System identification through Lipschitz regularized deep neural networks

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In this work we use neural networks to learn governing equations from data. Specifically, we reconstruct the right-hand side of a system of ODEs $\dot{x}=f(t,x(t))$ directly from observed uniformly time-sampled data using a neural network. In contrast with other neural network-based approaches to this problem, we add a Lipschitz regularization term to our loss function. In the synthetic examples we observed empirically that this regularization results in a smoother approximating function and better generalization properties when compared with non-regularized models, both on trajectory and non-trajectory data, especially in presence of noise. In contrast with sparse regression approaches, since neural networks are universal approximators, we do not need any prior knowledge on the ODE system. Since the model is applied component wise, it can handle systems of any dimension, making it usable for real-world data. I will talk about the advantages and limitations of our method and propose possible future directions of research.