Information Retrieval CS 834 : Assignment 4

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Abstract

Exercise questions 8.3, 8.4 , and 8.5 completed. Spring 2017.

1 Problem 8.3

For one query in the CACM collection (provided at the book website), generate a ranking using Galago, and then calculate average precision, NDCG at 5 and 10, precision at 10, and the reciprocal rank by hand.

1.1 Solution

I chose query 27 from the CACM collection.

```
memory management aspects of operating systems
```

I created an index for the cacm.corpus with Galago. Then I ran Galago with a batch-query to get the top 10 relavent documents, outputed to 83query-output.txt, shown below.

```
27 Q0 CACM-2297 1 -34.31623459 galago
27 Q0 CACM-2406 2 -35.42752838 galago
27 Q0 CACM-2357 3 -35.45236969 galago
27 Q0 CACM-1725 4 -35.51766968 galago
27 Q0 CACM-1752 5 -35.52021027 galago
27 Q0 CACM-2902 6 -35.60168457 galago
27 Q0 CACM-2988 7 -35.76276016 galago
27 Q0 CACM-2669 8 -35.86756134 galago
27 Q0 CACM-2798 9 -35.87216949 galago
27 Q0 CACM-2319 10 -35.92541885 galago
```

The relevant documents were obtained from the book website. For question 27 there are 29 relevant documents listed in 83relavancejudgements.txt.

I ran Galago eval to get the system evaluated metrics so that I could verify my hand done calculations.

```
galago.bat eval 83queryoutput.txt 83relavancejudgements
    .txt
num_ret            27 10
```

```
num_rel            27  29
num_rel_ret        27  6
map                27  0.1298
ndcg               27  0.3006
ndcg15             27  0.4594
R-prec             27  0.0000
bpref              27  0.0000
recip_rank         27  1.0000
P5                 27  0.4000
P10                27  0.6000
P15                27  0.4000
P20                27  0.3000
P30                27  0.2000
P100               27  0.0600
P200               27  0.0300
P500               27  0.0120
P1000              27  0.0060
```

```
Doc       Relevant
1         1
2         0
3         0
4         0
5         1
6         1
7         1
8         1
9         1
10        0
```

1.1.1 Average Precision

Comparing the returned documents to the relevant documents I found that the number of documents returned was 10 and the number of relevant documents returned was 6.

Doc	Rel	Precision
1	1	1
2	0	0.5
3	0	0.33
4	0	0.25
5	1	0.4
6	1	0.5
7	1	0.57
8	1	0.625
9	1	.666
10	0	0.6

$$AveragePrecision = \frac{1 + 0.4 + 0.5 + 0.57 + 0.625 + 0.666}{6} = 0.627$$

1.1.2 NDCG at 5

The NDCG is the normalized discounted cumulative gain. It is calculated with

$$NDCG_5 = \frac{DCG_5}{IDCG_5}$$

I made the assumption that the score would be 0 for a non-relevant document and 1 for a relevant document.

$$DCG_5 = \Sigma_{i=1}^{5} \frac{rel_i}{log_2(i+1)}$$

Doc	Rel	log2(i+1)	rel i/ log2(i+1)
1	1	1	1
2	0	1.585	0
3	0	2	0
4	0	2.322	0
5	1	2.585	0.386

Discounted Cumulative Gain = 1+0+0+0+0.386 = 1.386

Ideal Discounted Cumulative Gain = 1 + 0.631 + 0 + 0 + 0 = 1.631

$$NDCG_5 = \frac{1.386}{1.631} = .850$$

1.1.3 NDCG at 10

Doc	Rel	log2(i+1)	rel i / log2(i+1)
1	1	1	1
2	0	1.585	0
3	0	2	0
4	0	2.322	0
5	1	2.585	0.386
6	1	2.807	0.356
7	1	3	0.333
8	1	3.170	0.315
9	1	3.322	0.301
10	0	3.459	0

Discounted Cumulative Gain = 1+ 0 + 0 + 0 + 0.386 + 0.356 + 0.333 + 0.315 + 0.301 + 0 = 2.691

Reorder the documents to put all the relevant ones first to get the ideal discounted cumulative gain.

