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Accurate bundle adjustment calibration of multicamera volumetric velocimetry systems

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ABSTRACT

Several three-dimensional (3D) flow velocimetry systems use multiple cameras to perform volume reconstruction. The accuracy of velocity fields derived from reconstructed volumes depends on accurate camera calibration. Calibrating by accurately placing a precision target throughout the volume is an error prone chore. However, the use of multiple cameras allows for bundle adjustment, which results in very accurate calibration when applied appropriately. Bundle adjustment routines have traditionally been used in computer vision applications to simultaneously estimate camera parameters and 3D scene point locations through minimization of reprojection errors. This study presents a multicamera model that accounts for index of refraction changes in the lines of sight encountered at air–wall–water interfaces. Accurate estimation of camera parameters, scene points and refractive interface parameters is demonstrated using a bundle adjustment algorithm applied to simulated and experimental data. The only accurate a priori information required is the 2D geometry of a calibration plane and the wall thickness of the interface; other parameters can be initialized with relatively poor guesses. This talk also places an emphasis on how multicamera calibration accuracy is quantified. Oftentimes in multicamera 3D flow velocimetry literature, reprojection error is assumed to be the measure of calibration accuracy. In general, this is incorrect as bundle adjustment minimization routines are not guaranteed to converge to a global minimum. Without certain geometric constraints, camera parameters and scene points may be estimated inaccurately even while reprojection error is reduced to subpixel levels. Methods for ensuring accurate geometric calibration are reviewed and the pitfalls of unconstrained self-calibration are discussed.