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Simulation of fracture and damage with Peridynamics.jl

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1. Summary

`Peridynamics.jl` is an open source Julia [1] implementation of the nonlocal continuum mechanics formulation by Silling (ref?). In peridynamics, a body is described by material points and, based on interactions between them, internal force densities are calculated. The equation of motion reads

$$\varrho\,\ddot{\boldsymbol{u}}(\boldsymbol{X},t) = \boldsymbol{b}^{\mathrm{int}}(\boldsymbol{X},t) + \boldsymbol{b}^{\mathrm{ext}}(\boldsymbol{X},t) \qquad \forall \boldsymbol{X} \in \mathcal{B}_0,\ t \geq 0\ , \quad (1)$$

with the mass density ϱ, the point acceleration vector $\ddot{\boldsymbol{u}}$, and the point force density vectors $\boldsymbol{b}^{\mathrm{int}}$ and $\boldsymbol{b}^{\mathrm{ext}}$. In the original bond-based formulation (BB), the internal force density is calculated by

$$\boldsymbol{b}^{\mathrm{int}}(\boldsymbol{X},t) = \int_{\mathcal{H}} \boldsymbol{f}\ \mathrm{d}V'\ , \quad (2)$$

with the *pairwise force function* $\boldsymbol{f}$, which is evaluated for each material point $\boldsymbol{X}^i$ and depends on the deformation of the bonds to each point in its neighborhood $\mathcal{H}$. These point families contain each point within a distance δ, also called horizon.
To overcome the restrictions of the BB formulation with only one determinable material parameter, the state-based formulation was established. Here not only the bonds to neighboring material points, but also the states of neighboring points influence the internal force density $\boldsymbol{b}^{\mathrm{int}}$ of each material point. The equation reads

$$\boldsymbol{b}^{\mathrm{int}}(\boldsymbol{X},t) = \int_{\mathcal{H}} \boldsymbol{t} - \boldsymbol{t}'\ \mathrm{d}V'\ , \quad (3)$$

with the force vector states $\boldsymbol{t} = \boldsymbol{t}(\boldsymbol{\Delta X}, t)$ and $\boldsymbol{t}' = \boldsymbol{t}(-\boldsymbol{\Delta X}, t)$.
The `Peridynamics.jl` package enables users to perform peridynamic simulations.

2. Statement of need

The package was already used in numerous publications, e.g. [2, 4, 7, 5, 6, 3].

3. Acknowledgments

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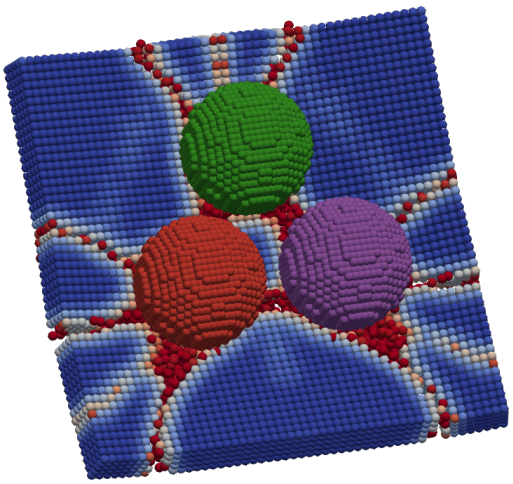

Fig. 1: High-velocity contact simulation of three spheres crashing into a rectangular panel; logo of Peridynamics.jl

Fig. 2: Fracture simulation of tensile tension test with a crack propagating in the middle of the specimen

4. References

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