PURDUE UNIVERSITY

CS54701: Information Retrieval

Federated Search

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Federated Search

Outline

- Introduction to federated search
- Main research problems
  - Resource Representation
  - ➢Resource Selection
  - Results Merging

Research Problems (Resource Selection)

Goal of Resource Selection of Information Source Recommendation

High-Recall**: Select the (few) information sources that have the most relevant documents**

Research on Resource Selection

Resource selection algorithms that need training data

- **Decision-Theoretic Framework** (DTF) (Nottelmann & Fuhr, 1999, 2003)

  DTF causes large human judgment costs

- **Lightweight probes** (Hawking & Thistlewaite, 1999)

  Acquire training data in an online manner, large communication costs

Research Problems (Resource Selection)

Research on Resource Representation

"Big document" resource selection approach: Treat information sources as big documents, rank them by similarity of user query

- **Cue Validity Variance (CVV)** (Yuwono & Lee, 1997)

- **CORI** (Bayesian Inference Network) (Callan,1995)

- **KL-divergence** (Xu & Croft, 1999)(Si & Callan, 2002), Calculate KL divergence between distribution of information sources and user query

CORI and KL were the state-of-the-art (French et al., 1999)(Craswell et al,, 2000)

But "Big document" approach loses doc boundaries and does not optimize the goal of High-Recall

Language Model Resource Selection

$$P(db_i \mid Q) = \frac{P(Q \mid db_i) * P(db_i)}{P(Q)}$$

DB independent constant

$$P(Q \mid db_i) = \prod_{q \in Q} \left(\lambda P(q \mid db_i) + (1-\lambda) P(q \mid G) \right)$$

Calculate on Sample Docs

In Language Model Framework, $P(C_i)$ is set according to DB Size

$$P(C_i) = \frac{\hat{N}_{C_i}}{\sum_j \hat{N}_{C_j}}$$

Research Problems (Resource Selection)

Research on Resource Representation

But "Big document" approach loses doc boundaries and does not optimize the goal of High-Recall

Relevant document distribution estimation (ReDDE) (Si & Callan, 2003)

Estimate the percentage of relevant docs among sources and rank sources with no need for relevance data, much more efficient

Research Problems (Resource Selection)

Relevant Doc Distribution Estimation (ReDDE) Algorithm

$$Rel\_Q(i) = \sum_{d \in db_i} P(rel|d) * P(d|db_i) * N_{db_i} \approx \sum_{d \in db_{i\_samp}} P(rel|d) * SF_{db_i}$$

Source Scale Factor: $SF_{db_i} = \frac{\hat{N}_{db_i}}{N_{db_{i\_samp}}}$

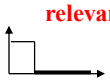
Estimated Source Size

Number of Sampled Docs

Rank on Centralized Complete DB

"Everything at the top is (equally) relevant"

$$P(rel|d) = \begin{cases} C_Q & \text{if } Rank_{CCDB}(Q,d) < ratio * \sum_i N_{db_i} \\ 0 & \text{otherwise} \end{cases}$$



Problem: To estimate doc ranking on Centralized Complete DB

Research Problems (Resource Selection)

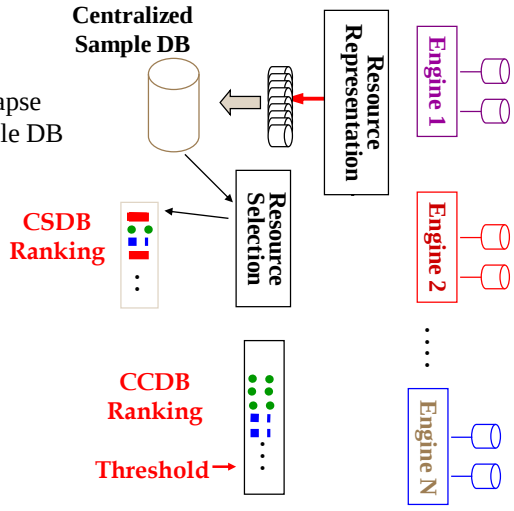
ReDDE Algorithm (Cont)

In resource representation:

- Build representations by QBS, collapse sampled docs into centralized sample DB

In resource selection:

- Construct ranking on CCDB with ranking on CSDB



Research Problems (Resource Selection)

