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Imaging-Based Lagrangian Particle Tracking: A Tutorial[1]

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Over the past ten years, there has been an explosive growth in the analysis of turbulent flows in the Lagrangian frame of reference. This is driven in large part by new capabilities in tracking particles in turbulent flows at high Reynolds numbers. Among the particle tracking techniques successfully implemented, imaging-based Lagrangian particle tracking is the most extensively used and provides the highest resolution and the most detailed Lagrangian data of particles in turbulence. Imaging-based particle tracking uses stereoscopic views of particle motions in turbulent flows to reconstruct the 3D trajectories. The most significant challenge is with obtaining the necessary (sub-Kolmogorov) spatial and temporal accuracy to resolve the fastest events in the flow (e.g., large particle accelerations). In this talk, I will review methods we have used to track single- and multiple-particle trajectories in three spatial dimensions and time, including detection of particles based on photo-diode arrays, silicon strip detectors, and ultra-fast CMOS cameras. I will describe in detail the image processing steps to obtain Lagrangian information, including the evaluation and suppression of the effect of noise in the measurement. I will also discuss a new strategy we have developed to dramatically extend particle trajectories by reconstructing trajectory fragments in the images.

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