Models for Interactive Retrieval

A Probability Ranking Principle for Interactive IR
Motivation
Approach
The Model
Estimating IPRP Parameters via Gaze Tracking

Classical Probability Ranking Principle

defines optimum retrieval for probabilistic models:
ranking documents according to decreasing values of the
probability of relevance

yields

optimum retrieval quality

Restrictions

- Relevance judgments of documents are independent
- Focus on user’s assessment of result list
The IPRP
Basic Assumptions

[Fuhr 08]
► Focus on a functional level of interaction (usability issues disregarded here)
► System presents list of choices to the user
► Users evaluate choices in linear order
► Only positive decisions/choices are of benefit for a user

Examples of decision lists
► ranked list of documents
► list of summaries
► list of document cluster
► KWIC list
► list of expansion terms
► links to related documents
► ...

Abstraction: Situations with Lists of Choices

Basic ideas
► A user moves from situation to situation
► In each situation $s_i$, the user is presented a list of (binary) choices $< c_{i1}, c_{i2}, \ldots, c_{in_i} >$
► The user decides about each of these choices sequentially
► The first positive decision moves the user to a new situation $s_j$
Probabilistic model focusing on single situation

Expected Benefit of a choice

- $p_{ij}$: probability that the user will accept choice $c_{ij}$
- $e_{ij} < 0$: effort for evaluating the choice $c_{ij}$
- $a_{ij} > 0$: resulting benefit from positive decision

Expected benefit of choice $c_{ij}$

$$E(c_{ij}) = e_{ij} + p_{ij}a_{ij}$$

Example for Expected Benefit

After formulating a query, a user may choose to perform the following actions with the corresponding parameter triple $(e_{ij}, p_{ij}, b_{ij})$

1. $(-1.0, 0.3, 8)$ add expansion term to the query
2. $(-2.0, 0.4, 10)$ look at the first result list entry
3. $(-10.0, 0.4, 25)$ immediately go to the first document
4. $(-5.0, 0.3, 20)$ look at an aggregated summary of the top ranking documents

In which order should these choices be presented to the user?

1. $(-1.0 + 0.3 \cdot 8) = 1.4$
2. $(-2.0 + 0.4 \cdot 10) = 2$
3. $(-10.0 + 0.4 \cdot 25) = 0$
4. $(-5.0 + 0.3 \cdot 20) = 1$

Expected benefit of a choice list

situation $s_i$ with list of choices $r_i = < c_{i1}, c_{i2}, \ldots, c_{in_i} >$

maximize expected benefit of choice list:

$$E(r_i) = e_{i1} + p_{i1}a_{i1} + (1 - p_{i1}) (e_{i2} + p_{i2}a_{i2} + (1 - p_{i2}) (e_{i3} + p_{i3}a_{i3} + \cdots (1 - p_{i,n-1}) (e_{in} + p_{in}a_{in}) ) )$$

$$= \sum_{j=1}^{n} (\prod_{k=1}^{j-1} (1 - p_{ik}) (e_{ij} + p_{ij}a_{ij})$$
PRP for Interactive IR

\[ a_{ij} + \frac{e_{ij}}{p_{il}} \geq a_{i,l+1} + \frac{e_{i,l+1}}{p_{i,l+1}} \]

\[ \Rightarrow \text{Rank choices by decreasing values of} \]

\[ \varrho(c_{ij}) = a_{il} + \frac{e_{il}}{p_{il}} \]

Parameter estimation

1. Selection probability \( p_{ij} \):
   focus of many IR models,
   but models for dynamic info needs required

2. Effort parameter \( e_{ij} \):
   most research needed

3. Benefit \( a_{ij} \): saved effort

User Interface

Estimating the iPRP parameters

- Effort: time spent for a choice
- Acceptance probability = transition probabilities
- Benefit: Saved time
Expected time for reaching the basket

- effort in states $t_q, t_r, t_d$
- $p_{XY}$: transition probability from state $X$ to state $Y$
- expected times $T_q, T_r$ and $T_d$ for reaching the basket state

\[
T_q = t_q + p_{qr} T_r \\
T_r = t_r + p_{rq} T_q + p_{rr} T_r + p_{rd} T_d \\
T_d = t_d + p_{dq} T_q + p_{dr} T_r
\]

\[
T_q = 122.7\, s \\
T_r = 117.8\, s \\
T_d = 104.9\, s
\]

