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PERIDYNAMICS WITH ADAPTIVE GRID REFINEMENT

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In recent years, a new non-local theory of continuum mechanics called Peridynamics [1,8] has proven to be an efficient framework for computational applications to analyze phenomena involving crack formation and propagation in structural materials. Such potentiality of Peridynamics is due to its formulation, which is based on an integral operator for the motion equation, and therefore differs from the classical continuum theory, based on spatial derivatives. Moreover an unambiguous damage criterion, determined by energy considerations, is easily implemented within the formulation.

In general, fracture mechanic phenomena are linked to a scale length which is comparable to the microscopic structure of the material and this length can be assumed as the maximum distance at which the non-local interaction is still present [5], that is the so called horizon. The peridynamic numerical implementation of uniform grid spacing and a constant horizon for the entire structure [7] does not allow the best choice for the management of the computational resources. An alternative promising approach is to implement an adaptive grid refinement technique [3,4] in order to automatically increase the nodal density and decrease the horizon length in those areas in which cracks form and propagate. This method is applied to two dimensional structures introducing activation triggers based both on the damage state and on the deformation energy associated to each node. The numerical solution of the peridynamic theory shows that three different types of convergence can be identified depending on how the ratio between horizon and the grid spacing is changed and whether one of the two quantities is maintained constant [3]. The adaptive grid refinement is applied in order to analyze how these kinds of convergence influence crack propagation. This analysis is carried out on a local level, since the type of convergence is employed for a limited area around cracks, while some previous studies applied it on the entire body [6].

The dynamic analyses show phenomena of distortion and spurious reflections [2] of tensile waves which pass through the interface regions: for this reason, the effects of non-uniform grid spacing within a multiscale approach on the propagation of a plane wave are analyzed. The possibility of implementing a concurrent multiscale modeling within the same theory is more advantageous than those concurrent multiscale models which couple atomistic models with local continuum models, since there is no need for further manipulations of the equations in order to correctly propagate tensile waves in the interface regions between different models.

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