Ideal Discounted Cumulative Gain = 1 + 0.631 + 0.5 + 0.431 + 0.386 + 0.356 + 0 + 0 + 0 + 0 = 3.304

$$NDCG_5 = \frac{2.691}{3.304} = .814$$

1.1.4 Precision at 10

$$Precisionat10 = \frac{RelDocsRetrieved}{DocsRetrieved} = \frac{6}{10} = 0.6$$

1.1.5 Reciprocal Rank

Reciprocal Rank is the reciprocal of the rank at which the first relevant document is retrieved.

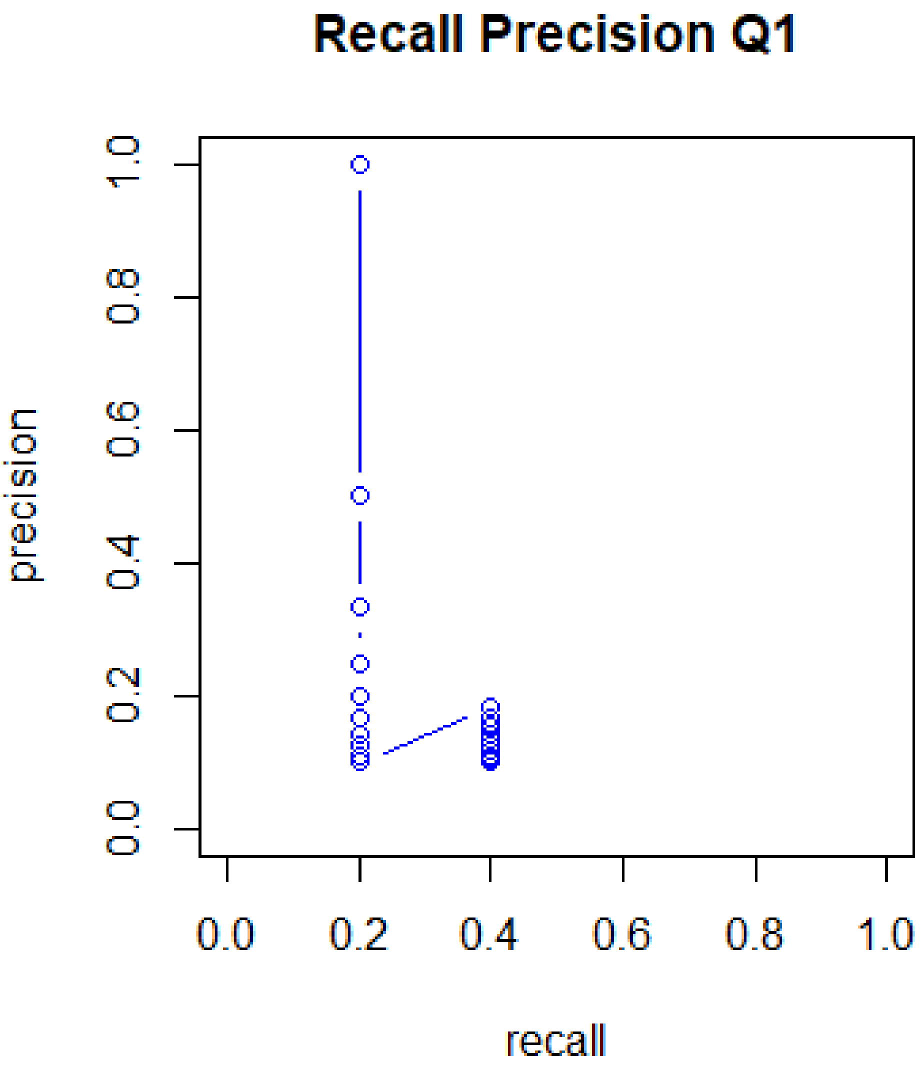
First document is relevant meaning Reciprocal Rank = 1.

