Online learning to rank for information retrieval: SIGIR 2016 tutorial

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Published in:
SIGIR'16

DOI:
10.1145/2911451.2914798

Citation for published version (APA):

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Online Learning to Rank for Information Retrieval

ART CIR 2016 Tutorial

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ABSTRACT

During the past 10–15 years offline learning to rank has had a tremen-
dous influence on information retrieval, both scientifically and in
practice. Recently, as the limitations of offline learning to rank for
information retrieval have become apparent, there is increased atten-
tion for online learning to rank methods for information retrieval
in the community. Such methods learn from user interactions rather
than from a set of labeled data that is fully available for training up
front.

Below we describe why we believe that the time is right for an
intermediate-level tutorial on online learning to rank, the objectives
of the proposed tutorial, its relevance, as well as more practical
details, such as format, schedule and support materials.

Keywords

Online learning to rank; Bandit algorithms; Exploration vs. exploita-
tion

1. INTRODUCTION

Today’s search engines have developed into complex systems that
combines hundreds of ranking criteria with the aim of producing the
optimal result list in response to users’ queries. For automatically
tuning optimal combinations of large numbers of ranking criteria,
learning to rank has proved invaluable. For a given query, each
document is represented by a feature vector. The features may
be query dependent, document dependent or capture the relationship
between the query and documents. The task of the learner is to find
a model that combines these features such that, when this model is
used to produce a ranking for an unseen query, user satisfaction is
maximized.

Traditionally, learning to rank algorithms are trained in batch
mode, on a complete dataset of query and document pairs with
their associated manually created relevance labels. This setting
has a number of disadvantages and is impractical in many cases.
First, creating such datasets is expensive and therefore infeasible for
smaller search engines, such as small web-store search engines. Second,
it may be impossible for experts to annotate documents, as in the case of personalized search. Third, the relevance of
documents to queries can change over time, like in a news search
engine.

Online learning to rank addresses all of these issues by incremen-
tally learning from user feedback in real time. Online learning is closely related to active learning, incremental learning,
and counterfactual learning. However, online learning is more diffi-
cult because the agent has to balance exploration and exploitation:
actions with unknown performance have to be explored to learn better solutions.

There is a growing body of established methods for online learn-
ing to rank for information retrieval (see the schedule below for a
broad range of examples). The time is right to organize and present
this material to a broad audience of interested information retrieval
researchers, whether junior or senior, whether academic or indus-
trial. The online learning to rank methods available today have
been proposed by different communities, in machine learning and
information retrieval. A key aim of the tutorial is to bring these
together and offer a unified perspective. To achieve this we illustrate
the core and state of the art methods in online learning to rank,
their theoretical foundations and real-world applications, as well
as existing online learning algorithms that have not been used by
information retrieval community so far.

We expect the tutorial to be useful for both academic and indus-
trial researchers who either want to develop new online learning to
rank methods, use them in their own research, or apply the methods
described in the tutorial to improve search and recommendation
systems.

2. OBJECTIVES

Online learning to rank from user interactions is fundamentally
different from currently dominant supervised learning to rank ap-
proaches for information retrieval, where training data is assumed to
be randomly sampled from some underlying distribution, and where
absolute and reliable labels are provided by professional annota-
tors. When learning from user interactions, a system has no
control over which queries it receives, it only receives feedback on
the result lists it presents to users, and it has to present high quality
result lists while learning, to satisfy user expectations.

Following Hofmann et al. [11], in this tutorial we formulate on-
line learning to rank as a reinforcement learning problem, in which
an agent, the search engine, learns from interactions with an envi-
ronment, the user and their interactions, by trying out actions (e.g.,
returning a ranked list of items) and observing rewards (e.g., inter-
preting user feedback as absolute or relative feedback) in multiple
rounds or discrete time steps; see Figure 1.

Particularly relevant to this tutorial are methods for tackling so-
called contextual bandit problems (also known as bandits with side
information) [1]. A contextual bandit problem is a special case of
These objectives are meant to give participants a thorough understanding of existing learning to rank methods and to present online learning methods that have so far not been applied to learning to rank, let alone to learning to rank for information retrieval. Part I is aimed at familiarizing participants with the key concepts and algorithms. In Part II we select a small number of topics to provide a more in-depth technical treatment.

Part I

[10 minutes] Introduction, aims and historical notes

Here we discuss the context in which online LTR is applied and the most important historical milestones in its development.

[10 minutes] LTR in IR.

- The task of ranking documents, its importance, relationship to other machine learning tasks, and the unique challenges of LTR [22].
- Current approaches to LTR and argue that they all have issues that have to be addressed, such as the cost of producing labelled data and the mismatch between manually curated labels and user intent [34].

[15 minutes] Online LTR: balancing exploration and exploitation.

- How does online LTR addresses the shortcomings of offline LTR [11, 34]?
- How does online LTR relate to, and differ from, other tasks such as learning from labelled data, active learning and learning from logged interactions [30]?
- We explain the importance of balancing exploration and exploitation [13].

[5 minutes] Introduction to bandits and reinforcement learning.

- An important formalism behind many online LTR methods: bandit algorithms [1, 20]
- Connection to reinforcement learning [11, 29]
- Illustrate the importance of formal analysis and present k-armed bandits [1], contextual bandits [20] and cascading bandits [19] as ways to formalize the online LTR setting.

[10 minutes] Online signals to learn from.

- Close connection with online and logged based IR Evaluation [9, 14], because in both settings one needs to make the connection between observed user feedback and the hidden quality of the system.
- How to use observed user feedback to train the ranking models? The observed user feedback includes clicks, absence of clicks, dwell times, abandonment and many other signals [17, 21].
- Signals can be interpreted in a number of ways, for example, clicks can be interpreted in the form of absolute click through rates, or as relative preferences between documents or retrieval systems or using click models [16].

[20 minutes] Dueling bandit gradient descent.

- Dueling bandit gradient descent [34, DBGD], one of the core methods used in online LTR. We present the theory behind this method and discuss under which conditions it is guaranteed to work.
- More advanced methods that build on DBGD such as Probabilistic Multileave Gradient Decent [23, 27] and DBGD with Candidate Preselection [12].

![Figure 1: The information retrieval problem modeled as a contextual bandit problem, with information retrieval terminology in black and the corresponding reinforcement terminology in green and italics. (Figure taken from [11].)](image-url)
4. TYPE OF SUPPORT MATERIALS TO BE SUPPLIED TO ATTENDEES

- Slides
- Draft survey on online learning to rank for information retrieval [8]
- Code and data samples to follow experimental segments of the tutorial
- Lerot – experimental environment for online learning to rank [25]

Acknowledgements

This research was supported by Ahold, Amsterdam Data Science, the Bloomberg Research Grant program, the Dutch national program COMMIT, Elsevier, the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement nr 312827 (VOX-Pol), the ESF Research Network Program ELIAS, the Royal Dutch Academy of Sciences (KNAW) under the Elite Network Shifts project, the Microsoft Research Ph.D. program, the Netherlands eScience Center under project number 027.012.105, the Netherlands Institute for Sound and Vision, the Netherlands Organisation for Scientific Research (NWO) under project nrs 727.011.005, 612.001.116, HOR-11-10, 640.006.013, 612.066.930, CI-14-25, SH-322-15, 652.002.001, 612.001.551, the Yahoo Faculty Research and Engagement Program, and Yandex. All content represents the opinion of the authors, which is not necessarily shared or endorsed by their respective employers and/or sponsors.

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