Semistructured Data Search Evaluation

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Outline

• Introduction
• The INEX Initiative
• INEX Adhoc Evaluation
• Other INEX tracks
• Summary
Semistructured Data

• **XML** as most important instance (but also RDF, relational tables/databases, …)
• Two types of XML documents:
  – „Documents with structure“: document-centric
  – „Structured data with text“: data-centric
Example for data-centric: DBLP

<article key="journals/cacm/Gentry10" mdate="2010-04-26">
  <author>Craig Gentry</author>
  <title>Computing arbitrary functions of encrypted data.</title>
  <pages>97-105</pages>
  <year>2010</year>
  <volume>53</volume>
  <journal>Commun. ACM</journal>
  <number>3</number>
  <ee>http://doi.acm.org/10.1145/1666420.1666444</ee>
  <url>db/journals/cacm/cacm53.html#Gentry10</url>
</article>

Rather regular structure across documents
not much text per element

```
<article xmlns:xlink="http://www.w3.org/1999/xlink/">
  <header>
    <title>Wiki markup</title>
    <id>42</id>
    <categories>
      <category>Markup languages</category>
    </categories>
  </header>
  <body>
    <section><st>Introduction</st>
      <p><b>Wiki markup</b> is used in <link xlink:href="../Wi/Wikipedia.xml" xlink:type="simple">Wikipedia</link>. It allows for a rather rich annotation of texts with structure such as tables and lists, links to other documents, and much more.</p>
    </section>
    <section>
      <st>Language Components</st>
      <list>
        <entry>tables</entry>
        <entry>lists</entry>
        ...
      </list>
    </section>
  </body>
</article>
```
Semistructured Data Search/Retrieval

• Why is this different from DB-style queries? Do not retrieve „all answers“, only „best answers“

• Why is this different from document retrieval? Do not retrieve full documents, but document fragments (elements) as results; focused retrieval

• Two general querying paradigms:
  – Keywords
  – Structured queries + keywords (XPath FullText)
Example: Document vs. Focused Retrieval

Query: „ticket method“
The INEX Benchmark Initiative

- started in 2002
- focus on document-centric XML
- large number of participants (>500)
- large number of organizers (100)
(Research) Questions at INEX

• Is focused retrieval better than document retrieval? For which tasks?
• Does document structure help? Are structured queries useful?
• What are good test collections to compare system performance?

• Most important for participants: Is my system better than the other systems?
Some Tracks at INEX over the Years

• Adhoc Track
• Multimedia Track
  keyword-based image search in XML docs
• Heterogeneous Track
  search over XML docs with different structure
• Relevance Feedback Track
• Interactive Track
• XML Mining Track
• Efficiency Track
  trade off result quality vs. processing time

More on current tracks later
Ingredients of IR Test Collections

• Collection (documents)
• Task
• Topics
• Assessments, relevant results
• Metrics & tools for evaluation
INEX Document collections

• Structured text documents
• 12,227 SGML/XML Articles from IEEE journals
• Wikipedia articles with simple XML markup
• Wikipedia articles with simple XML markup and semantic annotations
IEEE articles

<article>
  <fm>
    <ti>IEEE Transactions on ...</ti>
    <atl>Construction of ...</atl>
    <au>
      <fnm>John</fnm>
      <snm>Smith</snm>
      <aff>University of ...</aff>
    </au>
  </fm>
  <bdy>
    <sec>
      <st>...</st>
      <ssl>...</ssl>
      <ssl>...</ssl>
    </sec>
  </bdy>
  <bm>
    <bib>
      <bb>
        <au>...</au><ti>...</ti>
      </bb>
    </bib>
  </bm>
</article>

meta data:
title, journal,
author, affiliation

full-text content

cited references
Wikipedia with semantic annotations

Types from WordNet

Information from Infoboxes

```
<article>
  <group confidence="1.0" wordnetid="26729"
    source="categories">
  </group>
  <artist confidence="0.75" wordnetid="9187509">
    <header>
      <title>Queen (band)</title>
      <id>42010</id>
    </header>
    <Infobox_band>
      <band_name>Queen</band_name>
      <years_active>1971 - Present</years_active>
      <status>Active</status>
      <country confidence="1.0" wordnetid="8023668">
        <link xlink:href="../Un/United+Kingdom.xml"
          xlink:type="simple">
          United Kingdom
        </link>
      </country>
    </Infobox_band>
  </artist>
</article>
```
INEX Topics

