Math Indexer and Searcher under the Hood: History and Development of a Winning Strategy

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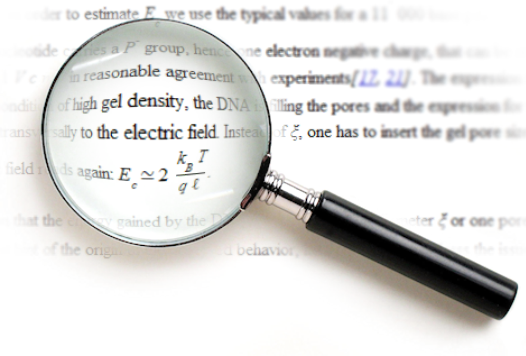

Illustrations by Jiří Franek.

Outline

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NTCIR-10 Math Task

- The first (pilot) year of the math task event last year (i.e. 2013).
- Formula search and Full-text search.
  - 4 runs submitted – differ in query language.
    - PMath – Run #1.
    - CMath – Run #2.
    - PCMath – Run #3.
    - TEX – Run #4.
- Open Information Retrieval.
  - 1 run submitted – TEX + text mixed queries.

NTCIR-10 Math Task Results

Table 1: Result metrics for submitted runs in Formula Search with Relevance Level ≥ 3 (Relevant)

Metric	Run 1	Run 2	Run 4
P-10 avg	0.105	0.191	**0.219**
P-5 avg	0.133	0.229	**0.276**
MAP avg	0.060	0.112	**0.127**
Precision	0.109 (64/589)	**0.185** (92/496)	0.123 (96/778)

Table 2: Result metrics for submitted runs in Formula Search with Relevance Level ≥ 1 (Partially Relevant)

Metric	Run 1	Run 2	Run 4
P-10 avg	0.143	0.214	**0.267**
P-5 avg	0.181	0.267	**0.343**
MAP avg	0.066	0.081	**0.100**
Precision	0.148 (87/589)	**0.232** (115/496)	0.161 (125/778)

NTCIR-11 Math-2 Task

- Only one type of queries.
  - 50 queries, each
    - 1–4 formulae,
    - 1–4 keyphrases.
- Wikipedia task in addition to the Main task.

NTCIR-11 Math-2 Main Task Results

Table: Results of submitted runs with Relevance Level ≥ 3 (Relevant). Main task team rank is in [ ] for our best runs (in bold).

	PMath	CMath	PCMath	TEX
MAP avg	0.3073	**0.3630 [1]**	0.3594	0.3357
P@10 avg	0.3040	**0.3520 [1]**	0.3480	0.3380
P@5 avg	0.5120	**0.5680 [1]**	0.5560	0.5400