Guidance based on the IPRP

Information Seeking Behavior

Information Seeking Behavior and Information Searching
Ellis’ Behavioral Model of Information Seeking Strategies
Support for seeking behavior according to Ellis/Meho/Tibbo
Models of information searching

- Classic IR
  - content-oriented search in unstructured documents
  - vague information needs, uncertain representations
  - system-oriented view, assume static information need

- Interactive information retrieval
  - focus on user interaction with information system
  - dynamic information need

- 2 views on interactive IR:
  1. Information Seeking Behavior
  2. Information Searching

Information Seeking Behavior

- broader view than content-oriented search
- model user’s actions, motivations and strategies for satisfying an information need
- questions of interest:
  - what triggers an information need?
  - what are users doing for solving this problem?

Information Searching

- focus on user’s interaction with information sources
- regard classic IR systems as well as other sources (e.g. personal communication)

Ellis’ Behavioral Model of Information Seeking Strategies

[Ellis 89]

- general model of search behavior
- based on empirical studies in social sciences and engineering companies
- general categories or properties of search behavior: Starting, Chaining, Browsing, Differentiating, Monitoring, Extracting, Verifying, Ending
Categories of search behavior according to Ellis (1)

Starting
▶ get overview of literature/locate key authors in a field, e.g. by
  ▶ selection of information source (e.g. personal collection, digital library, Web search engine)
  ▶ review articles
  ▶ personal contacts

Categories of search behavior according to Ellis (2)

Chaining
▶ follow different forms of referential connections between sources (in both directions)
  ▶ citations
  ▶ Web links
  ▶ same author/research team
  ▶ same conference/journal issue
  ▶ same category
▶ factors considered:
  ▶ topical relevance
  ▶ popularity of author
  ▶ timeliness
  ▶ citation frequency
  ▶ cost and time for document acquisition
▶ leads to finding new sources or even to reformulation of information need

Categories of search behavior according to Ellis (3)

Browsing
▶ starts from information sources and retrieved documents
▶ semi-goal-oriented search by browsing in promising areas
▶ scanning of tables of contents, references, lists of people and organizations
▶ browsing is used when relevant information is available in a comprehensive way

Categories of search behavior according to Ellis (3)

Differentiating
▶ judging of sources according to type, quality, importance, usefulness
▶ leads to information filtering
▶ e.g. comment vs. report, specification vs. manual
Categories of search behavior according to Ellis (4)

**Monitoring**
- maintain awareness of developments and technologies in a field
- by following particular sources
  - formal channels: scientific journals, conferences, alert profiles
  - informal channels: personal contacts, actual practice (field research, experimental work)

Categories of search behavior according to Ellis (5)

**Extracting**
- working through sources to locate material of interest
- material: documents, new sources, passages
- cognitive capture of information by the user
- user’s background knowledge important

Categories of search behavior according to Ellis (6)

**Verifying**
check information wrt. correctness and reliability

**Ending**
end of search, linking of new information with previous knowledge

Process model

- no strict sequential process
- starting, browsing, chaining and monitoring are search procedures
- differentiating is a filtering step
Extension by Meho/Tibbo

- Repeated Ellis’ study, new analysis (especially wrt. new technologies)
- confirmation of Ellis’ model
- but: extension by new categories

Additional categories

Accessing
- Access to full texts (instead of surrogates)
- acquisition of contents via different channels and with different costs

Networking
- personal communication with various persons
- discussion and evaluation of retrieved information via internet/intranet fora

Information Managing
- filing, storing and organizing retrieved and used information

Phases in search behavior

Support for seeking behavior according to Ellis/Meho/Tibbo

Starting
- Resource selection
- identifying popular authors
- entering search terms

Browsing
- Sort result list by different criteria
- highlighting, also user-defined

Chaining
- links in results pages
- comparison of result pages

Monitoring
- storing and periodical execution of queries

Extracting
- searching in the result page

Inform. Mgmt.
- Collate/organize result items
- Annotate items (Interpret)
Starting: Resource Selection

