Research Highlight:
Understanding Deep Learning through Dynamics

Work of Presidential Young Professor LI Qianxiao

Recently, deep learning has become an important tool is data science and machine learning. However, a complete theoretical understanding of its effectiveness remains elusive. One key reason is the lack of a good mathematical framework to analyse the effect of composition on learning, and this is widely believed to be the essence of deep learning. In this paper, we develop a mathematical framework to analyse deep learning by drawing connections with dynamical systems, calculus of variations and optimal control – encompassing classical areas of mathematics that started with the fundamental contributions of Euler and Lagrange. We prove some basic results on the idealization of deep neural networks as continuous time dynamical systems, including necessary and sufficient conditions for optimality in the framework of mean-field optimal control. This lays the mathematical basis for the investigation of deep learning through the dynamical systems viewpoint.

Reference:

Weinan, E, Jiequn Han, and Qianxiao Li. “A Mean-Field Optimal Control Formulation of Deep Learning.” Research in the Mathematical Sciences 6, no. 1 (2019): 10.