

A Full-Text Learning to Rank Dataset for Medical Information Retrieval



UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

Vera Boteva, Demian Gholipour, Artem Sokolov, Stefan Riezler
{boteva, gholipour, sokolov, riezler}@cl.uni-heidelberg.de

Motivation and Approach

- ▶ bridge lexical gap between layman's English and scientific medical literature
- ▶ website NutritionFacts.org (NF) provides information on health and nutrition topics with references to research articles
- ▶ use NF content and references to assemble a corpus for medical IR
- ▶ extract queries from NF content and documents from scientific articles linked on NF pages
- ▶ graded relevance scheme from internal linking structure and citation links

Extracting Queries

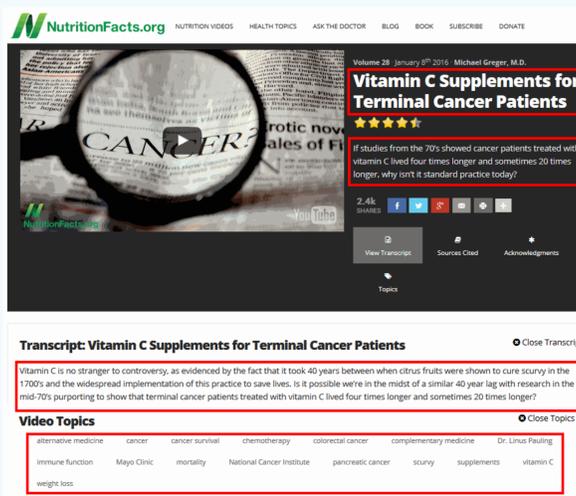
Sections in NF pages used for queries:

- ▶ video pages: title, short description, video transcript
- ▶ blog articles, Q&A pages, topic pages: title, text

Links between NF pages:

- ▶ used as indirect connection between queries and documents through intermediate queries
- ▶ videos and blog articles include a list of topics, useful for introducing additional links between queries

Statistics for different query types:



type	# queries	mean/median		mean # docs per query		
		# tokens	# tokens per query	lev. 2	lev. 1	lev. 0
all fields	3244	1890.0	43.5	4.6	41.6	33.8
all titles	3244	3.6	1.5	4.6	41.6	33.8
titles of non-topic pages	1429	6.0	4.0	4.6	25.4	26.3
video titles	1016	5.5	6.0	4.9	23.6	27.1
video descriptions	1016	24.3	21.0	4.9	23.6	27.1

Experiments

Baselines: retrieval with classical **tfidf** and **Okapi BM25** ranking scores

Two Learning-to-Rank methods:

- ▶ let $\mathbf{q} \in \{0, 1\}^Q$ and $\mathbf{d} \in \{0, 1\}^D$ be query and document vectors, dimensions indicating word occurrence for dictionaries of size Q and D
- ▶ score function $f(\mathbf{q}, \mathbf{d}) = \mathbf{q}^T W \mathbf{d} = \sum_{i=1}^Q \sum_{j=1}^D \mathbf{q}_i W_{ij} \mathbf{d}_j$, where $W \in \mathbb{R}^{Q \times D}$ is a matrix of word associations between query and document dictionaries
- ▶ \mathcal{R} is a set of tuples $(\mathbf{q}, \mathbf{d}^+, \mathbf{d}^-)$, document \mathbf{d}^+ being more relevant for query \mathbf{q} than \mathbf{d}^-
- ▶ relevance rank $r_{\mathbf{q}, \mathbf{d}}$, rank difference $m(\mathbf{q}, \mathbf{d}^+, \mathbf{d}^-) = r_{\mathbf{q}, \mathbf{d}^+} - r_{\mathbf{q}, \mathbf{d}^-}$
- ▶ **RankBoost**: $\mathcal{L}_{exp} = \sum_{(\mathbf{q}, \mathbf{d}^+, \mathbf{d}^-) \in \mathcal{R}} m(\mathbf{q}, \mathbf{d}^+, \mathbf{d}^-) e^{f(\mathbf{q}, \mathbf{d}^+) - f(\mathbf{q}, \mathbf{d}^-)}$
 - ▷ using batch boosting and bagging
- ▶ **SGD**: $\mathcal{L}_{hng} = \sum_{(\mathbf{q}, \mathbf{d}^+, \mathbf{d}^-) \in \mathcal{R}} (f(\mathbf{q}, \mathbf{d}^+) - f(\mathbf{q}, \mathbf{d}^-))_+ + \lambda \|W\|_1$
 - ▷ where $(x)_+ = \max(0, x)$
 - ▷ using Stochastic Gradient Descent

