Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Estimation of 3D Velocity and Pressure Fields from Tomographic Background Oriented Schlieren Videos using a Physics-Informed Neural Network SHENGZE CAI, ZHICHENG WANG, Brown University, FREDERIK FUEST, YOUNG JIN JEON, LaVision GmbH, CALLUM GRAY, LaVision Inc., GEORGE KARNIADAKIS, Brown University — Tomographic background oriented schlieren (Tomo-BOS) imaging measures density or temperature fields in 3D using multiple camera BOS projections, and is particularly useful for instantaneous flow visualizations of complex fluid dynamics problems. In this paper, we propose a new algorithm based on physics-informed neural networks (PINNs) to infer the full continuous 3D velocity and pressure fields from snapshots of 3D temperature fields obtained by Tomo-BOS imaging. PINNs seamlessly integrate the underlying physics of the observed fluid flow and the visualization data, hence enabling the inference of latent quantities using limited experimental data. In this hidden fluid mechanics paradigm, the neural network is trained by minimizing a loss function composed of a data mismatch term and a residual term associated with the coupled Navier-Stokes and temperature equations. The proposed method is first validated based on a 2D set of synthetic data for buoyancy-driven flow, and subsequently it is applied to the 3D Tomo-BOS data set. We demonstrate that by using PINNs, we are able to quantify accurately the instantaneous three-dimensional velocity and pressure of the flow over a coffee mug based on the temperature field provided by the tomographic Tomo-BOS imaging.

Shengze Cai
Brown University

Date submitted: 02 Aug 2020 Electronic form version 1.4