Center for Environmental & Applied Fluid Mechanics

"Stochastic Particle Advection Velocimetry (SPAV): Reconstructing Accurate Eulerian Fields from Noisy Lagrangian Particle Tracks"

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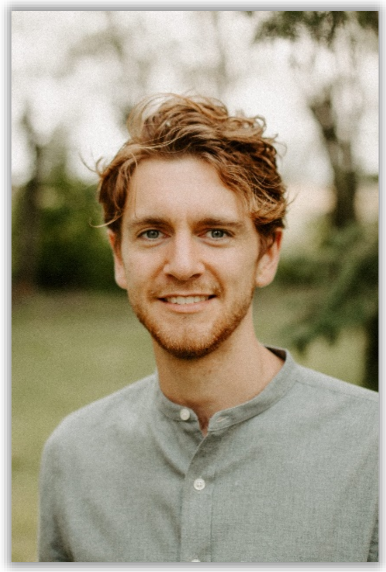

Particle tracking velocimetry (PTV) is a powerful tool for experimental research on fluid dynamics. Tracer particles are seeded into a flow and imaging or magnetic sensors are used to record the particle cloud over time. The particles are localized and linked across frames to produce Lagrangian tracks, which may be processed with a data assimilation algorithm to reconstruct Eulerian velocity fields and infer pressure. Inaccurate localization and tracking are key sources of error in PTV, especially for single camera defocusing, plenoptic imaging, and digital in-line holography (DIH) sensors. Stochastic particle advection velocimetry (SPAV) is a statistical data loss that improves the accuracy of PTV in the presence of noisy tracks. SPAV is based on an explicit particle advection model that predicts particle positions over time as a function of the estimated velocity field. The model can account for non-ideal effects like drag forces on inertial tracers. The technique is implemented using a physics-informed neural network, which simultaneously minimizes the SPAV data loss, a Navier–Stokes physics loss, and a wall boundary loss, where appropriate. Results are reported for simulated and experimental DIH-PTV measurements of laminar and turbulent flows. SPAV significantly improves the accuracy of PTV reconstructions compared to a conventional data loss, resulting in an average reduction of error close to 50%. Furthermore, it can be readily adapted to work with other data assimilation paradigms including state observer, Kalman filter, and adjoint–variational methods.

Spring 2023 CEAFM Seminar Series

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