LadHyX Seminar – May 4, 14:00 – LadHyX library

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Neural-implicit particle advection for PTV (with UQ) and beyond

Particle tracking velocimetry (PTV) is a powerful tool for experimental research on fluid dynamics. Tracer particles are seeded into a flow, localized with imaging or magnetic sensors, and tracked over time. Lagrangian particle tracks may be used to reconstruct the Eulerian velocity and pressure fields, but these estimates are adversely affected by localization and tracking errors. We introduce a neural-implicit data assimilation framework that can compensate for noisy tracks by modeling the advection of particles as well as the corresponding uncertainties. A neural network that maps space–time coordinates to flow fields, $(x, y, z, t) \rightarrow (u, v, w, p)$, serves as a functional representation of the flow. The network is trained to (approximately) satisfy the Navier–Stokes equations (NSE) by optimizing a "physics loss" that comprises exact residuals from the NSE, integrated over the spatiotemporal domain. A "data loss" is constructed by comparing measured and advected particle position probability density functions. Minimizing the aggregate loss yields a network that is consistent with the governing physics and experimental data, subject to the distribution of measurement uncertainties. The technique is demonstrated with numerical and experimental digital in-line holography PTV measurements of laminar and turbulent flows. Extensions to inertial particle transport are discussed.