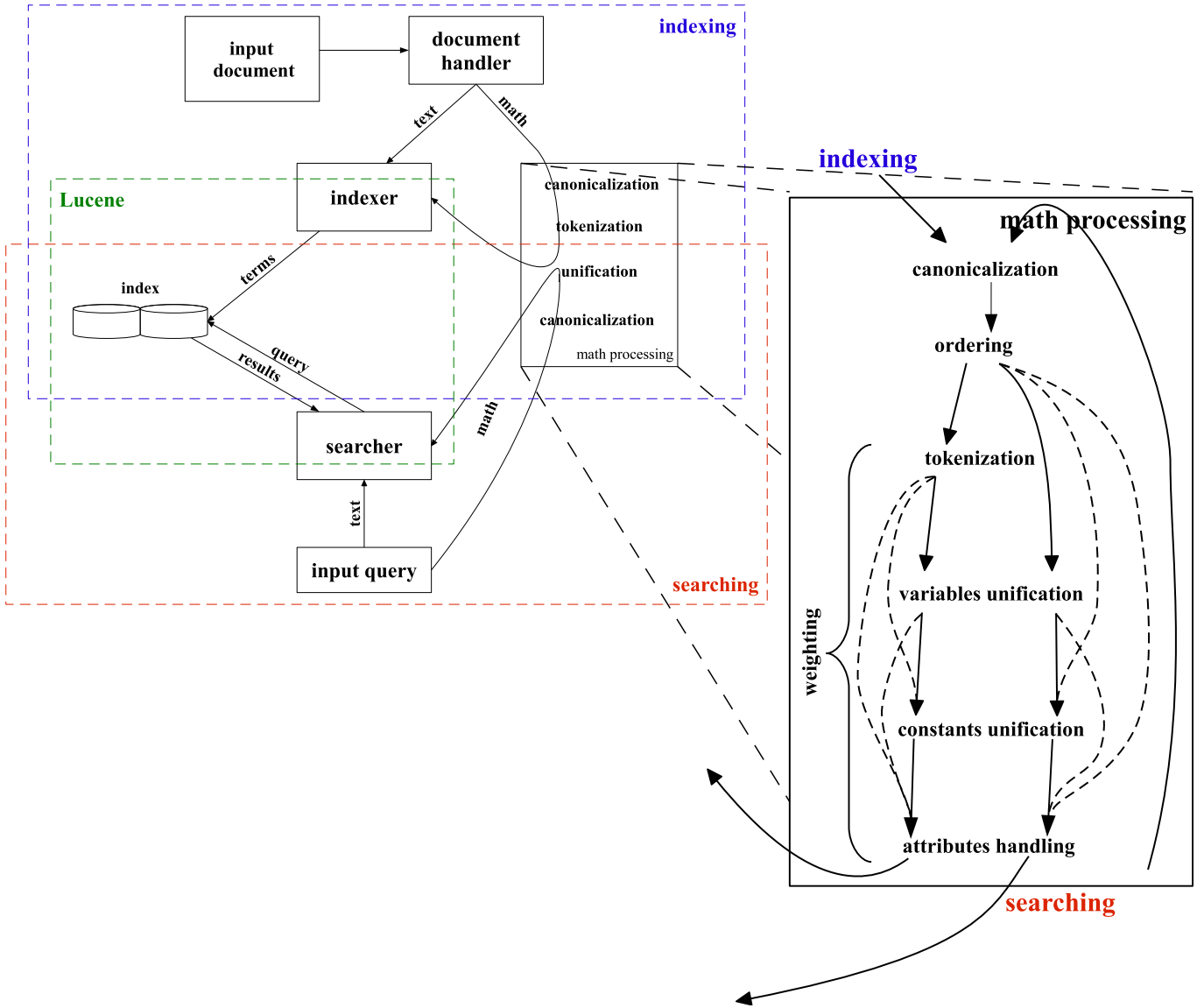
Table: Results of submitted runs with Relevance Level ≥ 1 (Partially Relevant). Number in [ ] is team rank of all runs.

	PMath	CMath	PCMath	TEX
MAP avg	0.2557	**0.2807 [2]**	0.2799	0.2747
P@10 avg	0.5020	0.5440	**0.5520 [1]**	0.5400
P@5 avg	0.8440	**0.8720 [2]**	0.8640	0.8480

NTCIR-11 Math-2 Wikipedia Task Results

- Topics with results:
  - 75 out of 100 (CMath run)
- Average position:
  - 64 correct results in top 100
  - 58 correct results in top 20
  - 56 correct results in top 10
  - 53 correct results in top 5
  - 52 correct results in top 4
  - 50 correct results in top 3
  - 48 correct results in top 2
  - 46 correct results in top 1

NTCIR-11 Math-2 Main Task Approach



NTCIR-11 Math-2 Main Task Approach: News

- Query expansion & strip-merging of subresults.
  - Query expansion.

query 1 (the original query):	f_1	f_2	k_1	k_2	k_3
query 2:	f_1	f_2	k_1	k_2	
query 3:	f_1	f_2	k_1		
query 4:	f_1	f_2			
query 5:	f_1		k_1	k_2	k_3
query 6:			k_1	k_2	k_3

NTCIR-11 Math-2 Main Task Approach: News

- Strip-merging of subresults.
  - Example on three subqueries (the original one and two derived subqueries).

