

## Overview of the Special Issue on Contextual Search and Recommendation

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Information systems that leverage contextual knowledge about their users and their search situations – such as histories, demographics, surroundings, constraints or devices – can provide tailored search experiences and higher-quality task outcomes. Within information retrieval, there is a growing focus on how knowledge of user interests, intentions, and context can improve aspects of search and recommendation such as ranking and query suggestion, especially for exploratory and/or complex tasks that can span multiple queries or search sessions. The interactions that occur during these complex tasks provide context that can be leveraged by search systems to support users' broader information-seeking activities. Next-generation recommender systems face analogous challenges, including integrating signals from user exploration to update recommendations in real time.

Within the space of search, much of the work on modeling context and search personalization has focused on constructing topical profiles of the user's short- and long-term search history [Gauch et al. 2004; Chirita et al. 2005; Speretta and Gauch 2005; Ma et al. 2007; Bennett et al. 2010; White et al. 2010; Xiang et al. 2010; Sontag et al. 2012] or more generally, models of their query and result-click sequences [Cao et al. 2008; Cao et al. 2009; Mihalkova and Mooney 2009]. Related research has also considered a more content-driven representation such as language-model based approaches [Tan et al. 2006] or weighted term vectors derived from long-term desktop search activities [Teevan et al. 2005; Matthijs and Radlinski 2011]. However, a variety of recent investigations to contextualize search include a broader set of factors based on: a user's location [Bennett et al. 2011], a user's task-based search activity [Jones and Klinkner 2008; Kanoulas et al. 2011b; 2011a; Kanoulas et al. 2012; Sontag et al. 2012; Melucci 2012; Raman et al. 2014], the long-term vs. short-term interests of the user [Sugiyama et al. 2004; Li et al. 2007; Bennett et al. 2012], the ability of users to consume information at differing levels of complexity [Collins-Thompson et al. 2011], and patterns of re-finding the same search result over time [Teevan et al. 2011; Shokouhi et al. 2013].

The growth in the types of context explored and the information available to search systems derives from the timely convergence of several factors. The rapid growth in the use of different devices – most notably smartphones and tablets, but also including stationary devices such as game consoles, smart televisions, and augmented conference rooms – provides opportunities to obtain both raw and derived contextual signals that could power next-generation search and recommendation systems. The use of such signals in search and recommendation tasks has been recently explored in such venues as the Context-awareness in Retrieval and Recommendation workshops at IUI 2011-2012 [Luca et al. 2011; Luca et al. 2012], WSDM 2013 [Böhmer et al. 2013], and ECIR 2014 [Said et al. 2014].

Furthermore, a variety of recent work and venues have noted that much information retrieval research on web search has focused on optimizing and evaluating single queries, even though a significant fraction of queries are associated with more complex tasks [Jones and Klinkner 2008; Kanoulas et al. 2011b; 2011a; Belkin et al. 2012a;

Kanoulas et al. 2012; Sontag et al. 2012; Bailey et al. 2012; Dean-Hall et al. 2013; Raman et al. 2014], which span one or more search sessions [Liu and Belkin 2010; Kotov et al. 2011], and often consist of multiple queries. Such complex tasks have additionally been the focus of a recent National Institute of Informatics sponsored workshop (Whole-Session Evaluation of Interactive Information Retrieval Systems [Belkin et al. 2012b]) as well as a recent National Science Foundation sponsored workshop (Task-Based Information Search [Kelly et al. 2013]). The interactions that take place during these complex tasks provide context that can be leveraged not simply in a query-myopic manner but in a way that supports users' broader information-seeking activities [Morris et al. 2008; Agichtein et al. 2012].

At the same time as e-commerce and mobile device usage have expanded, recommender systems have become increasingly important and received much research and commercial interest [Resnick and Varian 1997; Herlocker et al. 2004; Adomavicius and Tuzhilin 2011]. Recommender systems gather information from a given user, create and update the user's profile using implicit and explicit feedback, predict which items the user might prefer and, without requiring explicit user queries, recommend items tailored to the user's personal tastes. Recently, people have recognized the potential value of contextual information for recommendation in e-commerce, travel, and mobile applications. There has been an increasing research interest on contextual recommendation and different contextual information such as user intent, time, companion, weather, location, objects around, season, and temperature have all been studied in various recommender system settings [Palmisano et al. 2008; Karatzoglou et al. 2010; Li et al. 2010; Rendle et al. 2011; Baltrunas et al. 2012]. Like contextual search, the next generation of recommender systems face many of the same challenges of incorporating heterogeneous contexts into recommendations as well as an analogous challenge of incorporating the interactive process of the users exploration in a single session to contextually update recommendations on the fly.

We solicited articles for this special issue that describe the state-of-the-art and emerging trends in contextual search and recommendation. While manuscripts focused on all areas of contextual search and recommendation were considered, we especially encouraged submissions that targeted exploratory and/or complex tasks. In particular, representations and approaches to context that enable task-oriented search including tasks that persist longitudinally. From 20 submissions, we selected four high-quality articles that represent current themes of research on contextual search and recommendation. We now briefly summarize each of these accepted articles in turn.