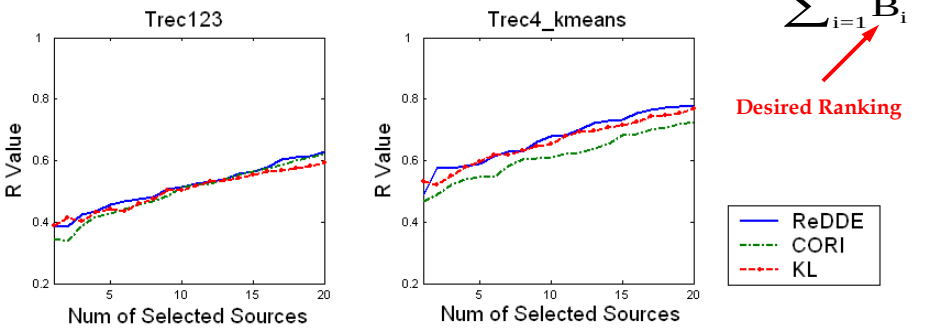
Experiments

On testbeds with uniform or moderately skewed source sizes

Evaluated Ranking

$$R_k = \frac{\sum_{i=1}^{k} E_i}{\sum_{i=1}^{k} B_i}$$

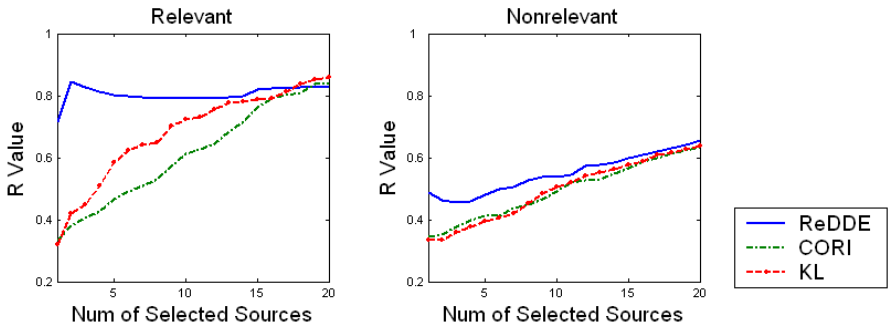
Desired Ranking



Research Problems (Resource Selection)

Experiments

On testbeds with skewed source sizes



Federated Search

Outline

- Introduction to federated search
- Main research problems
  - Resource Representation
  - Results Selection
  - ➢Resource Merging

Research Problems (Results Merging)

Goal of Results Merging

Make different result lists comparable and merge them into a single list

Difficulties:

- Information sources may use **different retrieval algorithms**
- Information sources have **different corpus statistics**

Previous Research on Results Merging

Most accurate methods directly calculate comparable scores

- **Use same retrieval algorithm and same corpus statistics** (Viles & French, 1997)(Xu and Callan, 1998), need source cooperation
- **Download retrieved docs and recalculate scores** (Kirsch, 1997), large communication and computation costs

Research Problems (Results Merging)

Research on Results Merging

Methods approximate comparable scores

- **Round Robin** (Voorhees et al., 1997), only use source rank information and doc rank information, fast but less effective
- **CORI merging formula** (Callan et al., 1995), linear combination of doc scores and source scores
  - Use linear transformation, a hint for other method
  - Work in uncooperative environment, effective but need improvement

Research Problems (Results Merging)

Thought

Previous algorithms either try to **calculate** or to **mimic** the effect of the centralized scores

Can we estimate the centralized scores effectively and efficiently?

Semi-Supervised Learning (SSL) Merging **(Si & Callan, 2002, 2003)**

- Some docs exist in both centralized sample DB and retrieved docs

  From Centralized sampled DB and individual ranked lists when long ranked lists are available

  Download minimum number of docs with only short ranked lists
- Linear transformation maps source specific doc scores to source independent scores on centralized sample DB

Research Problems (Results Merging)

SSL Results Merging (cont)

In resource representation:

