Data Driven Governing Equations Approximation Using Deep Neural Networks

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We present a numerical framework for approximating unknown governing equations using observation data and deep neural networks (DNN). In particular, we propose to use residual network (ResNet) as the basic building block for equation approximation. We demonstrate that the ResNet block can be considered as a one-step method that is exact in temporal integration. We then present two multi-step methods, recurrent ResNet (RT-ResNet) method and recursive ReNet (RS-ResNet) method. The RT-ResNet is a multi-step method on uniform time steps, whereas the RS-ResNet is an adaptive multi-step method using variable time steps. All three methods presented here are based on integral form of the underlying dynamical system. As a result, they do not require time derivative data for equation recovery and can cope with relatively coarsely distributed trajectory data. Several numerical examples are presented to demonstrate the performance of the methods.