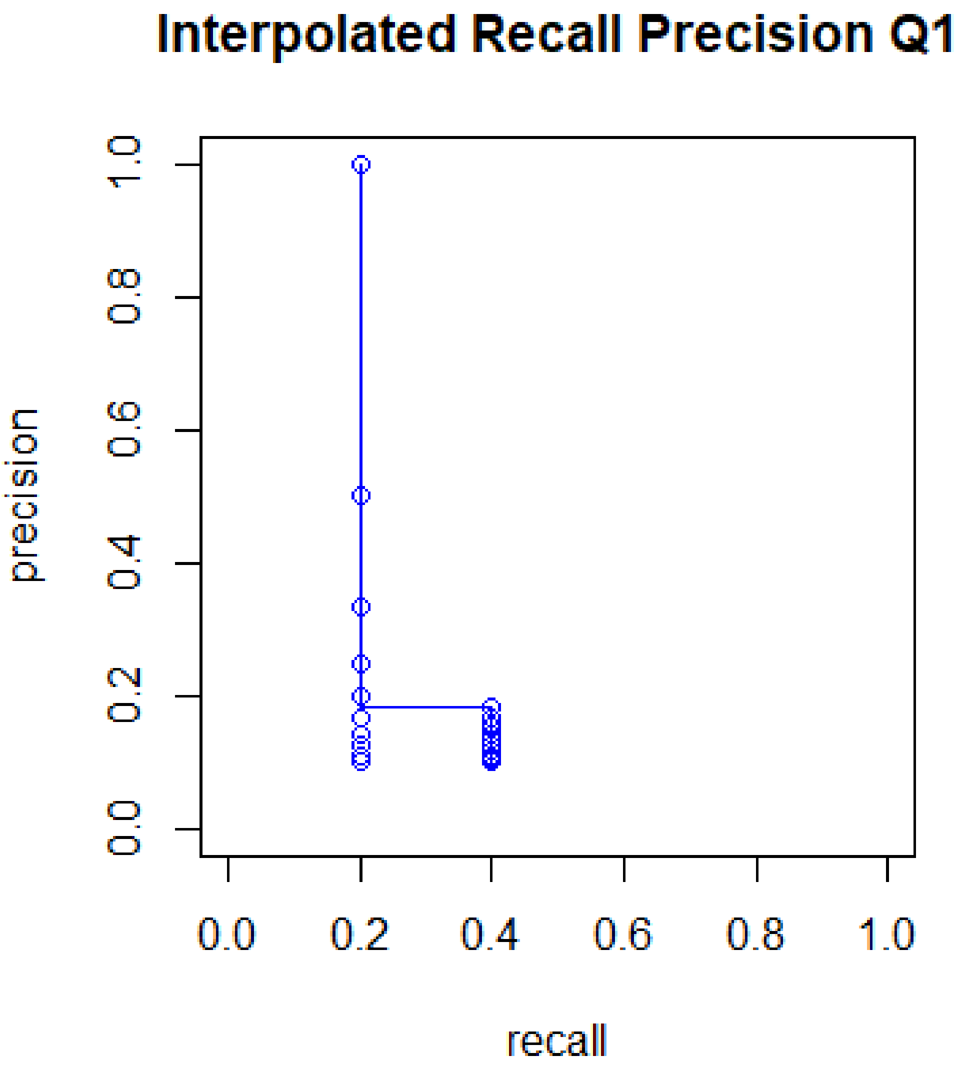
2 Problem 8.4

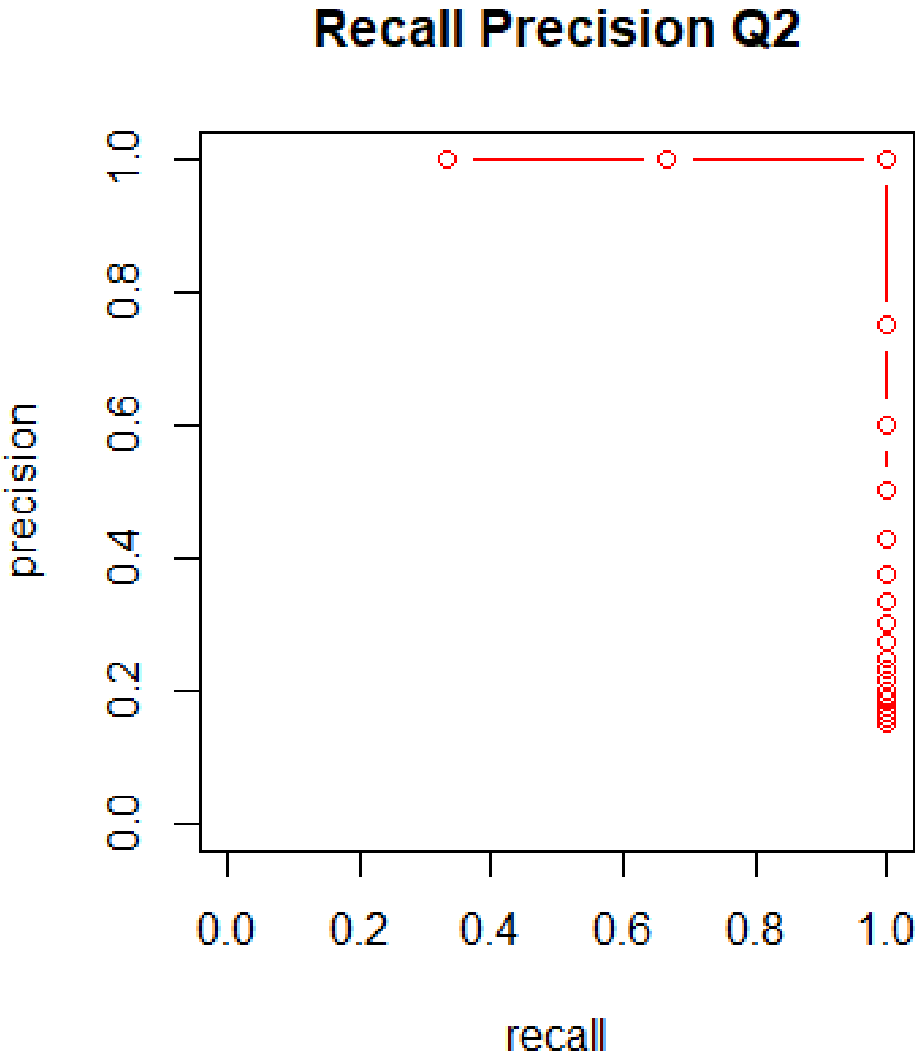
For two queries in the CACM collection, generate two uninterpolated recall-precision graphs, a table of interpolated precision values at standard recall levels, and the average interpolated recall-precision graph.

