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DPD-v2: Convolutional Neural Networks for Particle Diffusometry Measurements in the Presence of Flow and with Defocused Particles

Diffusion is a natural phenomenon in fluids. Its measurement can be done optically by seeding an otherwise featureless fluid with tracer particles and observing their motion using a microscope. However, existing particle-based diffusion coefficient measurement algorithms have multiple failure modes, especially when the fluid has a flow, or the particles are defocused. This work uses Convolutional Neural Networks (CNNs) as an alternative for predicting diffusion coefficients using PIV-styled crops in the presence of these real-world effects. The networks were trained, validated, and tested on datasets with Gaussian-shaped or defocused particles under an arbitrary flow condition. The results show that the CNNs have a low Mean Absolute Error (MAE) of 0.09 um2/s and 0.07 um2/s between the true and predicted diffusion coefficient values for the dataset with Gaussian-shaped and defocused particles respectively. The performance of the CNNs was also benchmarked against four conventional algorithms on the simulated datasets. The results show that the CNNs outperform conventional methods when the particles are defocused. Finally, the outputs of CNNs were compared against the outputs of conventional algorithms on experimental datasets, leading to uncertainty in the range of 0.19 um2/s - 0.47 um2/s. Hence, the study utilized CNNs to reliably predict diffusion coefficients from complex particle datasets where the conventional algorithms fail.

Focus areas

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