• Two different types:
  – Content-Only (CO)
  – Content and Structure (CAS)

• Contributed by participants, so diverse in nature
Content-Only (CO) topic

<INEX-Topic topic-id="45" query-type="CO" ct-no="056">
  <Title>
    <cw>augmented reality and medicine</cw>
  </Title>
  <Description>
    How virtual (or augmented) reality can contribute to improve the medical and surgical practice.
  </Description>
  <Narrative>
    In order to be considered relevant, a document/component must include considerations about applications of computer graphics and especially augmented (or virtual) reality to medicine (including surgery).
  </Narrative>
  <Keywords>
    augmented virtual reality medicine surgery improve computer assisted aided image
  </Keywords>
</INEX-Topic>
Structured Topics (CAS): INEX 2002

<INEX-Topic topic-id="09" query-type="CAS" ct-no="048">
  <Title>
    <te>article</te>
    <cw>non-monotonic reasoning</cw> <ce>bdy/sec</ce>
    <cw>1999 2000</cw> <ce>hdr//yr</ce>
    <cw>-calendar</cw> <ce>tig/atl</ce>
    <cw>belief revision</cw>
  </Title>
  <Description>
    Retrieve all articles from the years 1999-2000 that deal with works on nonmonotonic reasoning. Do not retrieve articles that are calendar/call for papers.
  </Description>
  <Narrative>
    Retrieve all articles from the years 1999-2000 that deal with works on nonmonotonic reasoning. Do not retrieve articles that are calendar/call for papers.
  </Narrative>
  <Keywords>
    non-monotonic reasoning belief revision
  </Keywords>
</INEX-Topic>
Structured Topics (CAS): INEX 2003

<inex_topic>
<title>
//article[(./fm/yr = '2000' OR ./fm/yr = '1999') AND about(., '"intelligent transportation system"')]//sec[about(.,'automation +vehicle')] ...
</title>
<description>
Automated vehicle applications in articles from 1999 or 2000 about intelligent transportation systems.
</description>
<narrative>
To be relevant, the target component must be from an article on intelligent transportation systems published in 1999 or 2000 and must include a section which discusses automated vehicle applications, proposed or implemented, in an intelligent transportation system.
</narrative>
<keywords>
intelligent transportation system, automated vehicle, automobile, application, driving assistance, speed, autonomous driving
</keywords>
</inex_topic>

Extended version of XPath:
about(path,keyword condition)

Too complex for IR people: 63% of topics with errors
Narrowed Extended XPath I (NEXI)

- Restricted axes and composition: only 2 types
  - //A[B]
  - //A[B]//C[D]
- tag wildcard *, tag disjunction (sec|p)
- content conditions: about(path, text)
- comparison for numeric values only

//article[(.//fm//yr = 2000 OR .//fm//yr = 1999)
    AND about(.,¨intelligent transportation¨)]
//sec[about(.,¨automation +vehicle¨)]
Strict vs. Loose/vague interpretation

- DB vs. IR interpretation of queries
- **Strict**: exact match of target element (SCAS)
- **Vague**: vague match of target element (VCAS); requested *article*, but *sec* is valid result

- IR interpretation of query: path specifications considered **hints** as to where to look
XYCAS: different CAS interpretations

• V – Vague
• X – target element
• VVCAS: both target and support elements are vague (classic IR view)
• SVCAS: target strict, support elements vague
• VSCAS: target vague, support elements strict
• SSCAS: both target and support elements are strict (classic DB view)
XYCAS example

```
//article[about('.', 'XML') and about(//sec, 'DB')]
```

**target**

**support**

**SSCAS:** only matching article elements with matching sec subelements

**VSCAS:** any matching elements with matching sec subelements

**SVCAS:** only matching article elements with any or no matching subelements

**VVCAS:** any matching elements with any or no matching sec subelements
CO+S topics

<Tolkien languages "lord of the rings"/>

//article[about(., Tolkien) or about(., "lord of the rings")]
//sec[about(., Tolkien languages)]

Find information about Tolkien languages from the Lord of the Rings.