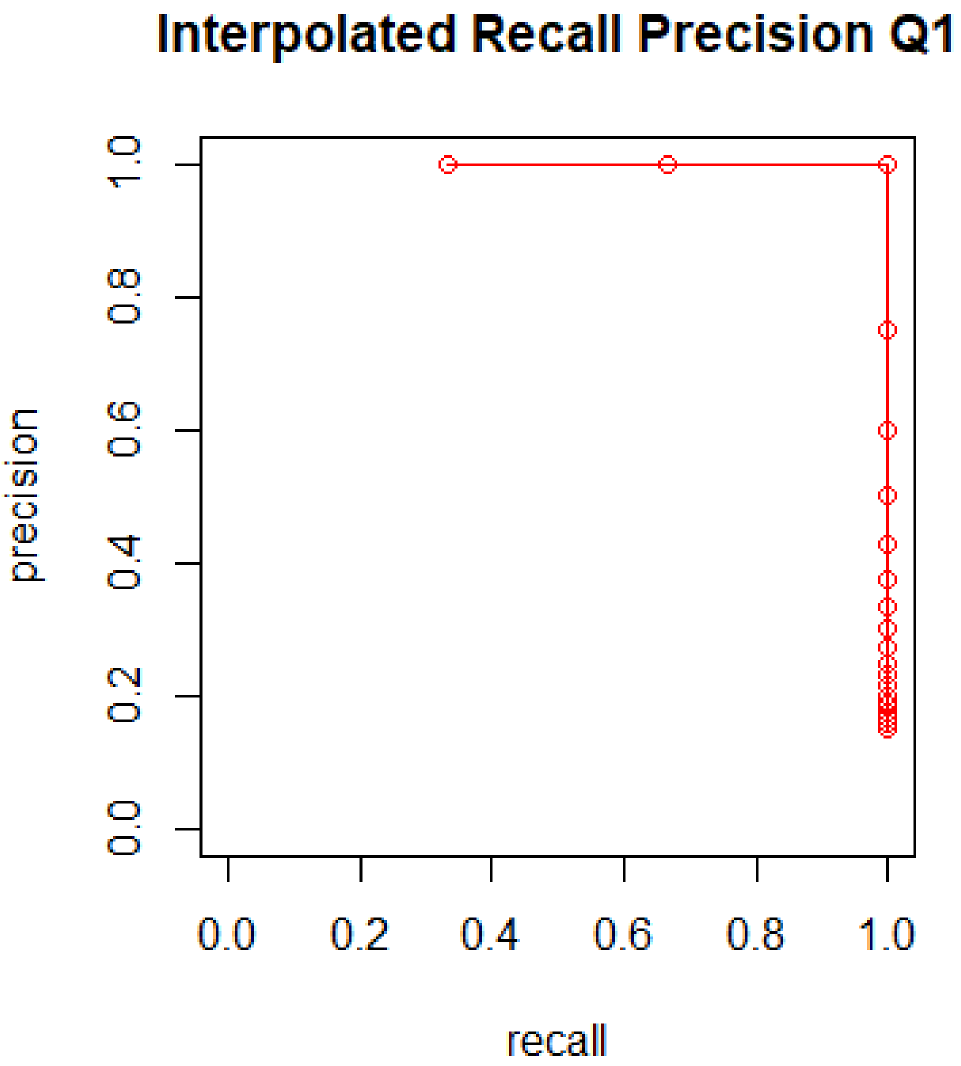
2.1 Solution

I chose query 1 and 2. I ran the queries through Galago Batch-Search to get 20 returned documents and calculated the recall and precision at each point to generate the following graphs.


Recall Precision Q1
precision
recall
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0


Interpolated Recall Precision Q1
precision
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
recall


Recall Precision Q2
precision
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
recall


Interpolated Recall Precision Q1
precision
0.0
0.2
0.4
0.6
0.8
1.0
recall
0.0
0.2
0.4
0.6
0.8
1.0

Doc	Rel	Recall	Precision	Interpolated Precision
1	1	0.2	1.	1.
2	0	0.2	.5	.5
3	0	0.2	.333	.333
4	0	0.2	.25	.25
5	0	0.2	.2	.2
6	0	0.2	.167	.182
7	0	0.2	.143	.182
8	0	0.2	.125	.182
9	0	0.2	.111	.182
10	0	0.2	.1	.182
11	1	0.4	.182	.182
12	0	0.4	.167	.167
13	0	0.4	.154	.154
14	0	0.4	.143	.143
15	0	0.4	.133	.133
16	0	0.4	.125	.125
17	0	0.4	.118	.118
18	0	0.4	.111	.111
19	0	0.4	.105	.105
20	0	0.4	.1	.1