Random division of queries into 80% train, 10% dev, 10% test sets

MAP/NDCG results evaluated for different query types:

queries	RankBoost	SGD	tfidf	bm25
all fields	0.2632/0.5073	0.3831/ 0.6064	0.1360/0.3932	0.1627/ 0.4169
all titles	0.1549/ 0.3475	0.1360/0.3454	0.1233/0.2578	0.1251/ 0.2582
titles of non-topic pages	0.1615/ 0.4039	0.1775/0.3790	0.0972/0.2851	0.1124/ 0.3032
video descriptions	0.1312/ 0.3826	0.1060/0.3112	0.1110/0.3509	0.1262/ 0.3765
video titles	0.1350/ 0.3804	0.1079/0.3109	0.1010/0.2873	0.1127/ 0.3042

Collecting Documents

Video pages list references, with links to scientific articles:

Video Sources

E T Creagan, C G Moertel, J R O'Fallon, A J Schutt, M J O'Connell, J Rubin, S Frytak. Failure of high-dose vitamin C (ascorbic acid) therapy to benefit patients with advanced cancer. A controlled trial. N Engl J Med. 1979 Sep 27;301(13):687-90.

C G Moertel, T R Fleming, E T Creagan, J Rubin, M J O'Connell, M M Ames. High-dose vitamin C versus placebo in the treatment of patients with advanced cancer who have had no prior chemotherapy. A randomized double-blind comparison. N Engl J Med. 1985 Jan 17;312(3):137-41.

J Verrax, P B Calderon. The controversial place of vitamin C in cancer treatment. Biochem Pharmacol. 2008 Dec 15;76(12):1644-52.

Other pages link external references in the text:

Where are the Lowest Rates of Alzheimer's in the World?

Written by: Michael Greger M.D. on November 12th, 2015

The rates of dementia **differ** greatly around the world, from the lowest rates in Africa, India, and South Asia, to the highest rates in Western Europe and especially North America. Is it all just genetics? Well, the incidence of dementia and Alzheimer's disease is **significantly lower** for Africans in Nigeria than for African Americans in Indianapolis, for example—up to five times lower.

- ▶ 89% of links to external pages lead to articles in PubMed or PubMed Central archives
- ▶ titles and abstracts of these articles were crawled
- ▶ 3,633 documents in total, mean/median number of tokens: 147.1/76.

Relevance Levels

- ▶ **level 2**: direct link between query \mathbf{q} and document \mathbf{d} (e.g. source in a video page)
- ▶ **level 1**: indirect link: \mathbf{q} links \mathbf{q}' and \mathbf{q}' links \mathbf{d} (e.g. article links video, video links source)
- ▶ **level 0**: \mathbf{q}' links \mathbf{d} and \mathbf{q} shares at least 70% of topics with \mathbf{q}'

Conclusion

Key features of the dataset:

- ▶ full-text queries of various length, enabling development of complete learning models
- ▶ relevance links at 3 levels
- ▶ queries in layman's English linked to abstracts of medical research articles
- ▶ public availability of the dataset:
www.cl.uni-heidelberg.de/statnlpgroup/nfcorpus/

Findings of experiments:

- ▶ dataset size sufficient for learning ranking models that outperform standard bag-of-words IR methods by far

Acknowledgements