The "Lord of the Rings" ... For my own personal interest, I would like to
learn more background about Tolkien's artificial languages. Later I may
want to add a section on the influence languages to my fan web page.
I expect to find relevant information as elements in larger documents that
deal with Tolkien or Lord of the Rings, e.g., as sections in documents
about Tolkien or the Lord of the Rings.
To be relevant an element should discuss Tolkien's artificial languages and
their influence on the Lord of the Rings books or movies. Information on
the languages alone without explicit discussion of their impact on the
books is not relevant; nor is general information on Tolkien or the Lord of
the Rings.

"High Elvish" ; Quenya ; Sindarin
inspired, film
INEX AdHoc Tasks

- **Thorough**: find all relevant information (elements)
- **Focused**: find all relevant information (elements) without any overlap
- **Relevant-in-context**: document ranking, within each document highlight relevant content
- **Best-in-context**: best entry point into an article
Thorough vs. Focused

Thorough: should return p, sec, article

Focused: should return only element with most relevant content
Relevant-in-Context Task

For each topic, return ranked list of documents with non-overlapping relevant elements

• rank 1: document 17
  //article[1]/sec[2]/p[1]
  //article[1]/sec[4]/p[2]

• rank 2: document 12
  //article[1]/sec[1]

• ...
Assessments: Estimate Relevant Results for each Topic

- **General approach**: humans assess all elements for relevance
- But: way too much effort (millions of elements)
- Build **pool of elements/documents to assess** from submitted results

- At INEX: **participants** assess
INEX (document-based) Pooling

- Build pool of size \( S = 500 \) documents per topic.
- Collect top-1 result from each run, then top-2, ... until \( S \) documents found.

Build pool of size \( S = 5 \):

- \( \text{doc17} \)
- \( \text{doc2} \)
- \( \text{doc5} \)
- \( \text{doc6} \)
- \( \text{doc56} \)
- \( \text{doc31} \)
INEX 2004: Two-dimensional relevance

- **Exhaustivity (E)**, which describes the extent to which the document component discusses the topic of request.
- **Specificity (S)**, which describes the extent to which the document component focuses on the topic of request.
4-point scale for exhaustivity

• **Not exhaustive (E0):** the document component does not discuss the topic of request at all.

• **Marginally exhaustive (E1):** the document component discusses only few aspects of the topic of request.

• **Fairly exhaustive (E2):** the document component discusses many aspects of the topic of request.

• **Highly exhaustive (E3):** the document component discusses most or all aspects of the topic of request.
4-point scale for specificity

• **Not specific (S0):** the topic of request is not a theme of the document component.

• **Marginally specific (S1):** the topic of request is a minor theme of the document component (i.e. the component focuses on other, non-relevant topic(s), but contains some relevant information).

• **Fairly specific (S2):** the topic of request is a major theme of the document component (i.e. the component contains mostly relevant content and only some irrelevant content).

• **Highly specific (S3):** the topic of request is the only theme of the document component.
INEX'04 Assessments
The ARPA-Rome Knowledge-Based Planning and Scheduling Initiative

The ARPA-Rome Knowledge-Based Planning and Scheduling Initiative
Assess each element in the pool on 3x3 relevance scale

High effort
(up to 1 week per topic)
2006 assessment tool: Highlighting

Ali Baba (Arabic: علي بابا) is a fictional character described in the adventure tale of "Ali Baba and the Forty Thieves" which was added to the traditional collection of *The Book of One Thousand and One Nights* by its European transcriber, Antoine Galland, an 18th-century French orientalist who had heard it in oral form from a Maronite story-teller from Aleppo. This story has also been used as a popular pantomime plot.

