Computational Modelling of Blade Erosion:

A Coupled Peridynamic & Discrete Element Method approach

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Vision and Objectives

To develop an open-source framework for modelling erosive impact of particles/ droplets with wind turbine blades.

The Problem

The erosion of wind turbine blades due to rain droplets and solid particles is becoming more severe due to the increase of the size of wind turbines and their tip speed making impacts more destructive. At the minimum this increases the drag. Worst case, it compromises the structural integrity of the blade. In order to better understand this phenomena a comprehensive study of the impact damage mechanisms must be conducted. This will be accomplished using a High-Fidelity simulation framework.

The Model

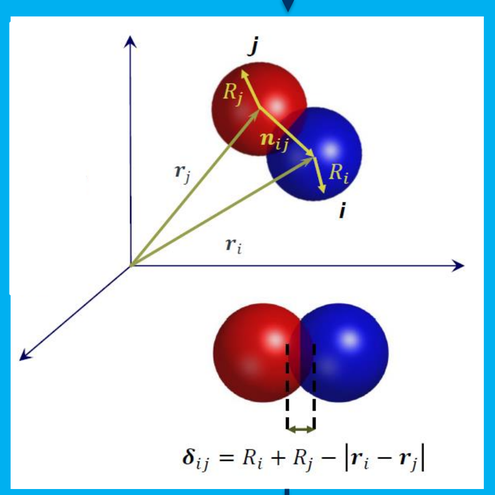
Utilise Discrete Element Method (DEM) to resolve the forces between particles and surface collision.
Peridynamics (PD) will be used in order to simulate the particle and surface damage / deformation.

Coupling these two methods will allow for detailed damage assessment and reduce the cost of computation in comparison to a pure Peridynamic approach

Discrete Element Method

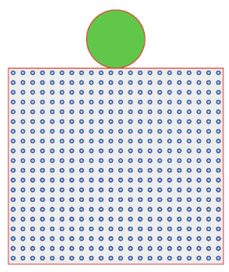
- Uses soft collision model.
- Forces between particles/wall can be modelled using a spring and dashpot.
- The model considers normal and tangential forces.

$$\boldsymbol{F}_{n_{ij}} = k_n \delta_{ij} \boldsymbol{n}_{ij} - \gamma_n m^* \boldsymbol{v}_{n_{ij}}$$
$$\boldsymbol{F}_{t_{ij}} = k_t \boldsymbol{u}_{t_{ij}} - \gamma_t m^* \boldsymbol{v}_{t_{ij}}$$



Peridynamics

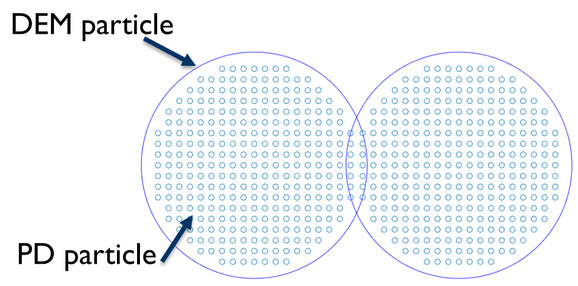
- Peridynamics is a particle based approach to model damage and deformation to particles and surfaces.
- Reformulation of classical continuum mechanics based on integrals which allows for the equation to be applied across surface cracks.



$$\rho_m \ddot{\mathbf{u}}(\mathbf{x},t) = \int_H \mathbf{f}(\eta,\xi) dV_{\mathbf{x}'} + \mathbf{F}_b(\mathbf{x},t) \qquad \forall \mathbf{x} \in R,$$

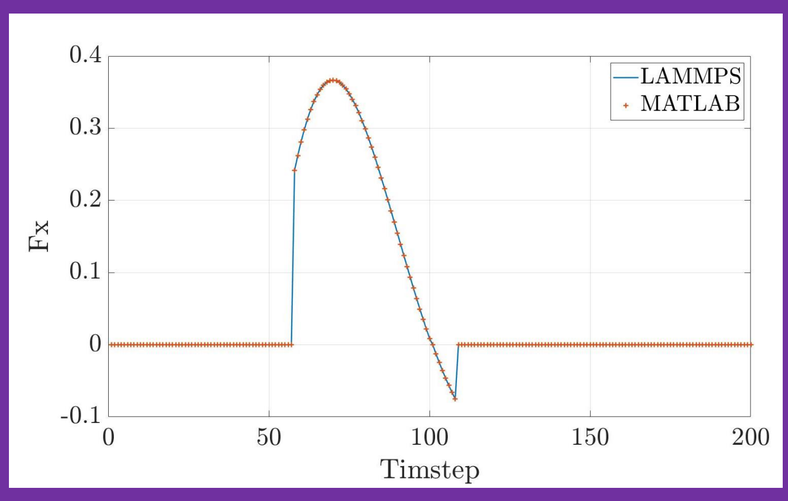
PD-DEM Coupling

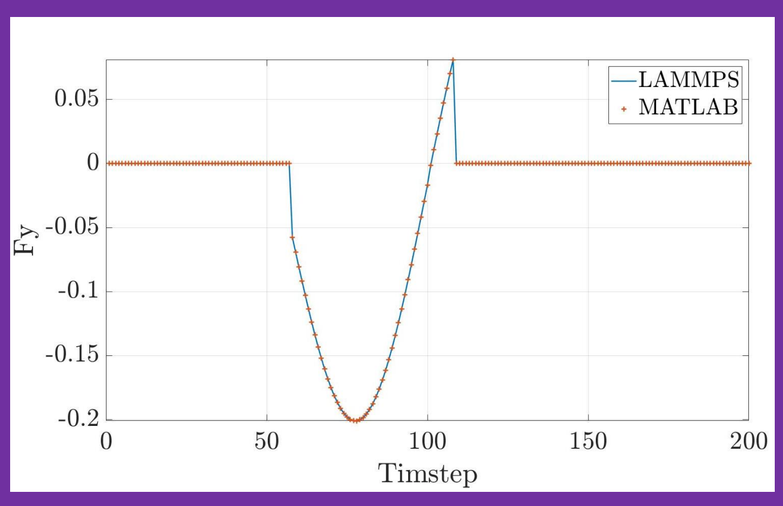
- Using DEM to resolve the impact forces and PD to simulate the damage allows for a computationally inexpensive way to asses damage
- Using this meshless approach will allow for easy integration of fluid solvers and reduces computational costs of remeshing



Initial Simulation Results

Two Spheres colliding DEM validation





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