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Ensemble Data Assimilation Method Applied to Meshless Simulations

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Data assimilation is a process used in many scientific fields (such as meteorology, oceanography, and hydrology) to integrate observed data with output from a numerical model. This process aims to provide more accurate and consistent information about the state of a system. These data assimilation methods aim to refine model predictions iteratively using observed data [1]. Intensive efforts have been made to apply these methods to high-dimensional and non-linear problems. In this work, we focus on the Ensemble Kalman Filter (EnKF) to perform data assimilation.

While these methods have been naturally applied to problems defined on solutions within Eulerian grids, their applications to Lagrangian (or meshless) simulations have been limited. Meshless methods discretize continuous fields and operators using a set of particles that move according to a velocity field.
The main challenge lies in updating an ensemble of meshless simulations from experimental data. Indeed, for the EnKF, the correction step requires a linear combination of states which is not convenient when each run has its own particle discretization.
Moreover, configurations may not share the same supports, necessitating the introduction of a method to reposition the particle distribution appropriately.

In this presentation, we will introduce various data assimilation filters capable of addressing this issue. These approaches specifically consider the particle structure of the state and implement methods to correct the different states. These methods involve remeshing schemes, particle approximation steps, or state alignment methods. The filters will be applied to a 2D incompressible fluid dynamics problem using The Vortex Method (VM) [2].

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