The Peridynamic Petrov Galerkin Method - A Generalized Peridynamic Correspondence Formulation for Finite Elasticity and Fluid Flows

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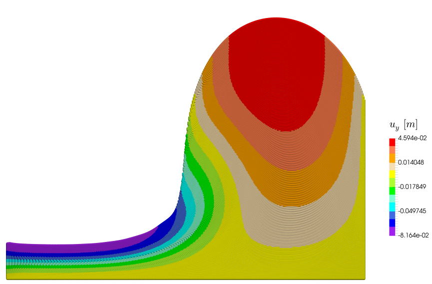
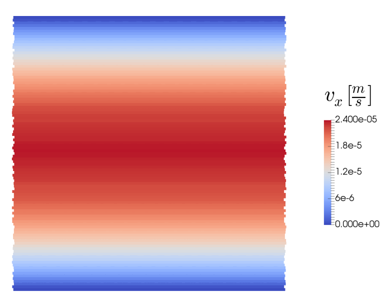
ABSTRACT

One advantage of meshfree methods is their flexibility in dealing with changing surfaces, large deformations and phase changes. Peridynamics is a non-local integro-differential reformulation of the balance of linear momentum (see [1]). It is widely used in solid mechanics for fracture simulation, but in past years the area of applications rapidly increased.

In the context of Peridynamics it is distinguished between two fundamental material modeling approaches presented in [2]: The first one is to derive the constitutive response from a non-locally distributed strain energy density function and the second one is, to use a locally defined strain energy density provided by the classical continuum mechanics. For this purpose, a correspondence formulation and the peridynamic reduction operation provide the link between local and non-local measures. The peridynamic pairwise force state and deformation state are the non-local counterparts to the stress tensor and deformation gradient in the local continuum mechanics theory. With this linking, the resulting non-ordinary state based peridynamic method is a flexible meshfree method which is equivalent to the total Lagrangian corrected SPH (see [3]) and thus suffers from the same drawbacks like low-energy modes. In terms of peridynamics, the oscillations were lead back to the locally averaged deformation gradient and in recent years, several stabilization techniques were introduced which shall overcome this issue.

The novel Peridynamic Petrov-Galerkin Method (PPG Method) is based on the weak form of the peridynamic momentum equation and yields a generalized correspondence formulation, which contains the common formulation as a special case. It is free of low-energy modes without the use of stabilizations and provides meshless ansatz function conditions for an accurate imposition of boundary conditions. Furthermore, the formulation can be consistently linearized and the power of Automatic Differentiation can be utilized to linearize more complex material models. An implicit updated Lagrangian PPG framework is used to demonstrate the flexibility and accuracy for finite elasticity and fluid flows.





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