(Pseudo)-Relevance Feedback & Passage Retrieval

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NLP Systems & Applications
April 28, 2011

Roadmap

- Retrieval systems
- Improving document retrieval
  - Compression & Expansion techniques
- Passage retrieval:
  - Contrasting techniques
  - Interactions with document retreival

Retrieval Systems

- Three available systems
  - Lucene: Apache
    - Boolean systems with Vector Space Ranking
    - Provides basic CLI/API (Java, Python)

  - Indri/Lemur: Umass /CMU
    - Language Modeling system (best ad-hoc)
    - ‘Structured query language
      - Weighting,
    - Provides both CLI/API (C++,Java)

  - Managing Gigabytes (MG):
    - Straightforward VSM

Retrieval System Basics

- Main components:
  - Document indexing
    - Reads document text
      - Performs basic analysis
        - Minimally – tokenization, stopping, case folding
        - Potentially stemming, semantics, phrasing, etc
    - Builds index representation
  - Query processing and retrieval
    - Analyzes query (similar to document)
      - Incorporates any additional term weighting, etc
    - Retrieves based on query content
      - Returns ranked document list

Example (I/L)

- indri-5.0/buildindex/IndriBuildIndex parameter_file
  - XML parameter file specifies:
    - Minimally:
      - Index: path to output
      - Corpus (+): path to corpus, corpus type
    - Optionally:
      - Stemmer, field information
- indri-5.0/runquery/IndriRunQuery query_parameter_file -count=1000 \

  -index=/path/to/index -trecFormat=true > result_file

  Parameter file: formatted queries w/query #

Lucene

- Collection of classes to support IR
  - Less directly linked to TREC
    - E.g. query, doc readers
- IndexWriter class
  - Builds, extends index
  - Applies analyzers to content
    - SimpleAnalyzer: stops, case folds, tokenizes
    - Also Stemmer classes, other langs, etc
- Classes to read, search, analyze index
- QueryParser parses query (fields, boosting, regexp)

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        - Aspect models, stemming
    - Expansion approaches
      - Add in related terms to enhance matching

Compression Techniques

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  - Matrix representations typically very sparse
  - Reduce dimensionality to small # key aspects
    - Mapping contextually similar terms together
    - Latent semantic analysis

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    - User interaction
      - Direct or relevance feedback
    - Automatic pseudo relevance feedback

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  - "push" toward relevant vectors, away from non-relevant
    - Vector intuition:
      - Add vectors from relevant documents
      - Subtract vector from non-relevant documents

Relevance Feedback

- Rocchio expansion formula

$$\vec{q}_{i+1} = \vec{q}_i + \frac{\beta}{R}\sum_{j=1}^{R}\vec{r}_j - \frac{\gamma}{S}\sum_{k=1}^{S}\vec{s}_k$$

  - $\beta + \gamma = 1$ (0.75,0.25);
    - Amount of 'push' in either direction
  - R: # rel docs, S: # non-rel docs
  - r: relevant document vectors
  - s: non-relevant document vectors
- Can significantly improve (though tricky to evaluate)

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  - Use collection-based evidence: global or local

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- Create index of concepts:
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  - Representation: Context
    - Words in fixed length window, 1-3 sentences
  - Concept identifies context word documents
- Use query to retrieve 30 highest ranked concepts
  - Add to query

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  - Select informative terms from highly ranked documents
  - Add those terms to query
- Specifically,
  - Add 50 most frequent terms,
  - 10 most frequent 'phrases' – bigrams w/o stopwords
  - Reweight terms

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- Mixes two previous approaches
  - Use query to retrieve top n passages (300 words)
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- Relatively efficient
- Applies local search constraints

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- Improvements over baseline:
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- All approaches have fairly high variance
  - Help some queries, hurt others
- Also sensitive to # terms added, # documents

- Global Analysis

hypnosis	meditation	practitioners
dentists	antibodies	disorders
psychiatry	immunodeficiency-virus	anesthesia
susceptibility	therapists	dearth
atoms	van-dyke	self
confession	stare	proteins
katie	johns-hopkins-university	growing-acceptance
reflexes	voltage	ad-hoc
correlation	conde-nast	dynamics
ike	illnesses	hoffman

- Local Analysis

hypnot	hypnotiz	19960500
psychosomat	psychiatr	immun
mesmer	franz	suscept
austrian	dyck	psychiatrist
shesaid	tranc	professor
hallucin	18th	centur
hilgard	11th	unaccept
19820902	syndrom	exper
physician	told	patient

- LCA

hypnosis	brain-wave	ms.-burns
technique	pulse	reed
brain	ms.-olness	trance
hallucination	process	circuit
van-dyck	behavior	suggestion
case	spiegel	finding
hypnotizables	subject	van-dyke

What are the different techniques used to create self-induced hypnosis?

