Ranking Methods for Query Relaxation in Book Search

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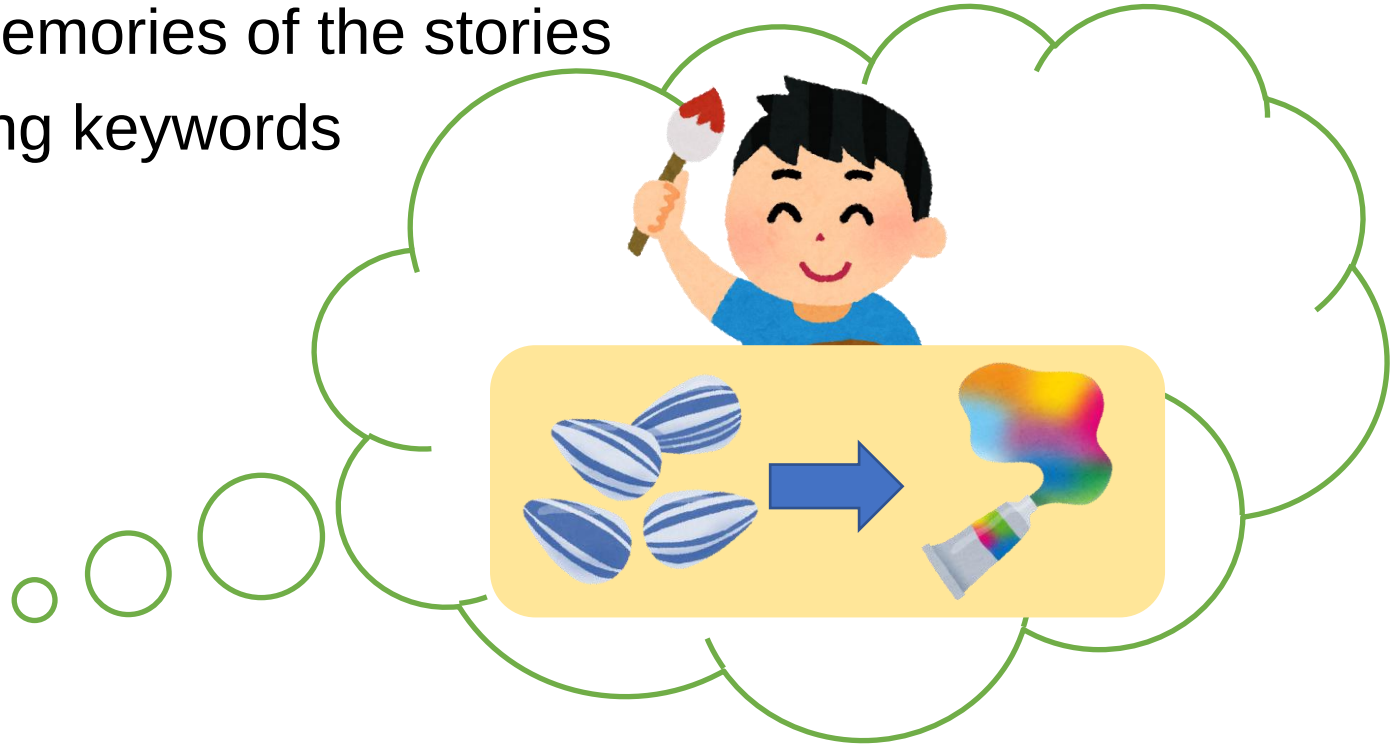
Background

- Book search situation
- Users only have vague memories of the stories
- Queries may include wrong keywords



