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Direct Measurement of Rotation and Scaling in Particle Image Velocimetry using the Fourier-Mellin Transform MATTHEW GIARRA, Virginia Tech, JOHN CHARONKO, Los Alamos National Laboratory, PAVLOS VLACHOS, Purdue University — Traditional particle image velocimetry (PIV) can fail in the presence of spatial velocity gradients because the shearing, stretching, and rotation of particle image patterns can corrupt Cartesian cross correlations. We propose a novel algorithm that measures the rotation and isotropic scaling of individual subregions of PIV images. Our algorithm adopts the Fourier-Mellin (FM) image transformation, which decouples rotation from isotropic scaling and is invariant to translation. Rotation and scaling in the original image manifest as orthogonal translations in the FM-domain, which can then be measured by standard cross correlation. These properties allow for the direct measurement of vorticity (rotation) within a region of interest without relying on the spatial differencing of adjacent velocity vectors. Our algorithm also improves velocity estimates in regions of large rotation (like vortex cores) by applying the inverse rotation and stretching of the particle pattern prior to performing Cartesian correlations that estimate displacements. In this work, we apply our algorithm to synthetic and experimental PIV images and show significant improvement to the vorticity and velocity estimates compared to traditional PIV in regions where rotation is significant.

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