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Publications:

Statistical learning for predictive targeting in online advertising
The focus in this thesis is investigation of machine learning methods with applications in computational advertising. Computational advertising is the broad discipline of building systems which can reach audiences browsing the Internet with targeted advertisements. At the core of such systems, algorithms are needed for making decisions. It is in one such particular instance of computational advertising, namely in web banner advertising, that we investigate machine learning methods to assist and make decisions in order to optimize the placements of ads. The industrial partner in this work is Adform, an international online advertising technology partner. This also means that the analyses and methods in this work are developed with particular use-cases within Adform in mind and thus need also to be applicable in Adform’s technology stack. This implies extra thought on scalability and performance. The particular use-case which is used as a benchmark for our results, is clickthrough rate prediction. In this task one aims to predict the probability that a user will click on an advertisement, based on attributes about the user, the advertisement the context, and other signals, such as time. This has its main application in real-time bidding ad exchanges, where each advertiser is given a chance to place bids for showing their ad while the page loads, and the winning bid gets to display their banner. The contributions of this thesis entail application of a hybrid model of explicit and latent features for learning probabilities of clicks, which is a methodological extension of the current model in production at Adform. Our findings confirm that latent features can increase predictive performance in the setup of click-through rate prediction. They also reveal a tedious process for tuning the model for optimal performance. We also present variations of Bayesian generative models for stochastic blockmodeling for inference of structure based on browsing patterns. Applying this structural information to improve click-through rate prediction becomes a two-step procedure; 1) learn user and URL profiles from browsing patterns, 2) use the profiles as additional features in a click-through rate prediction model. The assumption we implicitly make is reasonable: Users and URLs that are grouped together based on browsing patterns will have similar responses to ads, e.g., can be used as predictors of clicks. We report successful examples of applying this approach in practice. Finally, we introduce the multiple-networks stochastic blockmodel (MNSBM), a model for efficient overlapping community detection in complex networks which can be assumed to be an aggregation of multiple block-structured subnetworks.

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Efficient inference of overlapping communities in complex networks

We discuss two views on extending existing methods for complex network modeling which we dub the communities first and the networks first view, respectively. Inspired by the networks first view that we attribute to White, Boorman, and Breiger (1976)[1], we formulate the multiple-networks stochastic blockmodel (MNSBM), which seeks to separate the observed network into subnetworks of different types and where the problem of inferring structure in each subnetwork becomes easier. We show how this model is specified in a generative Bayesian framework where parameters can be inferred efficiently using Gibbs sampling. The result is an effective multiple-membership model without the drawbacks of introducing complex definitions of "groups" and how they interact. We demonstrate results on the recovery of planted structure in synthetic networks and show very encouraging results on link prediction performances using multiple-networks models on a number of real-world network data sets.

Predicting clicks in online display advertising with latent features and side-information: Technical report

We review a method for click-through rate prediction based on the work of Menon et al. [11], which combines collaborative filtering and matrix factorization with a side-information model and fuses the outputs to proper probabilities in [0,1]. In addition we provide details, both for the modeling as well as the experimental part, that are not found elsewhere. We rigorously test the performance on several test data sets from consecutive days in a click-through rate prediction setup, in a manner which reflects a real-world pipeline. Our results confirm that performance can be increased using latent features, albeit the differences in the measures are small but significant.
Dimensionality reduction for click-through rate prediction: Dense versus sparse representation

In online advertising, display ads are increasingly being placed based on real-time auctions where the advertiser who wins gets to serve the ad. This is called real-time bidding (RTB). In RTB, auctions have very tight time constraints on the order of 100ms. Therefore mechanisms for bidding intelligently such as clickthrough rate prediction need to be sufficiently fast.

In this work, we propose to use dimensionality reduction of the user-website interaction graph in order to produce simplified features of users and websites that can be used as predictors of clickthrough rate. We demonstrate that the Infinite Relational Model (IRM) as a dimensionality reduction offers comparable predictive performance to conventional dimensionality reduction schemes, while achieving the most economical usage of features and fastest computations at run-time. For applications such as real-time bidding, where fast database I/O and few computations are key to success, we thus recommend using IRM based features as predictors to exploit the recommender effects from bipartite graphs.

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Large scale topic modeling made practical
Topic models are of broad interest. They can be used for query expansion and result structuring in information retrieval and as an important component in services such as recommender systems and user adaptive advertising. In large scale applications both the size of the database (number of documents) and the size of the vocabulary can be significant challenges. Here we discuss two mechanisms that can make scalable solutions possible in the face of large document databases and large vocabularies. The first issue is addressed by a parallel distributed implementation, while the vocabulary problem is reduced by use of large and carefully curated term set. We demonstrate the performance of the proposed system and in the process break a previously claimed 'world record' announced April 2010 both by speed and size of problem. We show that the use of a WordNet derived vocabulary can identify topics at par with a much larger case specific vocabulary.

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**Statistical learning for predictive targeting in online advertising**

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