Passage Retrieval

- Documents: wrong unit for QA
  - Highly ranked documents
    - High weight terms in common with query
    - Not enough!
      - Matching terms scattered across document
      - Vs
      - Matching terms concentrated in short span of document
- Solution:
  - From ranked doc list, select and rerank shorter spans
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- Factors in reranking:

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  - Question match:
    - Question term overlap
    - **Span** overlap: N-gram, longest common sub-span
    - Query term **density:** short spans w/more qterms

Quantitative Evaluation of Passage Retrieval for QA

- Tellex et al.
- Compare alternative passage ranking approaches
  - 8 different strategies + voting ranker
- Assess interaction with document retrieval

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  - Results Boolean retrieval RANKED by tf-idf
    - Little control over hit list
- Oracle: NIST-provided list of relevant documents

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  - Units
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  - Factor: Term overlap count
- MITRE+stemming:
  - Factor: stemmed term overlap

Comparing Passage Retrieval

- Okapi bm25
  - Unit: fixed width sliding window
  - Factor: $$Score(q,d) = \sum_{i=1}^{N} idf(q_i) \frac{tf_{q_i,d}(k_1 + 1)}{tf_{q_i,d} + k_1(1 - b + (b * \frac{|D|}{avgdl}))}$$
    - k1=2.0; b=0.75

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- MultiText:
  - Unit: Window starting and ending with query term
  - Factor:
    - Sum of IDFs of matching query terms
    - Length based measure * Number of matching terms

Comparing Passage Retrieval

- IBM:
  - Fixed passage length
  - Sum of:
    - Matching words measure: Sum of idfs of overlap terms
    - Thesaurus match measure:
      - Sum of idfs of question wds with synonyms in document
    - Mis-match words measure:
      - Sum of idfs of questions wds NOT in document
    - Dispersion measure: # words b/t matching query terms
    - Cluster word measure: longest common substring

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- SiteQ:
  - Unit: n (=3) sentences
  - Factor: Match words by literal, stem, or WordNet syn
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      - Sum of idfs of matched terms
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$$dw(q,d) = \frac{\sum_{j=1}^{k-1} \frac{idf(q_j) + idf(q_{j+1})}{\alpha \times dist(j, j+1)^2}}{k-1} \times overlap$$

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- Alicante:
  - Unit: n (= 6) sentences
  - Factor: non-length normalized cosine similarity
- ISI:
  - Unit: sentence
  - Factors: weighted sum of
    - Proper name match, query term match, stemmed match

Experiments

- Retrieval:
  - PRISE:
    - Query: Verbatim quesiton
  - Lucene:
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- Retrieval:
  - PRISE:
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- Passage retrieval: 1000 word passages
  - Uses top 200 retrieved docs
  - Find best passage in each doc
  - Return up to 20 passages
    - Ignores original doc rank, retrieval score

Evaluation

- MRR
  - Strict: Matching pattern in official document
  - Lenient: Matching pattern
- Percentage of questions with NO correct answers

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	Strict				
	Lucene		PRISE		TREC
Algorithm	MRR	% Inc.	MRR	% Inc.	% Inc.
IBM	0.326	49.20%	0.331	39.60%	44.3%
ISI	0.329	48.80%	0.287	41.80%	41.7%
SiteQ	0.323	48.00%	0.358	40.40%	56.1%
MultiText	0.354	46.40%	0.325	41.60%	43.1%
Alicante	0.296	50.00%	0.321	42.60%	60.4%
bm25	0.312	48.80%	0.252	46.00%	n/a
stemmed MITRE	0.250	52.60%	0.242	58.60%	n/a
MITRE	0.271	49.40%	0.189	52.00%	n/a
Averages	0.309	49.15%	0.297	45.33%	n/a
Voting with IBM, ISI, SiteQ	0.350	39.80%	0.352	39.00%	n/a

Evaluation on Oracle Docs

Algorithm	# Incorrect	% Incorrect	MRR
IBM	31	7.18%	0.851
SiteQ	32	7.41%	0.859
ISI	37	8.56%	0.852
Alicante	39	9.03%	0.816
MultiText	44	10.19%	0.845
bm25	45	10.42%	0.810
MITRE	45	10.42%	0.800
stemmed MITRE	63	14.58%	0.762

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- Lucene:
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- Best systems:
  - IBM, ISI, SiteQ
  - Relatively insensitive to retrieval engine

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- Techniques: Density-based scoring improves
  - Variants: proper name exact, cluster, density score

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- ‘What is an ulcer?’
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  - Match doesn’t help
  - Need question type!!
- Missing relations
  - ‘What is the highest dam?’
    - Passages match ‘highest’ and ‘dam’ – but not together
  - Include syntax?