a boy makes paints with blue seeds **Search**

flowers

Approach

Problem

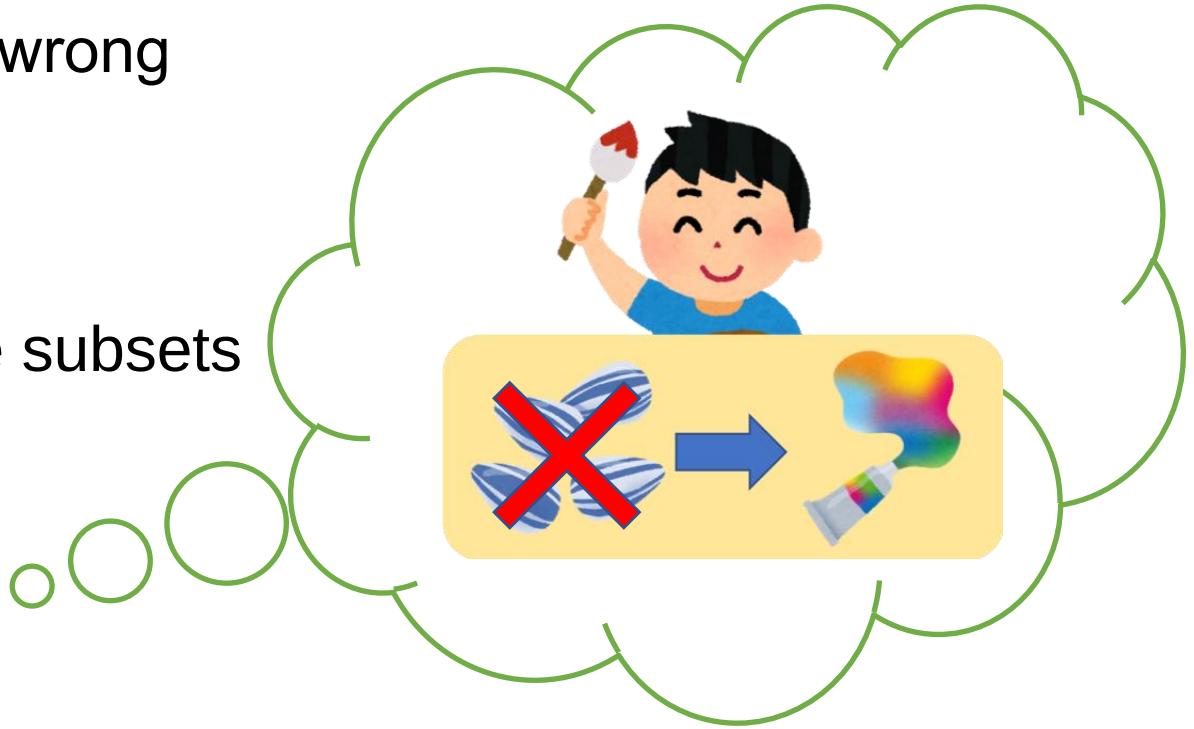
- Make new queries by removing wrong keywords

a boy makes paints with blue seeds **Search** → a boy makes paints with blue **Search**

→ Cannot know which words are wrong

Solution

- Use every subset as a new query
- Rank according to reliability of the subsets



Proposed method

A sentence query from a user

In the book,

a boy makes paints with blue seeds.

Generate all subset queries

a boy	make	paint	blue	seed
	make	paint	blue	seed
a boy		paint	blue	seed
⋮		⋮	⋮	⋮
				seed

Rank subset queries based on reliability of query words

1	a boy	make	paint	blue	seed
2	a boy		paint		seed
3	a boy		paint	blue	
	⋮		⋮	⋮	⋮
31					seed

Concatenate results

Result of query 1
1. Book 1
2. Book 2
3. Book 3

Result of query 2
1. Book 4
2. Book 5
3. Book 6

Result of query 3
1. Book 7
2. Book 8

⋮

Hypothesis

Reliability of each word depends on its semantic role

- Collect sentence queries from users
- Parse dependencies of the sentence query and classify words into four roles

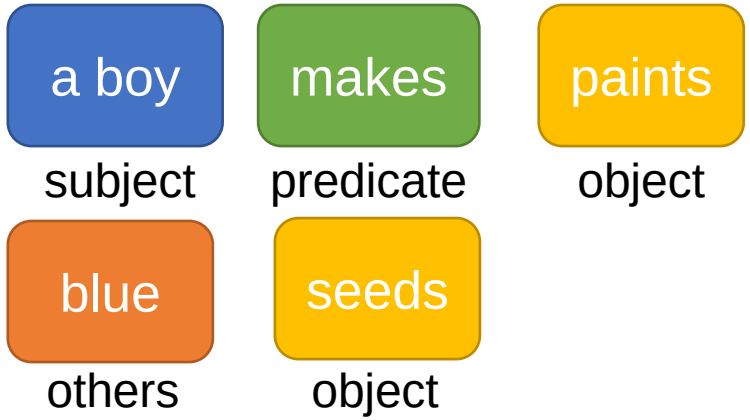
A sentence query from a user

In the book,

a boy makes paints with blue seeds.

