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A PINN Methodology for Temperature Field Inference in the PIV Measurement Plane: Case of Rayleigh-Bénard Convection

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Traditional PIV measurements only provide planar velocity data, and simultaneous spatially resolved measurements of temperature fields can only be performed with a different and more elaborated setup using temperature-sensitive tracer particles. PINNs have already shown great potential for improving the quality of PIV measurements [1] by combining data information and the knowledge of the governing equations. In this study, we present a method to infer temperature fields from planar PIV data in turbulent Rayleigh-Bénard convection (RBC), using a PINN approach that extends the methods outlined in [2, 3]. The physical setup is a cubic RBC cell (cf. fig. 1). With data only available in a plane $A : x = x_0$, the residuals of the governing PDEs are solved in an enclosing 3D domain with thickness δ_x . The parameter δ_x must be carefully chosen within $0 < \delta_x < 1$, depending on the flow normal to A . For developing several methodological approaches, we take advantage of available DNS data to mimic PIV measurements. Results with three velocity components show encouraging outcomes, with the coefficient of determination (R^2) exceeding 0.99. Reducing the input to just the two in-plane velocity components, requires the inclusion of additional physical constraints, due to the lack of information about the flow perpendicular to A . Our study provides a foundation for future research focused on inferring temperature fields through in-field measurements in industrial applications with more complex geometries.

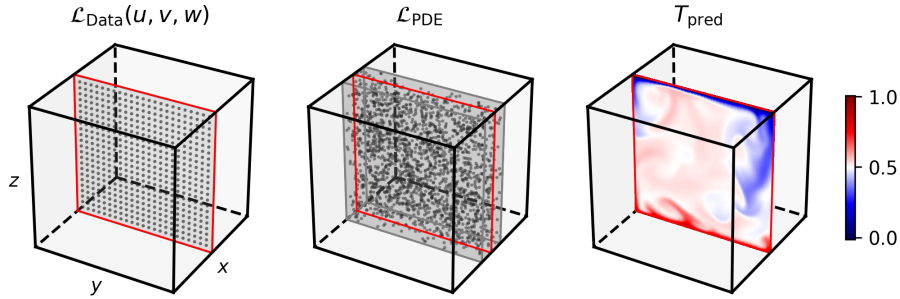


Figure 1: Schematic of a cubic RBC cell with height H for the test case $Ra = 10^7$ and $Pr = 0.7$. We aim to infer the temperature field within the vertical plane $A : x = 0.5 H$ (exemplary result on the right) using velocity data on A (left) and minimizing the residuals of the PDEs within a 3D collocation layer (middle).

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References

- [1] G. Hasanuzzaman, H. Eivazi, S. Merbold, C. Egbers, R. Vinuesa. *Meas. Sci. Technol.*, 34(4):044002, 2023.
- [2] D. Lucor, A. Agrawal, A. Sergent. *J. Comput. Phys.*, 456:111022, 2022.
- [3] M. Mommert, R. Barta, C. Bauer, M. Volk, C. Wagner. *Comput. Fluids*, 283:106419, 2024.