Results of the original query:

1: $r1_{\text{original}}$
2: $r2_{\text{original}}$
3: $r3_{\text{original}}$
4: $r4_{\text{original}}$
5: $r5_{\text{original}}$
6: $r6_{\text{original}}$
7: $r7_{\text{original}}$
8: $r8_{\text{original}}$
9: $r9_{\text{original}}$
10: $r10_{\text{original}}$
11: $r11_{\text{original}}$

Results of the subquery 1:

1: $r1_{\text{subquery 1}}$
2: $r2_{\text{subquery 1}}$
3: $r3_{\text{subquery 1}}$
4: $r4_{\text{subquery 1}}$
5: $r5_{\text{subquery 1}}$

Results of the subquery 2:

1: $r1_{\text{subquery 2}}$
2: $r2_{\text{subquery 2}}$
3: $r3_{\text{subquery 2}}$
4: $r4_{\text{subquery 2}}$
5: $r5_{\text{subquery 2}}$

The final result list:

1: $r1_{\text{original}}$
2: $r2_{\text{original}}$
3: $r3_{\text{original}}$
4: $r1_{\text{subquery 1}}$
5: $r2_{\text{subquery 1}}$
6: $r1_{\text{subquery 2}}$
7: $r4_{\text{original}}$
8: $r5_{\text{original}}$
9: $r6_{\text{original}}$
10: $r3_{\text{subquery 1}}$
11: $r4_{\text{subquery 1}}$
12: $r2_{\text{subquery 2}}$
13: $r7_{\text{original}}$
14: $r8_{\text{original}}$
15: $r9_{\text{original}}$
16: $r5_{\text{subquery 1}}$
No more results from subquery 1.
17: $r3_{\text{subquery 2}}$
18: $r10_{\text{original}}$
19: $r11_{\text{original}}$
No more results from the original query.
20: $r4_{\text{subquery 2}}$
21: $r5_{\text{subquery 2}}$
No more results from subquery 2.
22: $r1_{\text{random}}$
23: $r2_{\text{random}}$
...
1000: $r979_{\text{random}}$

