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Inferring Physical Laws from Data: Disambiguating Gravity from Fluid Forces on Falling Objects BRIAN DE SILVA, University of Washington, department of Applied Mathematics, DAVID HIGDON, Virginia Polytechnic Institute and State University, department of Statistics, STEVEN BRUNTON, University of Washington, department of Mechanical Engineering, NATHAN KUTZ, University of Washington, department of Applied Mathematics — Machine learning and artificial intelligence algorithms are now being used to automate the discovery of governing physical equations from measurement data alone. However, positing a universal physical law from data is challenging without simultaneously proposing an accompanying discrepancy model to account for the inevitable mismatch between theory and measurements. By revisiting the classic problem of modeling falling objects of different size and mass, we highlight a number of subtle issues that must be addressed by modern data-driven methods for the automated discovery of physics. Specifically, we show that measurement noise and complex secondary physical mechanisms, such as unsteady fluid drag forces, can obscure the underlying law of gravitation, leading to a faulty model. Using the sparse identification of nonlinear dynamics (SINDy) algorithm, with the added assumption that each falling object is governed by the same physical law, we are able to identify a viable discrepancy model to account for the fluid dynamic forces that explain the mismatch between a posited universal law of gravity and the measurement data. This work highlights the fact that the naive application of ML/AI will generally be insufficient to extract universal physical laws without further modification.

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