Empowering Probabilistic Inference with Stochastic Deep Neural Networks

Guoqing Zheng

Abstract

Probabilistic modeling are powerful tools in understanding real world data from various domains, such as natural languages, images, temporal time series. Often complex and flexible probabilistic model is preferred for accurate modeling, however inference difficulty often arise due to high computation or infeasible design cost for the inference algorithm. Meanwhile, recent advances with deep neural networks in both supervised and unsupervised learning have shown prominent advantages in learning complex deterministic functions from its input to its output. Integrating deep neural networks into probabilistic modeling thus becomes an important research direction. Though existing research has opened the door of using deep neural networks to model stochasticity for probabilistic modeling, it still suffers from limitations, such as a) the family of distributions that can be captured for inference is limited, b) probabilistic statements about the data cannot be made for some models, even though they take uncertainty into account, and c) applications to discrete and dynamic temporal data have not yet been fully explored.

In this thesis, we aim to address the above limitations of incorporating stochastic deep neural networks for probabilistic inference. Specifically, we propose: a) to enrich the family of variational distributions for inference, b) to equip probabilistic statements for the models that have been shown to capture real data well and c) to explore applications of stochastic neural inference to domains where data are discrete and dynamic, such as natural languages and temporal time series. Preliminary experimental results have demonstrate the effectiveness of the proposed approaches.