Query Expansion Results' Insight

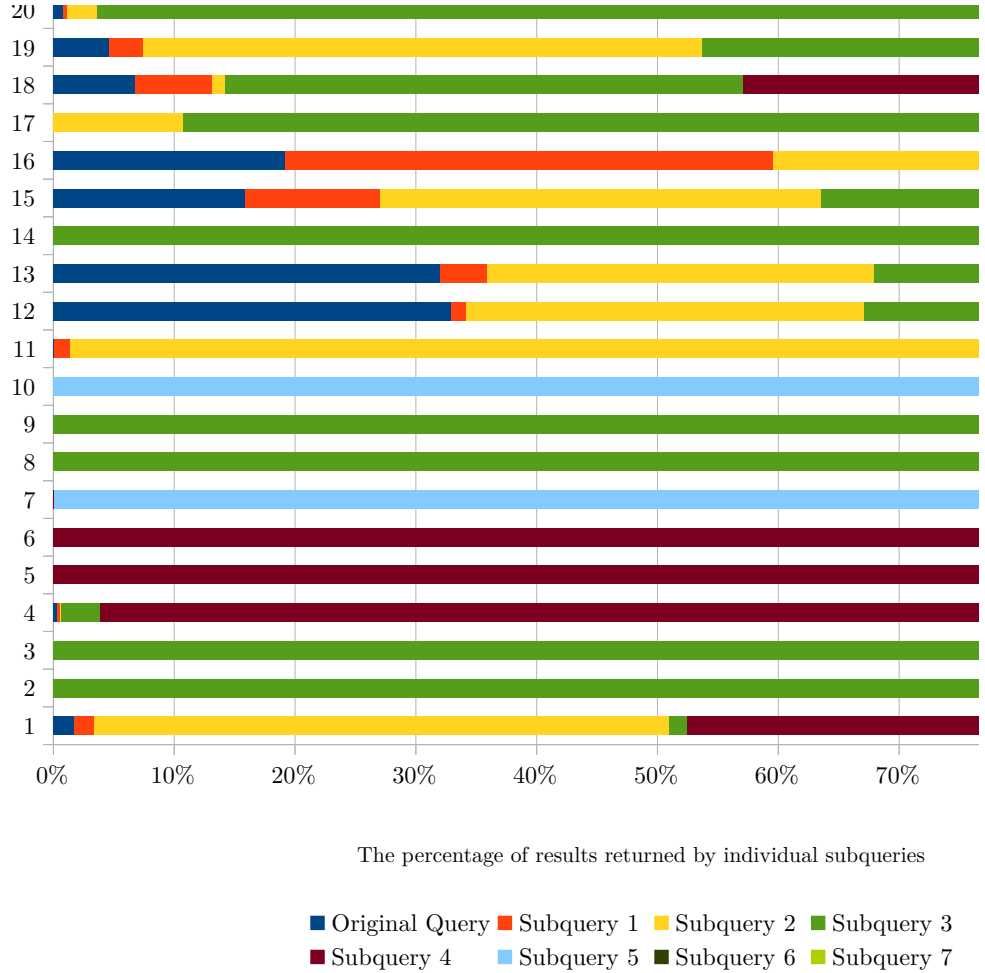


Figure: Relative number of results found using different subqueries for every query in CMath run

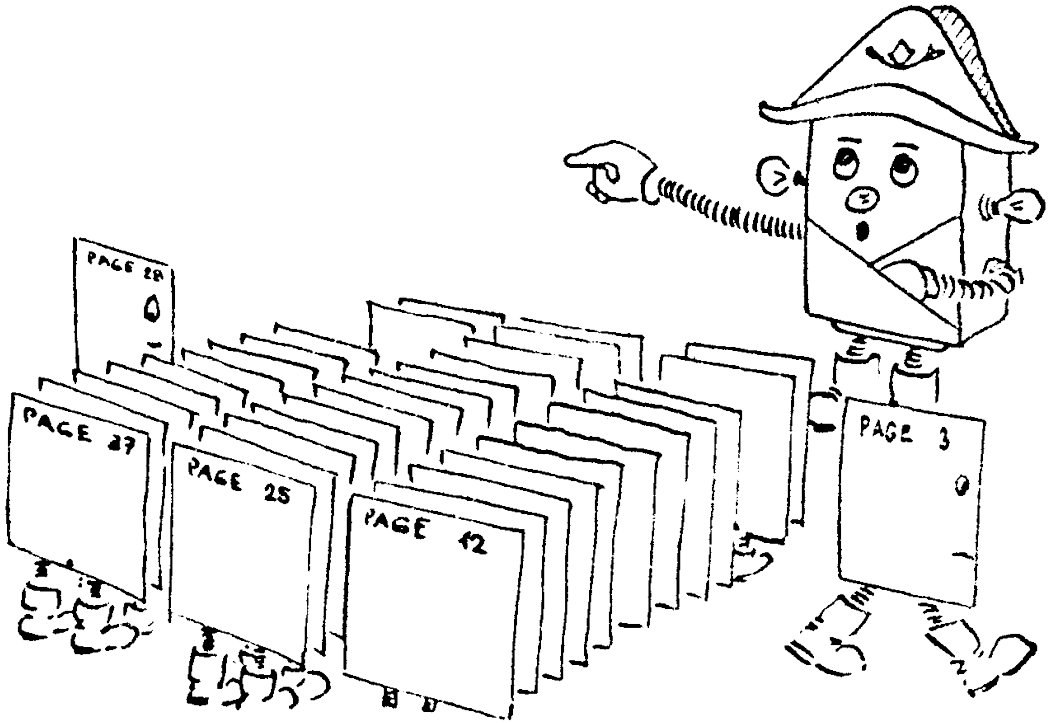
NTCIR-11 Math-2 Wikipedia Task Content Topics

- Completely the same fully automatic system used for the main NTCIR Math Task and Wikipedia subtask.
  - Only different data.
  - No tuning or modifications for the Wikipedia task.
- Input Content MathML was transformed to the format of the main NTCIR math task.
  - Manually added Presentation MathML and TeX representation of the data.
  - Performed all the four runs (CMath, PMath, PCMath, TeX) similarly to the main task.
- No query expansion & strip-merging possible as queries consist of a single formula only.

Summary

- Our results significanlty *improved* since the last year.
- Query expansion & strip-merging of subresults helps *a lot*.
- Better unification *definitely* needed.
- Wikipedia task *very* useful.

Questions?




Illustrations by Jiří Franek.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