- ACM DL: The digital library of the ACM - Association for Computing Machinery
- DBLP: The DBLP Computer Science Bibliography
- LEABB: Bibliography of the group for efficient algorithms at the University of Munich
- Hendey: The digital library of Hendey
- PubMed: A large and well-known resource for the life sciences including medicine and biology
- Wiley: The digital library of the publisher Wiley

Starting: Search term completion

- Search terms: du, dui

Starting: Related Terms

- Related terms: information retrieval, natural language processing, conferences, queries, machine learning, algorithms, search engines, Springer, theory

Starting: Identify important authors

- Search query: 'extract authors' in ezdl

- Results: 415

1. 09101 Abstracts Collection Dagstuhl
   - Authors: Belkin et al.
   - Year: 2009 (Manday)

2. On the role of user-centred evaluation in the advancement of interactive information...
Browsing: Sort/group results by different criteria

Browsing: Meaningful Surrogates

Chaining: Clickable Entries in Result Pages

Browsing: Highlighting in the Result List
Chaining: backward/forward chaining of references

Forward Chaining in Web Searches

Google

- www.inf.uni-due.de/courses/index.html

Google

- www.inf.uni-due.de/courses/index.html

Alius
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Bilder
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Maps
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Videos
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

News
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Shopping
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Mehr
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Das Web
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Sethen auf
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Deutsch
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Übersetzen Sethen
DAFFODIL-Strategic Support Evaluator
www.informatik.uni-duisburg.de/da-capitola/DaFa.html

Extracting: Highlighting in the result page

Sheffield July 29
27th Annual International ACM SIGIR Conference Workshop on Peer-to-Peer Information Retrieval

SIGIR is the major international forum for the presentation of new research results and the demonstration of new systems and techniques in the broad field of information retrieval.

This SIGIR workshop on Peer-to-Peer Information Retrieval focuses on new methods of resource representation, resource selection, and data fusion in peer-to-peer networks. The workshop particularly encourages papers that address heterogeneous peer-to-peer networks, as well as papers about methods that cope with partial and uncertain information. However, more broadly, papers are solicited on any topic related to information retrieval in peer-to-peer networks.

Differentiating: comparison of result pages
is messy. Molecules have to bind and unbind, and chemical and signal elements have to mix and diffuse.\textsuperscript{1} Nature bypasses this messiness in part by resorting to statistical methods. For example, Wang and his colleagues combined recordings of in vivo neural activity, with a computer simulation of neuron function in the visual cortex of a cat, to show that neurons fired most reliably when they were stimulated by the almost simultaneous arrival of approximately 30 input signals. With fewer than 20 signals arriving at once, the neuron was significantly less likely to fire, but the simultaneous arrival of more than 40 signals brought no gain in the reliability of the output sig-

The current puzzle is to understand how a brain built from fundamentally unreliable components can reliably perform tasks that digital computers have barely begun to crack.

Monitoring on the Web
Google Alerts and Watchthatpage.com

Information Management: Personal Library in Daffodil
Information Searching

Basic Functions of IR Systems
Simple models of the search process
Anomalous State of Knowledge
Types of searches
Ingwersen’s Cognitive Model

Select (S) functions

Select: Selecting possibly relevant items
Organize: How the set of result items is structured and organized logically
Project: Construction of the surrogates to be presented in the results

Select (S) functions

Ranking method: e.g. precision- or recall-oriented
Ranking principle: e.g. relevance or diversity ranking

Querying: simple (set of words) to complex (field, data types) queries, a-priori or by given items (query by example)

Formal filter conditions: Filtering by formal criteria
Organize (O) functions

Sorting: Sorting of items by one (1D) more criteria (2D, ...)

Grouping: Grouping by simple (e.g., grouping by document type) or complex criteria

Clustering: Content focused grouping by similarity, unknown meaning of clusters

Linking: Showing e.g., Web links, co-author relationships, ...
(see Chaining in Ellis’ model)

Project (P) functions

Selecting: Selection of specific fields for surrogates

Summarizing: Summaries of single answer documents

Aggregating: Generates single entry representing several items

Extracting: Extracting and generating new data (e.g., common terms or frequent authors)
SOP Flexibility

- Most IR systems only support flexible selection (but ranking is fixed)
- Flexibility wrt. organizing and projecting missing (should be helpful for advanced searchers)

Empirical studies

- Information search consists of a sequence of connected, but different searches
- Search result may trigger new searches
- Only task context remains the same
- Main goal of a search is accumulated learning and collection of new information while searching

Classical search process model

```
Information Need → Query → Send to System → Receive Results → Reformulate

Evaluate Results

No → Reformulate

Yes

Done?

Stop
```

Berrypicking Model

[Bates 90]

- Continuous change of information need and queries during search
- Information need cannot be satisfied by a single result set
- Instead: sequence of selections and collection of pieces of information during search
Support for Berrypicking

- Filing of single results
- Adding terms/items to the query
- Query history (where have I been before?)

