Automatic Identification of Information Searcher Intentions During an Information Seeking Session

Abstract

There is a clear and increasing realization that a large proportion of information seekers using search engines and other information retrieval (IR) systems engage in "search sessions" or "information seeking episodes", that comprise sequences of behaviors beyond that of a single query and the resulting Search Engine Result Page (SERP). Although there is a substantial literature on the possible goals or intentions that information seekers might engage in during such search sessions, to date there has been little or no substantive research on how to identify such intentions (or even to confirm that such intentions are indeed evident in information seeking). We propose a project to relate very low-level behaviors during information searching sessions to progressively higher-level behaviors and then to information seeking intentions. The results will be the association of sequences of behaviors such as eye fixations and mouse movements with specific intentions such as learning about a topic, evaluating relevance of retrieved items, reformulating queries in response to search results, and modification of search goals. This will lead to a model of the information seeking *process*, and a means both for evaluating IR system support for the various steps in this process, and for proposing, and testing methods for such support of the individual steps, and of the process as a whole.

Proposal

It has been long recognized in the information science/information behavior community that much information seeking behavior in IR systems, including search engines, consists not merely of a single query, a single response to that query, in the form of, e.g., a SERP, and a click on a result. Rather, information seekers often engage in information seeking *sessions*, or *episodes*, consisting of sequences of *intentions* associated with different kinds of interactions with the IR system and the information objects in it (cf. Bates, 1979a, 1979b; Belkin, 1995). Examples of such intentions include learning about the contents of a database or the vocabulary of a domain, exploring different opinions on a topic, judging the usefulness of information items, etc. Yuan & Belkin (2007) provide an example of research on supporting different intentions.

The IR research community has come to recognize the importance of this type of information seeking behavior, and begun to consider how best to support a search session as a whole, and to the elements or steps within a search session. Examples of this interest include Fuhr's (2008) paper on formal modeling of search sessions, the Dagstuhl (Fuhr, 2009) and NII Shonan (2012) workshops on different aspects of interactive IR, and the TREC Session Track, now in its third year. A major problem with all such attempts at understanding, supporting, and evaluating support for the information seeking process as a whole, and in its parts, has been the lack of a means to identify and characterize the information seeker's intentions during the search process; that is, to *segment* the information seeking session into distinct intentional units. We propose to develop a method for automatically associating very low level, system-loggable information seeker behaviors during an information search session with high-level information search intentions. This will result in an *empirically justified* classification of information searching intentions. It will also provide means to identify techniques for supporting searchers in their different intentions, techniques for suggesting optimal sequences of intentions, and methods to evaluate both the success of support for the information searching session as a whole, as well for the individual steps in the process. The project results will be the basis for an NSF proposal to establish such support and evaluation techniques.

The observed behaviors in information search sessions are complex because interaction in information seeking involves a complex system, a human, engaged in a process that often has ill-defined parameters. That process is subject to a variety of user and exogenous constraints. Further, the central and complex physical processes of cognition and decision-making are not observable. A key problem is to somehow go from real world observations of interaction to predictions about mental states and the consequences of those mental states for future interaction.

Interaction is not carried out in a uniform observation space. By this we mean that constraints are imposed on each action segment that restrict the observation space in some way. For example, a person with an information intent is keyed to recognize certain words or ideas. From moment to moment the possibilities of interaction change because attention changes – some observational features are emphasized, others de-emphasized, or even ignored, and so on.

Modeling an entire information search session involves this complication due to the momentary experience of interaction. That is, the current intention imposes conditions on the user's engagement with the observable space of information interactions. Consider a dynamic trace in the information search session modeling space. The

dimensions in the modeling space include features that depend on (the probability of) user attention. After issuing a query the user is primed to attend to text that (might) represent the concepts in the query and the user will (mostly) ignore concepts unrelated to the query. Of course, the concepts that receive the user's attention will change over the course of a complex search session, for example due to learning that allows a user to recognize a concept as germane where previously it was ignored or not understood.

Information searching sessions have some observable structure. We will use this to identify and model levels of the information searching session. Using a top down approach, we will use models of the higher levels to induce features onto the lower levels. Single-level induction scope will be used but multi-level induction scope, where a higher level induces features directly on several lower levels, will also be explored. These scoping conditions (single layer vs. multiple layer feature induction) can be captured for computational purposes by contrasting layer mediation of feature induction onto the next lower layer with propagation (i.e. direct linkage to lower levels weighted by an appropriate function). Intuition suggests the latter approach is more likely to be accurate because the influence can be seen as being a list (or structured list) of constraints, rather than a conclusion of a logical chain.

To ground the approach we will use direct observation of the (text) information acquisition process as revealed in reading eye movements. The bottom-most level of information search behaviors, at least in text-based settings, can be associated with eye movement patterns. They mediate the user's ongoing system interaction. Previous work has explored and validated reading eye movement pattern measurements in connection with user perceptions of task difficulty and user domain knowledge. (Cole et al. 2011a; 2011b; 2012) Eye movement patterns are directly connected to concept use (via lexical access) and can potentially be related to the causes of decision making during search that produce the session structure of query sequences and information seeking strategies. Other user actions, e.g. mouse movements, are correlated with some aspects of a user's visual attention, so models based on eye movements might be of practical use by discovering correlations with mouse movement, click activity, etc. Liu et al. (2012) provide evidence that features at different levels of task structure can be used to make models that improve task difficulty prediction. The proposed approach extends that idea using eye movement reading sequence data and an ensemble learning approach with the goal of detecting intention segments.

The project will work with three levels in the observable task structure. A query reformulation interval (QRS) is the scope of query actions that implement a querying strategy, e.g. successive refinement or generalization of the words in the successive queries. A query segment (QS) covers the interactions between issuing successive queries. A reading sequence (RS) is a sequence of eye fixations that (semantically) process words in a sentence or sentences.

First, the QRS level properties will be added as QS observation features. The enriched QS properties will then be added as features at the level of the reading sequences involved in the text information acquisition process. This work will use existing data from previous research at our lab (http://comminfo.rutgers.edu/imls/poodle).

We will use Random Forests (RFs), an ensemble modeling technique, for generating our models. The generation of the observable activity of an information seeking session involves non-local factors, for example the higher level intentions in the task. RFs are well-suited to learning from conditionalized observations. (Breiman, 2001; Bengio, 2009).

The learned RF models will be used to predict the onset of the observable events in the task structure, for example the beginning of a new query reformulation interval. The eye movements associated with those events have, by hypothesis, been conditionalized by the intention of the user at that point (and constrained by the user's higher intentions). The idea is that the causal connection between eye movement patterns and a user's information processing (which is linked to their concept use and informational intent) results in conditionalization on the observables (eye movement pattern classes) at these known points of intention change, which can be modeled. From this we may be able to learn general indicators of eye movement patterns that correspond to intention changes and properties of the information intents. The initial models will be developed using existing data. This data was collected in experiments that did not record searcher intentions. We will therefore conduct a study in which participants will be asked to conduct searches on tasks similar to those from our previous work, and then, in a post-hoc replay of their searches, to elaborate on why they did what they did at each event and event interval. The results of this study, with 24-32 participants, will constitute our "ground truth" of searcher intentions. We will then apply the models previously developed to the new searcher data to test for associations of behavioral sequences at each of the three levels to the high-level search intentions.

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