Table 1: Question 1

Doc	Rel	Recall	Precision	Interpolated Precision
1	1	.333	1.	1.
2	1	.667	1.	1.
3	1	1.	1.	1.
4	0	1.	.75	.75
5	0	1.	.6	.6
6	0	1.	.5	.5
7	0	1.	.429	.429
8	0	1.	.375	.375
9	0	1.	.333	.333
10	0	1.	.3	.3
11	0	1.	.273	.273
12	0	1.	.25	.25
13	0	1.	.231	.231
14	0	1.	.214	.214
15	0	1.	.2	.2
16	0	1.	.188	.188
17	0	1.	.176	.176
18	0	1.	.167	.167
19	0	1.	.158	.158
20	0	1.	.15	.15

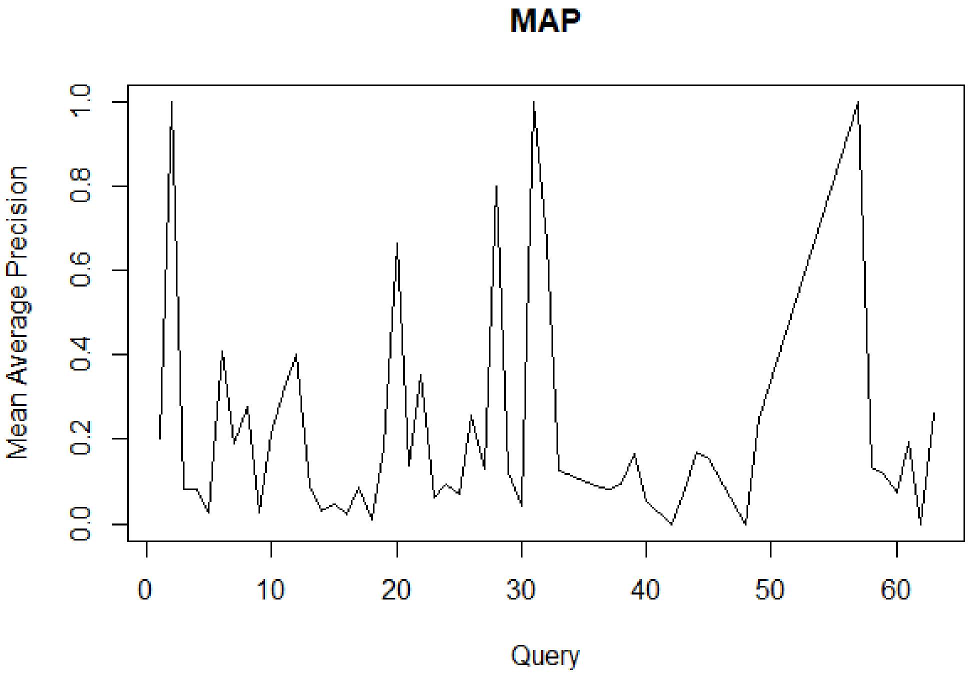
Table 2: Question 2

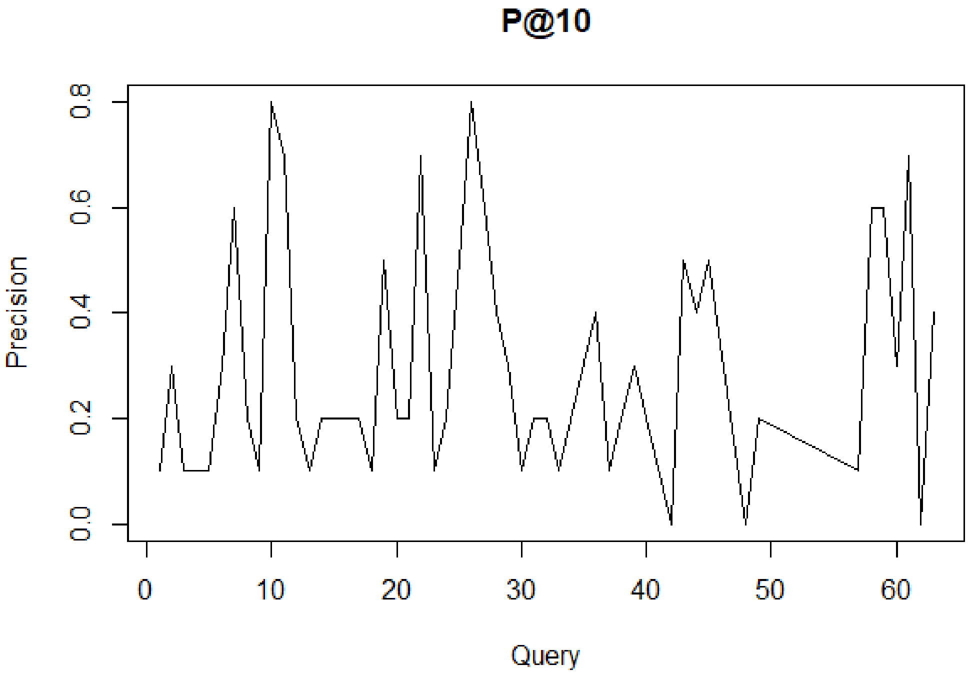
3 Problem 8.5

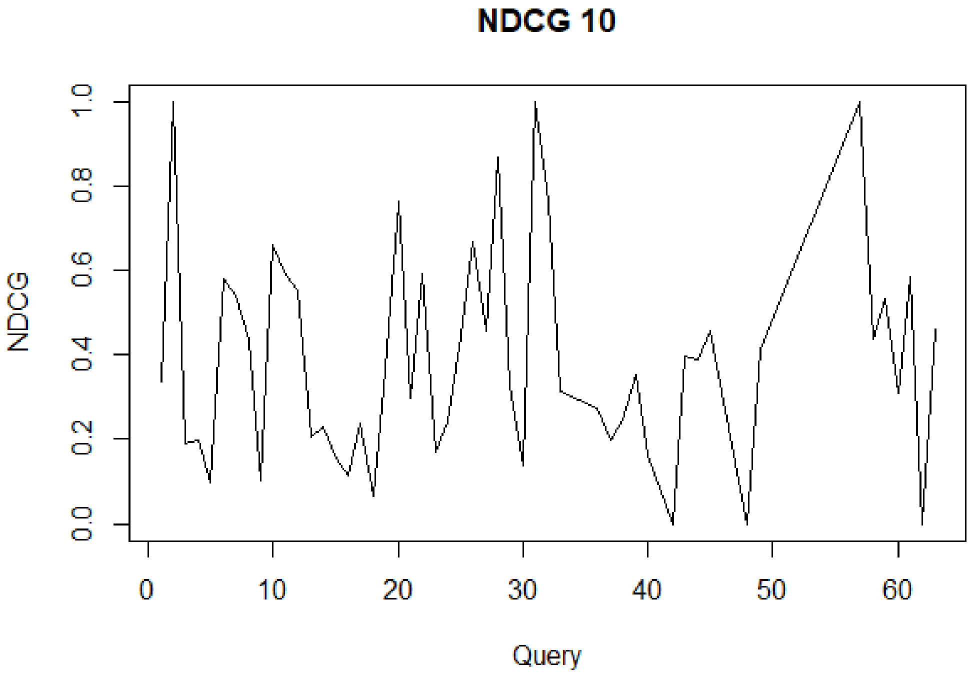
Generate the mean average precision, recall-precision graph, average NDCG at 5 and 10, and precision at 10 for the entire CACM query set.

3.1 Solution

I ran the queries through galago's batch search. Then I used Galago eval to find the statistics for MAP, P@ 10, and NDCG at 10. Eval only gives NDCG at 15, however I limited the returned documents to 10 so the values should be equivalent.


MAP
Mean Average Precision
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50
60
Query


P@10
Precision
0.0
0.2
0.4
0.6
0.8
Query
0
10
20
30
40
50
60


NDCG 10
NDCG
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
Query