Anomalous State of Knowledge (ASK)(1)

[Belkin 80]

Classic IR systems: "best match" principle

- system returns those documents that fit best to the representation of the information need (e.g. query statement)
- only feasible, if user can give precise specification of her information need (like e.g. in DBMS)

Anomalous State of Knowledge (ASK)(2)

ASK-Hypothesis

- information need results from user’s anomalous state of knowledge (ASK)
- user is unable to precisely specify information need for removing the ASK
- instead: describe ASK
- requires capture of cognitive and situation-specific aspects for resolving this anomaly

Taxonomies of Web Search I

[Broder 2002, Rose & Levinson 2004]

Navigational: to reach a particular site
Informational: to acquire information assumed to be present on one or more web pages
Transactional: to perform some web-mediated activity
Resource: to get access to an online resource
Taxonomies of Web Search II

[Russell et al 2009]

**Navigate:** query(ies) leading to a site at which the main task can be performed.

**Find-Simple:** searching for an evident piece of information that does not require multiple sources of information.

**Find-Complex:** searching for information that requires searches on very closely related topics to integrate information across resources.

**Locate/Acquire:** the searcher is looking to download something, purchase an item, obtain a good or service.

**Explore/Learn:** searches that are intended to discover something or learn about a topic area.

**Play:** activity where the searches are intended to find games, fun content or items for amusement.

**Meta:** search tasks that are to test some capability.

### Ingwersen’s Cognitive Model

> Global perspective
> comprises all factors influencing a search
>  - social context
>  - IR system
>  - information objects
>  - user interface
>  - user
> focuses on cognitive structures – manifestations of human cognition, reflexions and ideas

### Exploiting Search Taxonomies

develop type-specific retrieval methods

- **Ranking:**
  - Navigational: find home page
  - Informational: find page containing requested info
  - Transactional: find page w/ transaction form
  - ...

- Task-specific selection + presentation functions: (see below)
Polyrepresentation

[Ingwersen 94]
- representation of information objects in different forms
- representations should correlate with cognitive structures
- example: document can be represented by
  - title (specified by the author)
  - keywords (by indexer)
  - other documents citing the current doc (extern)
  - annotations (extern)
- retrieval system should support several representations (thus, also several cognitive structures) → intentional redundancy
- good search result, when several representations point to the same document (Overlap)

Experimental Results for Polyrepresentation

[Koolen 2014]

<table>
<thead>
<tr>
<th>Fields</th>
<th>ndcg@10</th>
<th>R@1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title+Author+BL/LoC</td>
<td>0.0366</td>
<td>0.3457</td>
</tr>
<tr>
<td>Title+Author+BL/LoC+Review</td>
<td>0.1344</td>
<td>0.5294</td>
</tr>
<tr>
<td>Title+Author+BL/LoC+Tag</td>
<td>0.1020</td>
<td>0.4391</td>
</tr>
<tr>
<td>Title+Author+BL/LoC+Review+Tag</td>
<td>0.1640</td>
<td>0.5639</td>
</tr>
</tbody>
</table>

Experimental Results for INEX Social Book Search
- Amazon Title + Author
- British Library + Library of Congress Classification
- Amazon Reviews
- Librarything Tags

Polyrepresentation of the cognitive user space

cognitive space can be represented via polyrepresentation
- requests
- problems/goals
- work task
Global Polyrepresentation Model

Representations of Problems and Work Tasks
Example: LibreOffice FAQ

▶ How do I install the latest version of LibreOffice?
▶ How to convert an odt to pdf?
▶ How to maintain document compatibility between LibreOffice and other office suites?
▶ LibreOffice Spell Checker doesn’t work?
▶ Can’t open .xlsx file with LibreOffice
▶ No page number in first page
▶ LibreOffice missing certain Microsoft fonts

