Rediscovering Newton's gravity and Solar System properties using deep learning and inductive biases

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Abstract

We present an approach for using machine learning to automatically discover a physical law and associated properties of the system from real observations. We trained a neural network-based architecture, whose structure corresponds to classical mechanics, to simulate the dynamics of our Solar System from 30 years of observed trajectory data. We then used symbolic regression to extract a symbolic formula for the force law, which our results show matches Newtonian gravity. We find that by scaling the model's predicted acceleration by a trainable scalar variable, we could infer bodies' (relative) masses despite that they were not observable in the data itself. Though "Newtonian" gravity has of course been known since Newton, our approach did not require knowledge of this physical law, and so our results serve as a proof of principle that our method can extract unknown laws from observed data. This work takes a step towards using modern machine learning tools beyond data processing and analysis, but automated scientific theory formation and development.
Slides: in Keynote

Video: https://youtu.be/y05V_q69ryg

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