Simulation of deformation and fracture in very large shell structures

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Wednesday, March 2, 2016

221 MEC

1:00 to 2:25pm

Abstract: Fracture is often a critical concern in the design of large, thin structures such as aircraft fuselages, ship hulls, and automobiles, which has spurred the development of numerous numerical shell fracture techniques in the last 10-15 years. Despite considerable progress on this front, two important aspects have received relatively little attention. First, many existing methods are not scalable, in the sense of parallel computing, and consequently simulation of large structures remains out of reach. Second, while in-plane tensile failure is always treated, modeling fracture due to transverse shear is typically omitted, although it occurs in important applications such as impacts, blasts, and sheet metal cutting and blanking. I will present a new parallel computational framework for shells that is composed of two main ingredients: (i) a discontinuous Galerkin (DG) finite element method for shear-flexible shells, and (ii) a cohesive zone model of fracture. This scheme permits the simulation of crack propagation, branching, and merging without topological changes to the mesh, thus conferring good scalability almost automatically. Furthermore, I will argue that shear-flexible shell theory (e.g., Reissner-Mindlin, not Kirchhoff-Love) is necessary to model transverse shear fracture, in addition to appropriate constitutive models for the cohesive zones. Numerical examples will be presented that highlight the ability to capture the sought transverse shear failure modes and that demonstrate that the proposed framework can successfully tackle large-scale engineering problems through parallel computation.

About the Speaker: Brandon Talamini is a postdoctoral research associate in the Department of Mechanical Engineering at the Massachusetts Institute of Technology. He earned his PhD from MIT in 2015 in Aeronautics and Astronautics. Prior to this, he worked as an engineer at the Volpe National Transportation Systems Center of the U.S. Department of Transportation. His current research interests include modeling of hydrogen-induced failure in ferritic steels and in mesh adaptation schemes for phase field models of fracture.

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