Information Seeking Behavior & Information Searching

▶ searching consists of sequence of different phases
▶ experienced searchers employ a variety of actions in different phases
▶ these actions should be supported by the system as much as possible
▶ each phase should be supported appropriately by the system

Bates’ model for strategic system support

▶ Levels of search activities
▶ Degrees of system involvement

Strategic Support

Information Seeking Behavior & Information Searching
Levels of search activities
Degrees of system involvement
Proactivity in IR Systems
Levels of search activity

1. **Move**: An identifiable thought or action that is a part of information searching.
2. **Tactic**: One or a handful of moves made to further a search.
3. **Stratagem**: A larger, more complex set of thoughts and/or actions than the tactic, all designed to exploit the file structure of a particular search domain thought to contain desired information.
4. **Strategy**: A plan, which may contain moves, tactics, and/or stratagems, for an entire information search.

Types of Tactics

- **Term tactics**: modification of words or phrases in the query (spelling, related terms)
- **Information structure (file) tactics**: following links like references (in both directions), structural relationships (journal, proceedings, web site), searching within a structure
- **Search formulation tactics**: narrowing/broadening the query, more/less terms
- **Idea tactics**: open search possibilities /variants
- **Monitoring tactics**: monitor search progress, compare it with search goals

Information structure (file) tactics

**Structural and referential links**

- Online shop example

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Authors</th>
<th>References</th>
<th>Citations</th>
<th>Index Terms</th>
<th>Publication</th>
<th>Reviews</th>
<th>Comments</th>
<th>Table of Contents</th>
</tr>
</thead>
</table>

The ACM Computing Classification System (CCS rev:2012)

The Amazon Computing Classification System (CCS rev:2012)
Example stratagems

**Subject Search**

**Journal Run** Having identified a journal central to one’s topic of interest, one reads or browses through issues or volumes of the journal.

**Citation Search** Using a citation index or database, one starts with a citation and determines what other works have cited it.

**Area Scan** After locating a subject area of interest in a classification scheme, one browses materials in the same general area.

**Footnote Chase** One follows up footnotes or references, moving backward in time to other related materials.

---

**Stratagem**

**Area Scan**

---

**Primary Classification:**

H: Information Systems

H.3 INFORMATION STORAGE AND RETRIEVAL

H.3.3 Information Search and Retrieval

**Subjects:** Query Formulation

**Additional Classification:**

H: Information Systems

H.3 INFORMATION STORAGE AND RETRIEVAL

H.3.3 Information Search and Retrieval

**Subjects:** Search process, Relevance feedback

H.5 INFORMATION INTERFACES AND PRESENTATION (I.7)

H.5.2 User Interfaces (I.2, I.12.1.3.6)

**Subjects:** Interaction styles (e.g., commands, menus, forms, direct manipulation)

---

**Degrees of system involvement**

0 — No system involvement All search activities human generated and executed.

1 — Displays possible activities System lists search activities when asked. Said activities may or may not also be executable by system (higher levels).

2 — Executes activities on command System executes specific actions at human command.

3 — Monitors search and recommends System monitors search process and recommends search activities:

   a) Only when searcher asks for suggestions.
   b) Proactive: Always when it identifies a need.

4 — Executes automatically System executes actions automatically and then:

   a) Informs the searcher.
   b) Does not inform the searcher.
Monitors search and recommends

Executes automatically + informs

Executes automatically + does not inform

Combination of search activities and system support
Daffodil desktop

Daffodil: Search Continuation

- proposal based on automatic analysis of the current search result
- case-based reasoning
- availability of suggestions indicated as button at the bottom of result list window

Daffodil: Search Continuation 2

- suggestions displayed as ranked list
- descriptive title, explanation, success rate
- execute on or more suggestions, with following feedback
- icons indicate the state of suggestions: (executable, used, useful)

Evaluation of search suggestions

- 24 test subjects, half of them w/ suggestion component
- each subject worked on 3 tasks
- case base contained 30 different suggestions

Results:
- supported users
  - are more content with the search process ($p = 0.067$)
  - are significantly more satisfied with the result
  - find more relevant documents
  - use significantly more often Daffodil’s advanced search tools
- (unsupported users mainly restrict on reformulating queries)
From Cognitive Models to IR Interfaces

