PHYSICS-INFORMED NEURAL NETWORKS FOR BLOOD FLOW INVERSE PROBLEMS

JEREMÍAS GARAY, JOCELYN DUNSTAN, SERGIO URIBE, AND FRANCISCO SAHLI COSTABAL

Abstract. Physics-informed neural networks (PINNs)[1, 2] have emerged as a powerful tool for solving inverse problems, especially in cases where no complete information about the system is known and scatter measurements are available. This is especially useful in hemodynamics since the boundary information is often difficult to model, and high-quality blood flow measurements are generally hard to obtain. In this work, we use the PINNs methodology for estimating reduced-order model parameters such as the ones used in the Windkessel model [3], and the full velocity field from scatter 2D noisy measurements in the ascending aorta. The results show robust and accurate parameter estimations when using the method with simulated data, while the velocity reconstruction accuracy shows dependence on the measurement quality and the flow pattern complexity. In conclusion, the presented methodology allows for solving clinical-relevant inverse problems in hemodynamics and complex coupled physical systems.

Keywords: Physics-informed neural networks, hemodynamics, reduced-order modeling, blood flow, patient-specific model

References

[1] Raissi, Maziar and Perdikaris, Paris and Karniadakis, George E. Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations *Journal of Computational Physics*, 378: 686–707, 2019.

[2] Cai, Shengze and Mao, Zhiping and Wang, Zhicheng and Yin, Minglang and Karniadakis, George Em Physics-informed neural networks (PINNs) for fluid mechanics: A review. *Acta Mechanica Sinica*, 37: 1727–1738, 2021.

[3] Westerhof, N and Lankhaar, JW and Westerhof, BE. The arterial Windkessel *Medical biological engineering and computing*, 47: 131-41, 2009.

Pontifical Catholic University of Chile
Email address: jeremias.garay.l@gmail.com

Pontifical Catholic University of Chile
Email address: jdunstan@ing.puc.cl

University of Monash
Email address: sergio.uribe@monash.edu

Pontifical Catholic University of Chile
Email address: fsc@ing.puc.cl