Markov Logic Networks: Theory, Algorithms and Applications

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ABSTRACT

Most real world problems are characterized by relational structure i.e. entities and relationships between them. Further, they are inherently uncertain in nature. Theory of logic gives the framework to represent relations. Statistics provides the tools to handle uncertainty. Combining the power of two becomes important for accurate modeling of many real world domains. Last decade has seen the emergence of a new research area popularly known as Statistical Relational Learning (SRL) which aims at achieving this merger. Markov logic is one of the most well-known SRL models which combines the power of first-order logic with Markov networks. The underlying domain is represented as a set of weighted first-order logic formulas. The associated weight of a formula represents the strength of the corresponding constraint. Higher the weight, stronger the constraint is. Markov logic theory can be seen as defining a template for constructing ground Markov networks, and hence, the name Markov logic networks.

Inference problem in Markov logic corresponds to finding the state of a subset of nodes (query) given the state of another subset of nodes (evidence) in the network. Learning corresponds to finding the optimal set of weights for the formulas as well as discovering the formulas themselves. Many of the standard algorithms for inference and learning in ground Markov networks do not scale well to the size of the networks that can be represented using Markov logic. Further, there is a rich template structure across ground formulas which can be exploited to devise efficient inference and learning algorithms. Due to their representational strength, availability of inference and learning algorithms, ease of use and the availability of an open source implementation, Markov logic has been effectively applied to a variety of application domains including entity resolution, web-mining, link prediction, social network analysis, image analysis, robotics, natural language processing and plan recognition, to cite a few.

This tutorial will cover in detail the theory behind Markov logic starting from the basics of first-order logic and Markov networks. We will also look at various inference and learning algorithms for Markov logic. Second half of the tutorial will focus on some of the applications to which Markov logic has been applied. We will look at the modeling aspect of the problem as well as actually writing up the theory using the open source software, Alchemy, which implements Markov logic framework.

Bio-Sketch

Parag is an undergraduate from IIT Bombay batch 2002. He studied at the University of Washington Seattle to get his Masters and PhD degrees. His PhD work focused on Markov logic, a formalism to combine the power of logic and probability. He has done some pioneering work in developing lifted inference techniques for Markov logic. He has also worked extensively in applying Markov logic to a variety of real world problems including entity resolution, link prediction, abductive plan recognition and vision related problems. His paper on a new technique for entity resolution using attribute-mediated dependences won the best paper award at PKDD 2005. After finishing his PhD in 2009, he spent a couple of years at UT Austin for a post-doc. He has been working as an Assistant Professor at IIT Delhi since December 2011. His current research work continues to focus on developing efficient inference and learning algorithms for SRL (statistical relational learning) models. He is also looking at their application to social network analysis and video activity recognition. Parag has over a dozen publications in top tier peer-reviewed international conferences and workshops, one best paper award and two patents to his name. He has been a reviewer for many reputed international journals and served on the program committee for several premiere international conferences including senior program committee for IJCAI-11 and program committees for AAAI-12 and ECAI-12.

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