Story Summary

Ali Baba, a poor woodcutter, happens to see and overhear bandits visiting their treasure store in the forest where he is cutting wood. The mouth of which is sealed by magic - it opens on the word "Sesame". When the thieves are gone, Ali Baba enters the cave himself, and takes some of the treasure home.

Ali Baba's rich brother, Kasim, finds out about his brother's unexpected wealth, and Ali Baba tells him cave to take more of the treasure, but forgets the magic and gets killed.
INEX 2010++ Assessment Tool

Takes about 1 minute/doc (or 5 turkers on MechTurk à 0,10€)
Metrics: General principles

• Quantization Q: Map (E,S) value to [0,1]
• Recall-based evaluation for each topic
• For a run: Average metrics value for each topic
Quantizations (INEX 2004)

• **Strict**: map to 1 only for (3,3) results (INEX 2002)

• **Generalized** (INEX 2002): graded relevance

• **Specificity-oriented generalized**: more focus on specificity component

• **Specificity-oriented**: map to 1 only for (3,*) results

• **Exhaustivity-oriented**: map to 1 only for (*,3) results
INEX 2002 Thorough metrics: Recall

Consider recall base: set of all elements with $Q>0$

$$P(\text{rel} \mid \text{retr})(x) := \frac{x \cdot n}{x \cdot n + \text{esl}}$$

$x$: recall point 0, 0.01, ..., 1 (point in the run where fraction $x$ of relevant elements are found)

$n$: number of relevant elements

$\text{esl}$: expected search length (number of nonrelevant elements at recall $x$, more difficult when ranking includes ties)
INEX 2006 Thorough metrics: xCG

• Consider ideal run: elements from recall base in descending order of their Q value (here: fraction of relevant characters in element)

• Compute extended cumulated gain of run (xCG) and ideal run (xCI) at rank i

\[ xCG[i] = \sum_{j=1}^{i} xG[j] \quad xG[i] = Q(\text{result}(i)) \]

• Compute relative effort (rank) to achieve target gain r:

\[ ep[r] = \frac{i_{\text{ideal}}}{i_{\text{run}}} \]

• Use normalized xCG:

\[ nxCG[i] = \frac{xCG[i]}{xCI[i]} \]
INEX 2006 metrics

\[ n \times CG[i] = \frac{xCG[i]}{xCI[i]} \]

\[ ep[i] = \frac{i_{\text{ideal}}}{i_{\text{run}}} \]

From Lalmas et al., INEX 2006 proceedings
Not yet considered: Overlap of results

<table>
<thead>
<tr>
<th>doc12/article[1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>doc12/article[1]/sec[1]</td>
</tr>
<tr>
<td>doc12/article[1]/sec[2]</td>
</tr>
<tr>
<td>doc12/article[1]/sec[1]/par[1]</td>
</tr>
</tbody>
</table>

- Results beyond 1 do not contribute new content, so are useless for user
- But: included in recall base, must be returned for high **Precall** or **ep[r]** value
INEX 2006 Focused metrics

• Compute ideal overlap-free recall base
  – Select elements with highest Q
  – Break ties by choosing element toward the top of the XML tree
From Elements to Passages

Major insight around 2007:
Elements as results are too restrictive since
• boundaries are arbitrary
• Relevant content (aka highlighted text) independent of element boundaries

Natural consequence:
retrieve text passages instead of elements
(XML structure only hints!)
INEX 2007 Focused Measures

• Based on retrieved relevant text

• For a result \( p \)
  
  \( \text{size}(p) \): number of characters in \( p \)
  
  \( \text{rsize}(p) \): number of unseen relevant characters in \( p \)

• Rank-based measures precision & recall

\[
P[r] = \frac{\sum_{i=1}^{r} \text{rsize}(p_i)}{\sum_{i=1}^{r} \text{size}(p)}
\]

\[
R[r] = \frac{\sum_{i=1}^{r} \text{rsize}(p_i)}{\text{Trel}(q)}
\]

where \( \text{Trel}(q) \)=number of relevant characters for \( q \)
INEX 2007: interpolated precision