One critical aspect of context for search activity is the overall task goal that a user has in seeking information [Ingwersen and Järvelin 2005]. In their article, *Task-Based Information Interaction Evaluation: The Viewpoint Of Program Theory*, Järvelin and colleagues target the task-based evaluation of information systems, user behaviors, and their interactions. They define task-based information interaction (TBII), and examine a number of interrelated behavioral and cognitive activities related to task planning, searching for information items, deciding between items, working with items, and synthesizing and reporting content and outcomes. To ground their research on TBII, the authors focus on learning tasks [Marchionini 2006], i.e., those that include an intentional or unintentional learning component. They develop an evaluation framework based on program theory (PT) [Rossi et al. 2004]. PT is useful since it supports the comprehensive evaluation of complex programs, which have several interacting factors affecting their performance. This is clearly the case in information seeking scenarios, especially during multi-faceted complex search tasks. PT facilitates an enhanced understanding of whether a program comprising TBII activities and tools will be effective, the salient processes involved, and importantly, the causal factors that determine search effectiveness. Järvelin and colleagues describe how the evaluation

of TBII could be accomplished using PT. Although they do not offer fully developed or verified program theories for the activities or the entire task process, their research charts a course toward a more complete evaluation of information interactions and their supporting tools. The application of PT to TBII places an increased focus on human factors within IR evaluation. It also enables a holistic assessment of the effectiveness of search systems designed to help people tackle complex search tasks, such as those with an emphasis on learning.

Continuing the focus on search task as context, the article *User Activity Patterns During Information Search* by Cole and colleagues explores the connection between a user's interaction behavior and the nature and difficulty of their task goal. The authors study information-finding tasks in two different domains – journalism and genomic research – by capturing interaction signals that reflect both high-level activity in the form of page interaction sequences from log files, and low-level reading activity based on eye movement patterns. The authors contribute techniques for representing a user's activity patterns during extended search sessions, and present results showing that these techniques can be used to accurately differentiate task types using complexity-based measures of activity patterns. Applications of this research include improved contextual retrieval that can adapt ranking algorithms or other aspects of the search interface to better match the properties of the inferred task goal.

The two articles described thus far adopted an individual task-centered view of context. In *Profile-Based Summarisation For Web Site Navigation*, Alhindi and colleagues approach the topic of contextual search from the perspective of personalizing search to a community of users, rather than to an individual. They present a series of laboratory user studies to evaluate the effectiveness of different approaches to creating profile-based summaries in scenarios where users navigate a common information space, in their case, a university website. These summaries are created using the accumulated search histories of those who have used the website in the past. The basic idea is that members of the community have information needs that distinguish them from non-members, and furthermore, that many of these needs occur with some regularity. The community profile is acquired by using an ant colony optimization analogy, which takes temporal context into consideration. This allows the model to associate concepts with certain times of the academic year and anticipate the occurrence of certain needs. The community model is then used to generate customized summaries of webpages that appear as community members mouse-over hyperlinks. This work represents a unique perspective on contextual search by focusing on search support that is tailored to groups, or communities of users, and their information needs. In this way, it is similar to what Teevan et al. [2009] refer to as 'groupization,' or using group information to personalize retrieval and also extends past work by Smyth, Freyne and colleagues who explored search and recommendation techniques tailored to communities of users [Freyne et al. 2007; Smyth et al. 2005]. This work also exemplifies the successful translation of information retrieval research into local practice; Alhindi and colleagues use their own university website logs in this research and design techniques specifically to help their university community. Others might use these ideas and techniques to tailor search to their own local communities.

Finally, when people access content via smart phones, tablets and wearable devices, contextual information such as location, time, and recorded activities are important aspects that can be used to improve search and recommendation performance. In their article, *Who, Where, When and What: a Non-parametric Bayesian Approach to Context-aware Recommendation and Search for Twitter Users*, Yuan and colleagues consider how to leverage such types of context. In particular, they focus on four context variables: user (who), spatial (Where), temporal (When), and activity (What). They propose a new topic model to jointly model the four components for information in micro-blogs.

In their experiments with two data sets, the authors show that the proposed model can discover users' spatial-temporal topics, predict the location for a particular tweet, and make location recommendations given a user requirement. Their work serves as an example of how to integrate complex contextual information in social media and how to develop new models for a particular contextual recommendation problem based on good intuitions. In addition, this article also represents a unique perspective on how to evaluate context based recommendations – a very challenging problem due to the lack of good evaluation data sets or methodologies. We hope the discussion in this article prompts future research in this direction. In particular, while some researchers might follow the authors' ideas of using an existing data set and a reasonable amount of manual effort to build a data set tailored to their own contextual recommendation problem, others might borrow ideas from search engine evaluations or propose new evaluation methodologies.

Thus, the recent growth in work on complex task-oriented search and recommendation combined with the interest in context derived from mobile and situated devices – as well as across devices – make this an opportune time for a special issue in this area. Given the timeliness and breadth of the topic, and the level of interest in events such as related workshops, we believe that readers will find these articles both informative and thought-provoking.

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