Using Eye Movements to Infer Search Task Properties, Task Difficulty, and Cognitive Effort During Information Search

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July 15, 2011

Abstract

The POODLE project has been working to develop personalized information retrieval systems by inferring aspects of the user's situation as they engage in information search properties. A series of user studies have investigated the influence of task type, level of user knowledge, and individual differences, especially cognitive abilities, on observable behaviors with the goal of building user models that can be used to predict user and task properties during the search session. A multiple source logging systems was used that captured high level behaviors, such as document use, along with low-level activities including mouse movement and eye movements.

Eye tracking has already been used by several groups to investigate information retrieval problems, such as attention during SERP link selection processes and detection of relevance. Eye movement is cognitively-controlled and it provides direct evidence for user cognitive processing states. There is a strong foundation of research in cognitive science regarding cognitive processing and eye movements. With a user-centered perspective on information search and retrieval, eye movement analysis is a new research frontier to study information search. It has the promise of making direct measurement of user mental states during search to infer task and user properties that can provide a basis for personalization of the ongoing interaction with the search system.

We have developed a new methodology for analysis of eye movement patterns based on models of the reading process. I'll describe the methodology and algorithmn and present recent published work showing users change low-level information acquisition strategies in ways that reflect properties of their high-level task. Our most recent work has extended the methodology to measure some aspects of the amount of cognitive processing by a user while acquiring information during realistic IR work tasks in the journalism domain. The results show the cognitive effort measures are well correlated with task properties that contribute to task difficulty. They also match with the participant's assessment of the actual difficulty of their task.

One attractive element of our methodology is that it can be applied to eye tracking data in any (textual) information setting and used to give real-time estimates of cognitive effort, and rate of information acquisition. We are using these measures to explore relationships with query formulation and document use, and to identify sub-task segments and task stages. I'll discuss the potential to extend our cognitive effort modeling approach to make direct measurement of user domain knowledge and recognize when learning takes place during search.

Bio and acknowledgments

Michael Cole is a PhD. candidate at Rutgers University in the School of Communication and Information. His advisor is Nick Belkin. He received his BS (honors) in physics from the University of Wisconsin - Madison and studied philosophy of physics at the University of Michigan for two years before entering the business world and focusing on technology strategy development. His dissertation work concerns automated learning of search task structure.

He has worked in the POoDLE project[1] for three years and this work grows out of that effort. It owes much to the insights of the PIs (Profs. Belkin, Jacek Gwizdka, and Xiangmin Zhang) and the hard work of the Poodlers, especially Ralf Bierig, Jingjing Liu, and Chang Liu. Amongst his active current research is a Google-funded project to investigate the implicit detection of relevance judgments and the effect of affect on relevance judgments using physiological measurement of eye movements, brain electrical activity, and skin resistance.

Selected recent publications

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[1] http://comminfo.rutgers.edu/imls/poodle