Semantic roles
- Subject
- Predicate
- Object
- Others

Classify query words



Data used in our experiments

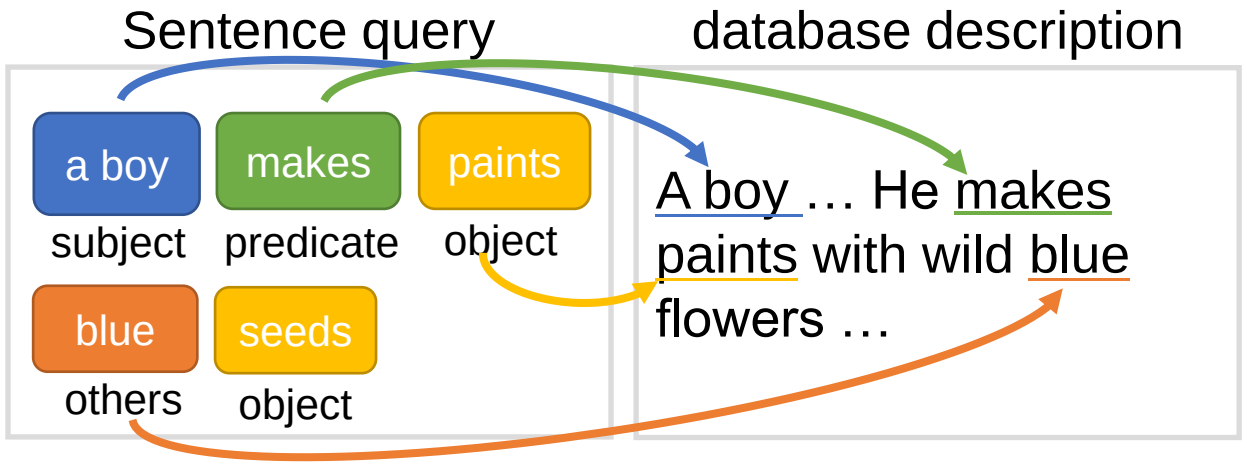
- 37 sentence queries by users
  - collected from Yahoo! Chiebukuro (a Japanese popular QA site)
  - question and answer data
    - Q : users asked for titles of books based on vague memories
    - A : questioners found that the answer books were correct

Question	Answer	Comment from questioner
I am searching for a book that I read when I was a child. In the book, a boy makes paints with blue seeds.	It may be wrong, but I think the book is “Real Sky-Blue”. You can see the design of the book in this web page.	I checked the web page and I found that the book is what I was searching for. Thank you very much.

- Correct descriptions of target books
  - collected from the database of National Diet Library of Japan (NDL)

Which semantic role is more reliable?

- Examine whether each word in the sentence queries also appears in the database description
- Calculate the ratio of the appearing words in both descriptions for each of the four roles
- Use each ratio as the probability that a query word in each class also appears in the correct description of the target book



class	in user description	in database description	ratio
subject	43	19	0.442
predicate	62	3	0.048
object	55	30	0.545
others	34	15	0.441

The reliability of predicate is lowest

Ranking queries

- Proposed method : Probability Ranking Principle (PRP)
  - Classify query words according to their reliability
  - Rank queries by their reliability
- Baseline 1 : Number of Words method
  - Rank queries by number of included words
- Baseline 2 : TF-IDF
  - Rank queries by the cosine similarity to the original query in the descending order

Probability Ranking Principle (PRP)

- $QP(q)$: the probability that all words in a generated query q appear in the description in the database
  - Defined as the product of the reliability value of each word in the query

e.g.

$q =$ a boy (subject) paints (object) seeds (object)

A sentence query from a user

In the book,

a boy makes paints with blue seeds.

$$QP(q) = 0.442 \times 0.545 \times 0.545 = 0.131$$

- The probability that a word in subject class appears in the correct description is 0.442
- The probability that a word in object class appears in the correct description is 0.545

Probability Ranking Principle (PRP)

- $hit(q)$: the number of search results for the query q
  - ex. $hit(q) = 5$
- $p(q)$: the probability that each book in the search results is correct
  - Define $p(q)$ as $QP(q)/hit(q)$
  - ex. $p(q) = QP(q)/hit(q) = 0.131/5 = 0.026$
- Ranked queries by $p(q)$ in descending order

a boy paints seeds **Search**

Number of Search Result: 5

$QP(q) = 0.131$

Book 1	$p(q) = 0.026$
Book 2	$p(q) = 0.026$
Book 3	$p(q) = 0.026$
Book 4	$p(q) = 0.026$
Book 5	$p(q) = 0.026$

Baseline 1: Number of Words method

- Rank the queries by the number of included words in the descending order

A sentence query from a user

In the book,

a boy makes paints with blue seeds.

