A Finite Volume Method for Pressure Extraction on Unstructured Flow Data

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HIGHLIGHTS
• A Lagrangian pressure-extraction technique based on the finite volume method is presented and evaluated.
• The novel technique is evaluated using an analytical test case in comparison to a finite difference-based Lagrangian technique, and a basic Eulerian technique.
• The novel technique is shown to produce pressure fields with half the error as the basic Eulerian technique, and an order of magnitude less error than the Lagrangian finite difference-based technique.

ABSTRACT
A novel, finite volume method-based, Lagrangian pressure-extraction technique (Lagrangian FVM) is proposed and comparatively evaluated using an analytical test case. First, the derivation of the finite-volume formulation of the Poisson equation for pressure is presented, along with a detailed explanation of how the method is implemented. Next, the analytical test case, the Taylor-Green vortex field, is defined. Over a range of spatial particle densities, and using mixed Neumann and Dirichlet boundary conditions, the performance of the Lagrangian FVM is compared to a Lagrangian pressure-extraction technique based on finite-differences (Lagrangian FDM), as well as a basic second-order Eulerian pressure-extraction technique. Over the range of spatial particle densities surveyed, the Lagrangian FVM is found to estimate the pressure field with one half of the error as compared to the Eulerian technique, and an order of magnitude less error as compared to the Lagrangian FDM. Further, Lagrangian FVM produces the most consistent error fields, both spatially and between trials. Finally, a path forward for further investigation of the technique is described, including further comparative tests with high-fidelity experimental data, and a more thorough investigation into the propagation of errors in the underlying flow data.

Fig. 1 Error in 2D slice of extracted pressure fields using (a) basic Eulerian method, (b) Lagrangian FDM, (c) Lagrangian FVM.