Precision:
\[ p[0.01] = \frac{\text{# rel chars at } 1\% \text{ recall}}{\text{# chars at } 1\% \text{ recall}} \]

Interpolated Precision:
\[ iP[r] = \max_{r' \geq r} \{ p[r'] \} \]

Average Interpolated Precision:
\[ AiP = \frac{1}{101} \sum_{r=0.0}^{1.0} iP[r] \]

[MAiP: Mean over many topics]
Reminder: Relevant-in-Context Task

For each topic, return ranked list of documents with non-overlapping relevant elements

• rank 1: document 17
  //article[1]/sec[2]/p[1]
  //article[1]/sec[4]/p[2]

• Rank 2: document 12
  //article[1]/sec[1]

• …
Two-step metrics for relevant in context

- Per-document score $S(d)$: F-measure

\[
P(d) = \frac{\sum_{p \in \mathcal{P}_d} r \cdot \text{size}(p)}{\sum_{p \in \mathcal{P}_d} \text{size}(p)} \quad \quad R(d) = \frac{\sum_{p \in \mathcal{P}_d} r \cdot \text{size}(p)}{|\text{Trel}(d)|} \quad \quad F(d) = \frac{2 \cdot P(d) \cdot R(d)}{P(d) + R(d)}
\]

- Per-topic score: generalized precision &

\[
gP[r] = \frac{\sum_{i=1}^{r} S(d_i)}{r} \quad \quad gR[r] = \frac{\sum_{i=1}^{r} \text{IsRel}(d_i)}{|\text{Nrel}|}
\]

\[
AgP = \frac{\sum_{r=1}^{\mathcal{L}} \text{IsRel}(d_r) \cdot gP[r]}{|\text{Nrel}|}
\]
Effect of Pool Size (INEX 09)

How good is ranking with a smaller pool?

- Consider **Kendall’s tau** of run ranking to original ranking (with poolsize=500 for assessments)

General agreement: tau=0.9 is good enough

Any cheaper solutions?
Find **Minimal Test Collection** (to assess)
- For document retrieval
- For rank-based metrics (e.g., precision@10, AvgPrec)

**Impact** of document d on run‘s AvgPrec:
- Depends only on rank r(d) of d in the run
- Can be precomputed: contributes 1/R to precision@R for each rank R ≥ r
- Select documents to assess based on best impact for run1, best impact for run2, etc.

**Stop** when
- best run found (threshold)
- best run found with high probability (under assumptions)

[Carterette et al, SIGIR 2006]
Impact of Assessing a Document

Problem with iP[0.01] (a recall-based metric):

– value may **reduce** with more assessments
  (even docs not included in a run!)

Old point of 0.01 recall:
80 rel chars
p[0.01]=1.0

New point of 0.01 recall:
100 rel chars= 1% recall
p[0.01]=0.7

New point of 0.01 recall:
130 rel chars= 1% recall
p[0.01]=0.8
Impact of Assessing a Document

Problem with iP[0.01] (a recall-based metric):
  – value may reduce with more assessments
    (even docs not included in a run!)

Problem with passage-level assessment:
  – Which part of the document will be relevant?

Solution:
  – Consider every retrieved fragment f plus whole doc
  – impact(f)= absolute change in iP[0.01] when f relev.
  – impact(doc)= max impact of any fragment
  – Assess document with highest impact next
Rank-Based Relevance Probability

- Approximate $P[\text{rel}|\text{rank}]$ through exponential function
- Weight impact($f$) by minimal rank of $f$ in any run
Experiment (INEX09)

- approx. 5 times cheaper than INEX pooling

overall assessment cost vs. tau to original ranking

- INEX
- simple
- rank-bias
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Relevance Feedback Track

• Goal: use user‘s feedback to some results for improving further results of the same query

• Evaluation non-trivial: relevance of some results is known

• Traditional approaches:
  – Freeze known results at top of result list
  – Remove known results from result pool
Both used for the INEX 2006 RF track
RF track 2010-2012

• Interleaved retrieval & feedback
• Variant of freezing with many rounds
• Track provided interface to feedback module
• Submit implementation, not results
• Evaluate resulting list of results with standard tools
Natural Language Query Track

- Goal: Create structured NEXI query from description in natural language

Find sections about compression in articles about information retrieval.