1	a boy		paints	blue	seeds
2	a boy	makes		blue	seeds
3		makes	paints	blue	seeds
4	a boy	makes	paints		seeds
5	a boy	makes	paints	blue	
6	a boy			blue	seeds
7		makes		blue	seeds
⋮	⋮	⋮	⋮	⋮	⋮
14	a boy	makes	paints		seeds
15	a boy	makes	paints	blue	

- Queries composed 4 words
- Ranked randomly

- Queries composed 3 words
- Ranked randomly

Baseline 2 : TF-IDF

- Queries are ranked by the cosine similarity to the original query in the descending order
- Ex: $q =$ a boy (subject) paints (object) seeds (object)

	a boy	makes	paints	blue	seeds
Original	1	1	1	1	1
Subset	1	0	1	0	1

Experiment

- Generate queries with data mentioned in the preliminary experiment
  - Question and answer pairs collected in the Japanese QA site
- Use the NDL search engine to execute generated queries
- Compare results by Mean Reciprocal Rank (MRR) and distribution of the rank of target books
- Number of Words method has a random factor
  - the average of 10 runs

Result (1)

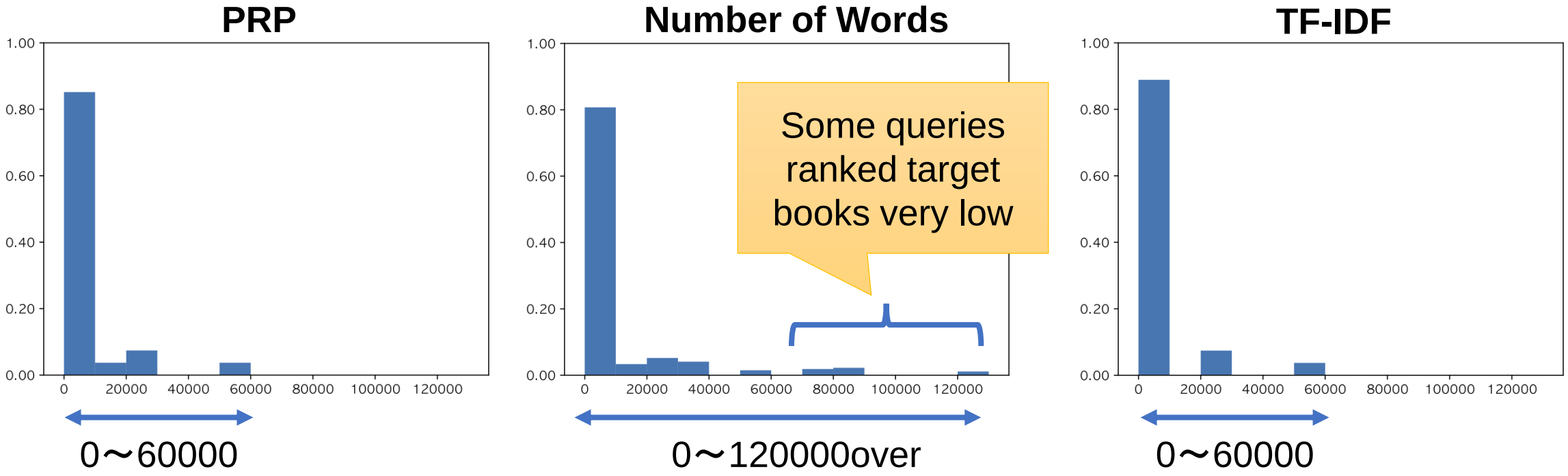
- MRR

PRP	Number of Words	TF-IDF
0.157	0.164	0.121

→ PRP was
  - better than TF-IDF
  - worse than Number of Words method

Result (2)

- Distribution of the rank of target books



→ PRP is more stable than Number of Words method

Discussion

- A query has more words
  - the probability that the correct description includes all query words becomes low
  - The result of this query may not contain the target book
- A query has less words
  - The number of search results becomes larger
  - The average rank of the target book becomes lower

→ PRP can control this trade-off appropriately

Conclusion

- Our method consists of two parts
  1. Ranking subsets of the original sentence query
     - Classify words in a subset query into 4 semantic roles
     - Use reliability of each query word for ranking queries
  2. Concatenating the results of subset queries

- Conduct an experiment to compare ranking methods
  - PRP was better than TF-IDF in MRR
  - PRP was more stable than Number of Words method