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Machine learning in cardiovascular flows modeling: Predicting pulse wave propagation from non-invasive clinical measurements using physics-informed deep learning[1] GEORGIOS KISSAS, YIBO YANG, EILEEN HWUANG, WALTER WITSCHEY, JOHN DETRE, PARIS PERDIKARIS, University of Pennsylvania, CORLAB TEAM, PREDICTIVE INTELLIGENCE LAB TEAM — Advances in computational science offer a principled pipeline for predictive modeling of cardiovascular flows and aspire to provide a valuable tool for monitoring, diagnostics & surgical planning. Such models can nowadays be deployed on large patient-specific topologies of systemic arterial networks; but their success heavily relies on tedious pre-processing and calibration procedures that typically induce a significant computational cost. In this work we put forth a machine learning framework that enables the seamless synthesis of non-invasive in-vivo measurement techniques & computational flow dynamics models derived from first physical principles. We illustrate this new paradigm by showing how one-dimensional models of pulsatile flow can be used to constrain the output of deep neural networks such that their predictions satisfy the conservation of mass and momentum principles. Once trained on noisy and scattered clinical data of flow and wall displacement, these networks can return physically consistent predictions for velocity, pressure and wall displacement pulse wave propagation, and calculate the Windkessel model parameters as a post-processing step.

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