NTCIR-10, SPOKENDOC06

GIFU UNIVERSITY

# Spoken document retrieval using extended query model and web documents

Kiichi Hasegawa, Masanori Takehara, Satoshi Tamura, Satoru Hayamizu
Gifu University

## Our approach

- Our basic framework is a query model.
- Two types of extension:
  - 1) One is to use web documents to expand the corpus as dynamic documents.
  - 2) The other is to use a topic model (LDA) to estimate similarities between web documents and the corpus in the test collection.
- These two extensions are incorporated in a smoothing formula with Dirichlet smoothing.

## Query model

- The probabilities where q is a given query and d is a document.

$$P(d|q) = \frac{P(q|d)P(d)}{P(q)} \propto P(q|d)$$

- In language modeling of multinomial model, each term is assumed to be independent.

$$P(q|\theta_d) = \prod_{w_i \in V} P(w_i|\theta_d)^{C(w_i,q)}$$

$$w_i \in V = \{w_1, w_2, ..., w_{|V|}\}$$

- Relative frequency of each term;

$$P(w_i|\theta_d) = \frac{C(w_i,q)}{|d|}$$

## Dirichlet smoothing

- The Dirichlet smoothing is given by;

$$P(w_i|\theta_d,\mu) = \frac{|d|}{|d|+\mu} \cdot P(w_i|\theta_d) + \frac{\mu}{|d|+\mu} \cdot P(w_i|\theta_c)$$

- with a parameter $\mu$ and,
- the probability for all the collection $P(w_i|\theta_c)$
- For a long document, the smoothing effect becomes smaller.

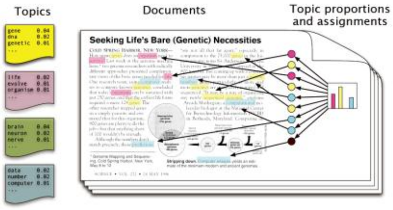
## Smoothing using dynamic documents

- Dynamic documents are web pages obtained according to given queries.
- Dirichlet smoothing is extended as follows:

$$P(w_i|\theta_d,\mu,\nu) = \frac{|d|}{|d|+\mu+\nu} \cdot P(w_i|\theta_d) + \frac{\mu}{|d|+\mu+\nu} \cdot P(w_i|\theta_c) + \frac{\nu}{|d|+\mu+\nu} \cdot P(w_i|\theta_W)$$

- where $P(w_i|\theta_W)$ is for the dynamic documents (web pages) and $\mu$ and $\nu$ are the smoothing parameters.

## LDA (latent Dirichlet allocation)

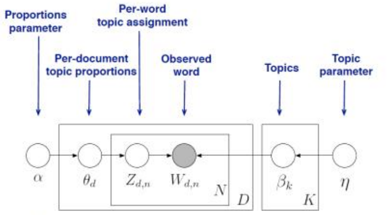


- LDA posits that each document is a mixture of topics, and that each word's creation is attributable to one of the document's topics.

from David M. Blei, KDD2011, tutorial

## graphical model of LDA

$$\prod_{i=1}^{K} p(\beta_i|\eta) \prod_{d=1}^{D} p(\theta_d|\alpha) \left( \prod_{n=1}^{N} p(z_{d,n}|\theta_d) p(w_{d,n}|\beta_{1:K}, z_{d,n}) \right)$$



from David M. Blei, KDD2011, tutorial

## Weighting method

- Weighted score is used for probability of the web page which is extracted by the query.
- Its weight is average similarity between the web page and documents in the collection.

$$P(w_i|\theta_W) = \frac{\sum_{j=1}^{|W|} \delta(p_j,C) \cdot C(w_i,P_j)}{\sum_{J=1}^{|W|} \sum_{k=1}^{N_j} \delta(p_j,C) \cdot C(w_k,p_j)}$$

- where

$$\delta(p,C) = \frac{1}{|C|} \sum_{m=1}^{|C|} \delta(p,d_m)$$

$$C = \{d_1, d_2, ..., d_{|C|}\}$$

## Similarity by topic mixture

- Similarity between a document and a web page is defined as cosine distance between topic mixture ratio vectors.

$$\gamma = (\gamma_1, \gamma_2, ..., \gamma_{|Z|})$$

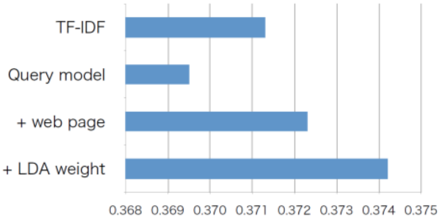
- For each document, a topic mixture ratio vector (topic proportion) is estimated using LDA with the parameters $\alpha$, $\beta_k$ from the whole document collection.
- For a web page, a topic mixture ratio vector is estimated using the same parameters $\alpha$ , $\beta_k$ .
- Finally, cosine distance between two vectors are calculated as the similarity measure.

## Experiments

- Experimental setup
- SpokenDoc-2 SCR subtask in NTCIR-10
- Sub-subtask: Lecture retrieval
- Spoken document: Ref-Word-Matched
- LDA training data: Mainichi newspaper corpus (2007-2008)
- Web search engine: Yahoo! API
- Dynamic documents: 30 web pages per query
- Smoothing parameters: $\mu$ =4000, $\nu$ =50

## NTCIR-9 Dry-run results

- Preliminary experiment by NTCIR-9 Dry-run.
- The score is the Mean Average Precision (MAP).



## NTCIR-10 Formal-run results

- Table 2. Results for NTCIR-10 SpokenDoc-2 Formal-run.

| | |
|---|---|
| Query model + LDA (RunID L36) | 0.408 |
| Query model + Web (RunID L37) | 0.399 |
| Query Expansion (RunID L38) | 0.372 |

- Note: since queries in NTCIR-10 Formal-run were longer than those in NTCIR-9 Dry-run, it seemed that more related and informative web pages were obtained.

## Conclusion

- Our spoken document retrieval method uses the language model approach.
- We extend query model in two ways.
- One is to use web page retrieval for dynamic document collection.
- The other is to employ a topic model (latent Dirichlet allocation) for the measure between documents and retrieved web pages.
- We expand the Dirichlet smoothing for dynamic documents and the topic model.
- We showed improvements at NTCIR-9 Dry-run and NTCIR-10 Formal-run.