI)



(a) Cracked heterogeneous microstructure made up with nodular graphite cast iron [Rannou et al. 2010]



(b) Probabilistic Learning on manifolds [Soize and Ghanem 2016, 2017]

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