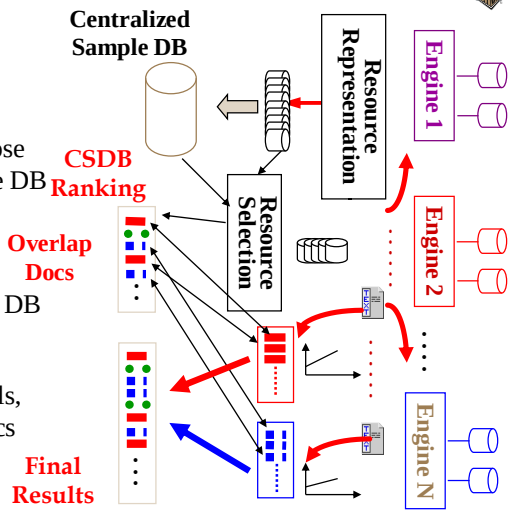
- Build representations by QBS, collapse sampled docs into centralized sample DB

In resource selection:

- Rank sources, calculate centralized scores for docs in centralized sample DB

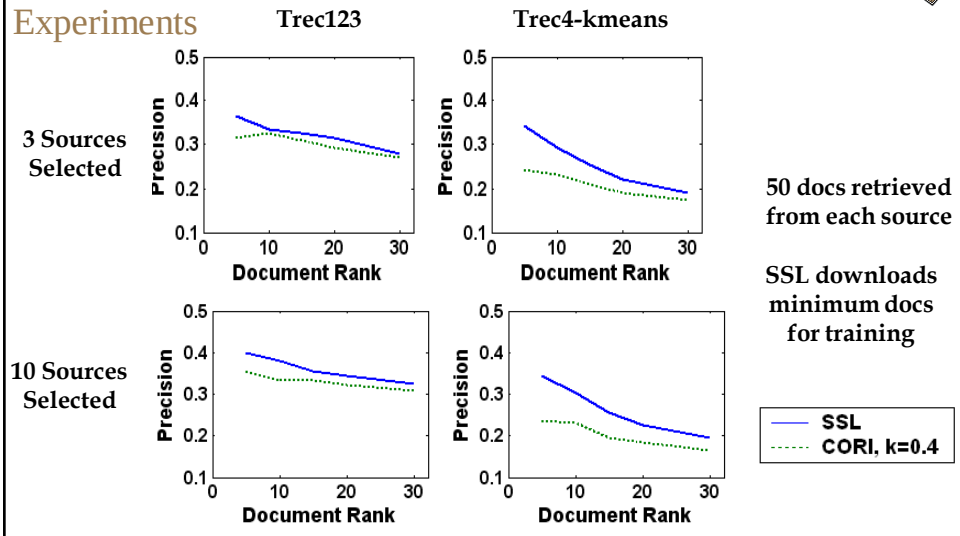
In results merging:

- Find overlap docs, build linear models, estimate centralized scores for all docs



Research Problems (Results Merging)

Experiments



Final Project

- Self-directed final project
  - You must decide what to do
- First step: Proposal
  - What is the problem?
  - How is it solved today?
  - What is your approach? Why should it work?
  - How long will it take? (Milestones)
  - What is your measure for success?
  - Deliverables

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Final Project: Ideas

- Identify an unsolved (or poorly solved) problem
  - Try a new solution
- Take an existing approach and try to improve it
- Compare existing approaches
- "Reproducibility": Validate existing work
  - Does it hold in different conditions / data?

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Final Project: Deliverables

Dependent on the project

- Written report describing outcomes / experiments
- (Taped) oral presentation describing outcomes
  - Include system demonstration?
- System that can be tried out
  - Runs on SSLab machines
  - Web accessible
- Other ideas?

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More on Federated Search

- Search Result Diversification (Hong&Si SIGIR'13)
- Problem: Lack of diversity in results
  - E.g., several copies of the same document
- Key contribution: Metric
  - Need to be able to measure diversity
- Builds on ReDDE and others

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Base: R-Metric

- Ranking algorithm independent metric
  - Based on top, or ranked list, of documents
- $R_k = \frac{\sum_{i=1}^{k} E_i}{\sum_{i=1}^{k} B_i}$
  - E_i is relevant documents in source *i* according to algorithm *E*
  - B_i is true relevant documents in source *i*
- Basic idea: Replace "Relevant" with a diversity metric

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Diversity

- Query has multiple *aspects*
  - Evaluate each aspect separately
  - Remember something like this?
  - *Macro vs. Micro F1*
- What is an aspect?
  - *Topic*

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