/article[about(.,IR)]/sec[about(.,compression)]

- Evaluation: Process resulting queries with search engine and compare result quality to CAS query in the topic
Link the Wiki

Goal: automated discovery of document links

Wikipedia Collection

XML

MS SQL

Oracle

index structures

New document

XML

Relational databases

B+ tree

Find link targets
Book Search

• Goals: Investigate
  – book-specific relevance ranking strategies
  – user interface issues

<document>
<page pageNumber="1" label="PT CHAPTER" [coords] key="0" id="0">
<region regionType="Text" [coords] key="0" id="0">
<section label="SEC BODY" key="408" id="0">
<line [coords] key="0" id="0">
<word [coords] key="0" id="0" val="Moby"/>
<word [coords] key="1" id="1" val="Dick"/>
</line>
<line [...]><word [...] val="Melville"/>[...]</line>[...]
</section> [...]
</region> [...]
</page> [...]
</document>
Social Book Search Task

• Goal: study relative value of authoritative metadata and user-generated content

• Collection:
  – meta data for 2.8 million books from Amazon
  – tags, ratings, reviews from LibraryThing (LT)

• Task: Recommend books to read based on request in LT forum

• Additional input: LT profile of requesting user

• Assessments:
  – books recommended by others
  – pooling + Mechanical Turk
Multimedia Track (now at CLEF)

• 2 Collections:
  – Wikipedia XML including image files (60GB)
  – Image Metadata (from Wikipedia)

• Additional precomputed information provided:
  – Classification scores for 101 categories
    (Aircraft, Racing, Walking, …)
  – 120-dimensional feature vector
    (based on natural images statistics)
Multimedia Track

• Task 1: Retrieve document fragments for an info need with a multimedia character

//section[about(.//figure//image,concept:maps)]

(may include example images)

• Task 2: Pure image retrieval (from the metadata collection)
Tweet Contextualization Track

Example: @alfred #AlfredNobelPrize ceremony this evening in Scottsdale, AZ

1 The Alfred Noble Prize is an award presented by the combined engineering societies of the United States, given each year to a person not over thirty-five for a paper published in one of the journals of the participating societies.
2 The prize was established in 1929 in honor of Alfred Noble, Past President of the American Society of Civil Engineers.
3 It has no connection to the Nobel Prize, although the two are often confused due to their similar spellings.
Snippet Retrieval Track

• **Goal:** generate informative snippets for search results

• Two-stage assessment:
  – Use snippet to predict relevance of result
  – Use result document to determine relevance
Linked Data Track

<j jeopardy_clue> Niagara Falls has its source of origin from this lake. </jeopardy_clue>
<j keyword_title> Niagara Falls source lake </keyword_title>
<j sparql_ft>
select ?q Where {
  filter FTContains( ?o, "river water course niagara") .
  filter FTContains( ?q, "lake origin of")
}</sparql_ft>
Summary – Lessons Learned

Two main insights of the AdHoc track:

• Advantage (if any) of structured queries over content-only queries depends on collection & information need

• Focused retrieval is often not better than document (aka article-level) retrieval

Good understanding how to evaluate adhoc search tasks on document-centric XML

Retrieval of data-centric documents (or relational tables) largely unexplored
References

- INEX proceedings 2002-2012, https://inex.mmci.uni-saarland.de/
- Andrew Trotman, Mounia Lalmas: Strict and vague interpretation of XML-retrieval queries. SIGIR 2006: 709-710
- Besnik Fetahu, Ralf Schenkel: Retrieval evaluation on focused tasks. SIGIR 2012: 1135-1136