An Introduction to Click Models for Web Search

SIGIR 2015 Tutorial

Aleksandr Chuklin
Google Switzerland &
University of Amsterdam
Zürich, Switzerland
a.chuklin@uva.nl

Ilya Markov
University of Amsterdam
Amsterdam, The Netherlands
i.markov@uva.nl

Maarten de Rijke
University of Amsterdam
Amsterdam, The Netherlands
derijke@uva.nl

ABSTRACT

In this introductory tutorial we give an overview of click models for web search. We show how the framework of probabilistic graphical models help to explain user behavior, build new evaluation metrics and perform simulations. The tutorial is augmented with a live demo where participants have a chance to implement a click model and to test it on a publicly available dataset.

Categories and Subject Descriptors

H.3 [**Information Storage and Retrieval**]: H.3.3 Information Search and Retrieval

Keywords

Click models; web search

1. INTRODUCTION

Click models, probabilistic models of the behavior of search engine users, have been studied extensively by the information retrieval community during the last five years.

A good body of work has been published on click models over the past 5 to 10 years. Importantly, the area continues to be an active one, with new models aimed at describing and/or predicting behavioral data being proposed at each of the main information retrieval conferences (SIGIR, WSDM, WWW, CIKM) over the past few years. There is also a fair number of publications that use click models presented in the main information retrieval conferences as well as ACM journals such as TOIS. All this indicates that there is a substantial and continued level of interest in the topic.

Indeed, we now have a handful of basic click models, inference methods, evaluation principles and applications for click models, that form the building blocks of ongoing research efforts in the area. The time is right to organize and present this material to a broad audience of interested information retrieval researchers, whether junior or senior. Many of the click models available today have been proposed by different industrial and academic research groups—one of the key aims of our proposed tutorial is to bring these together and offer a unified perspective. To achieve this, we describe the basic click models, inference methods and evaluation principles. We supplement this with an account of available datasets and packages plus a live demo based on these. We also present click model applications accompanied by examples.

We expect the tutorial to be useful for both researchers and practitioners that either want to develop new click models, use them in their own research in other areas or apply the models described here to improve actual search systems.

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2. OBJECTIVES

A large body of research on click models has been developed. This research has improved our understanding of user behavior in web search and facilitated the usage of click models in various search-related tasks. Current studies use a broad range of notations and terminology, perform experiments using different and mostly proprietary datasets, do not detail the model inference procedures used and, thus, do not provide a general systematic view on the research area. This, in turn, slows down the development and hinders the application of click models. The goal of this tutorial is to bring together current efforts in the area, summarize the research performed so far and give a holistic view on existing click models for web search. More specifically, the aims of this tutorial are the following:

1. Describe existing click models in a unified way, i.e., using common notation and terminology, so that different models can easily be related to each other.
2. Compare commonly used click models, discuss their advantages and limitations and provide a set of recommendations on their usage.
3. Provide ready-to-use formulas and implementations of existing click models and detail general inference procedures to facilitate the development of new ones.
4. Give an overview of existing datasets and tools for working with click models and develop new ones.
5. Provide an overview of click model applications and directions for future development of click models.

Our target audience consists of researchers and developers in information retrieval who are interested in formally capturing user interactions with search engine result pages, whether for ranking purposes, to simulate user behavior in a lab setting, or simply to gain deeper insights in user behavior and interaction data. The tutorial will be useful as an overview for anyone starting research work in the area as well as for practitioners seeking concrete recipes.

The tutorial aims to provide a map of an increasingly rich landscape of click models. By the end of the half-day tutorial, attendees

should be familiar with the basic definitions and intuitions of what we consider to be the core models, with inference tasks for these models, and with uses of these models. While our presentation is necessarily formal in places, we make a serious effort to relate the models, the inference procedures and the applications back to the core information retrieval task and to web search data by including a fair number of examples. We hope that this supplies attendees who are new to the area with effective means to start using click models in their own research.

3. DETAILED SCHEDULE

This introductory tutorial consists of two blocks of 1.5 hours. Each block will incorporate three types of activity: (1) presentation of the material, (2) live coding sessions, and (3) discussions at the end of the block. For the coding sessions, we will provide code examples and data samples. The participants will be able to either follow the examples on the slides or perform them live along with the presentation. During the discussion sessions at the end of each the 1.5 hour blocks, we will offer the participants a number of quizzes aimed to (self-)assess the comprehension of the presented material. The schedule of the introductory tutorial is as follows.

Block 1 (1.5 hours)

1. Introduction and Historical Notes
2. Aims of this Tutorial
3. Basic Click Models

   Here, we describe basic click models for web search, starting with the simplest random click model and arriving to the more sophisticated DCM, DBN and UBM models. We discuss models' assumptions, observed and hidden random variables, models' parameters and relations between parameters and random variables. This discussion is concluded with a summary of differences and similarities between the presented models. The following click models will be covered in this part:

   (a) Random Click Model
   (b) Position-Based Model
   (c) Cascade Model [3]
   (d) User Browsing Model [4]
   (e) Dependent Click Model [6]
   (f) Click Chain Model [5]
   (g) Dynamic Bayesian Network Model [1]

4. Click Model Inference

   In this part, we describe the process of training click model parameters from past click observations. We review two main inference techniques, namely maximum likelihood estimation (MLE) and the expectation-maximization algorithm (EM). We then give several examples of MLE and EM inference for existing click models to support the theory. Finally, we present the ready-to-use MLE estimates and EM update rules for the parameters of previously discussed click models. The detailed plan of this part is as follows:

   (a) Maximum Likelihood Estimation
      i. MLE Inference for RCM
      ii. MLE Inference for simplified DCM
      iii. MLE Inference for simplified DBN
   (b) EM Inference
      i. Expectation (E-step)
      ii. Maximization (M-step)
      iii. EM Inference for UBM
   (c) Alternative Inference Methods
      i. Bayesian Inference [7]
      ii. Probit Inference [9]
      iii. Matrix Factorization [8]

5. Recap and Discussion

Break (30 minutes)

Block 2 (1.5 hours)

6. Live Demo: Click Model Inference

   In this part, we use samples of publicly available datasets and open-source software packages to guide the participants through click model inference in practice. In particular, we will use an open source package maintained by Markov[1] as well as samples from interaction data shared by Yandex.[2]

7. Click Model Evaluation

   Here, we discuss different ways to evaluate click models and to compare them to each other. We start with traditional approaches, such as log-likelihood/perplexity evaluation and click-through rate prediction, and then discuss more application-oriented evaluation methods like NDCG evaluation. The outline of this part is as follows:

   (a) Log-Likelihood and Perplexity Evaluation
   (b) Click-Through Rate Prediction Evaluation
   (c) Relevance Prediction Evaluation

8. Data and Tools

   Here, we discuss publicly available datasets for experimenting with click models. We also describe open-source software packages and libraries that facilitate working with click models. The outline of this part is as follows:

   (a) Public Datasets
   (b) Software Libraries and Open-Source Projects

9. Recap and Discussion

4. TYPE OF SUPPORT MATERIALS TO BE SUPPLIED TO ATTENDEES

- Complete draft of the book [2]
- Copy of the slides
- Code and data samples to follow live demos

[1] https://github.com/markovi/PyClick
[2] http://imat-relpred.yandex.ru/en/datasets

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