Session support in the user interface

Design Patterns for Search Modes

Session Support

- Term completion and query expansion
- Show results together with the query
- Allow editing of the previous query
- Show search history
- Allow for combination of queries
- Filing of single results
- Storing of sessions

Term completion and query expansion

Show results together with the query

Query
- title – at least retrieval in context

As MQL query:
```
word(1, 0, @RDATA & title = "retrieval", 1, 0, @RDATA & title = "IR", 1, 0, @RDATA & title = "context")
```

Results

100 documents found, 100 documents displayed (with FIPR)

Massimo Marchiori (2006)
A Basis for Information Retrieval in Context. ACM Transactions on Information Systems 26(2)

Kuokko Kukkonen, David C. Richardson, Thomas R. Roth-Berghofer, Laure Wac (eds.) (2007)

Giuseppe Attardi, Benigno Di Marzio, Osvaldo Stahli (1998)
Categorisation by Context. Journal of Universal Computer Science 4(9)

Peter Ingwersen (2000)
Design Patterns for Search Modes
Support for Marchionini’s search modes

[Marchionini 1995] [Beckers & Fuhr 12] [Russell-Rose & Tate 13]

**Search Modes**

- **Lookup**
  - Locating
- **Learn**
  - Comparing
  - Comprehending
- **Investigate**
  - Analyzing
  - Evaluating
  - Synthesizing

**Lookup: Locating - Autocomplete**

- Fact retrieval
- Known item search
- Navigation
- Transaction
- Verification
- Question answering

- Knowledge acquisition
- Comprehension/Interpretation
- Comparison
- Aggregation/Integration
- Socialize

- Accretion
- Analysis
- Exclusion/Negation
- Synthesis
- Evaluation
- Discovery
- Planning/Forecasting
- Transformation
Summary

- Interactive PRP for analysis and design of IIRS
- Information seeking behavior vs. searching
- Cognitive models:
  - Search as iterative process
  - Large variation in search tasks
  - Search influenced by many factors
- Systems:
  - Strategic support through high-level search functions (especially for typical cognitive actions)
  - Proactive support
- User interface design based on cognitive models
References I

M. J. Bates.
The design of browsing and berrypicking techniques for the online search interface.

Marcia J. Bates.
Where should the person stop and the information search interface start?

Thomas Beckers and Norbert Fuhr.
Search system functions for supporting search modes.
In 2nd European Workshop on Human-Computer Interaction and Information Retrieval (EuroHCIR) @ IIiX 2012, August 2012.

N. J. Belkin.
Anomalous states of knowledge as a basis for information retrieval.

N. J. Belkin.
Intelligent information retrieval: Whose intelligence?

References II

Andrei Broder.
A taxonomy of web search.
ISSN 0163-5840.

Colleen Cool and Nicholas J. Belkin.
A classification of interactions with information.

D. Ellis.
A behavioural approach to information retrieval system design.

N. Fuhr.
A probability ranking principle for interactive information retrieval.
http://dx.doi.org/10.1007/s10791-008-9045-0.

Marti A. Hearst.
Search User Interfaces.

References III

P. Ingwersen.
Information Retrieval Interaction.
URL http://www.db.dk/pi/iri/.

P. Ingwersen.
Polyrepresentation of information needs and semantic entities, elements of a cognitive theory for information retrieval interaction.

P. Ingwersen and K. Järvelin.
The turn: integration of information seeking and retrieval in context.
ISBN 140203850X.

Sascha Kriewel and Norbert Fuhr.
Adaptive search suggestions for digital libraries.

References IV

Sascha Kriewel and Norbert Fuhr.
An evaluation of an adaptive search suggestion system.

Lokman I. Meho and Helen R. Tibbo.
Modeling the information-seeking behavior of social scientists: Ellis’s study revisited.
ISSN 1532-2882.
doi: http://dx.doi.org/10.1002/asi.10244.

S. E. Robertson.
The probability ranking principle in IR.

Daniel E. Rose and Danny Levinson.
Understanding user goals in web search.
ISBN 1-58113-844-X.
Conference Chair-Feldman, Stuart and Conference Chair-Uretsky, Mike and Program Chair-Najork, Marc and Program Chair-Wills, Craig.
References V


References VI