Beijing-Dublin International College

SEMESTER 2 FINAL EXAMINATION - 2022/2023

School of Computer Science

COMP3009J Information Retrieval

Dr. Robert Ross
Assoc. Prof. Neil Hurley
Dr. David Lillis *

Time Allowed: 120 minutes

Instructions for Candidates

Answer Question 1 and any two other questions. Question 1 has 30 marks available. All other questions have 35 marks available.

BJUT Student ID: _____ **UCD Student ID: _____**

I have read and clearly understand the Examination Rules of both Beijing University of Technology and University College Dublin. I am aware of the Punishment for Violating the Rules of Beijing University of Technology and/or University College Dublin. I hereby promise to abide by the relevant rules and regulations by not giving or receiving any help during the exam. If caught violating the rules, I accept the punishment thereof.

Honesty Pledge：_____ (Signature)

Instructions for Invigilators

Candidates are allowed to use non-programmable calculators during this examination.

Question 1:

(a) Describe what is meant by *"information need"* in the context of Information Retrieval. What are the different types of information need?

[6 marks]

(b) Below is part of a positional index relating to the term "same". In creating this index, stopword removal and stemming have not been used. Postings lists begin at 1 for the first term in each document. Which document(s) could contain the phrase "the same day at the same time"? Explain your answer.

```
<same: 41825;
1: 120, 124, 167;
2: 9, 10, 13;
3: 121, 162;
4: 4, 101, 105, 106;
5: 1, 5, 88, 888, 889;
...>
```

[6 marks]

(c) A *modern Information Retrieval pipeline* may include Boolean searches, simple ranking and reranking based on machine learning. Explain why these are all useful to make an effective Information Retrieval system.

[6 marks]

(d) The *BM25* method of Information Retrieval is based on the belief that a good term weighting scheme is based on three principles. Briefly describe each of these principles.

[6 marks]

(e) Compare and contrast the preprocessing steps of *stemming* and *lemmatisation*. In particular, what are the advantages and disadvantages of each?

[6 marks]

[Total 30 marks]

Question 2:

(a) The *Boolean Model* makes use of the query operators *AND*, *OR* and *NOT*. Explain how these work and how they affect the number of documents returned by an Information Retrieval system. Also show how each of these can be implemented by using operations from Set Theory.

[6 marks]

(b) Briefly describe **two** ways in which the process of running Boolean queries can be optimised so that they can be processed more efficiently.

[6 marks]

(c) The *probabilistic model* of Information Retrieval makes use of two probabilities relating to query terms. These are $P(k_i|R)$ (the probability that a relevant document will contain the term k_i) and $P(k_i|\bar{R})$ (the probability that a non-relevant document will contain the term k_i). However, these probabilities cannot be calculated directly and must be estimated.

(i) Briefly describe how initial values for these probabilities may be generated.

(ii) Explain how these initial estimates can be improved with user feedback.

[8 marks]

(d) Below is a small document collection, containing three documents. Answer the questions that follow.

Stopwords: and, be, is, it, to, will

Document 1: It is going to rain and rain and rain today.

Document 2: Today I will be playing sport.

Document 3: I am going to watch the play.

(i) Describe the preprocessing steps you would use when creating an index for these documents.

(ii) Calculate a vector to represent each document, using the TF-IDF weighting system. You should use the stopword list provided, but do not perform stemming.

(iii) Calculate the cosine similarity for each vector using the query "going to play football", and show the final ranked list of documents for this query.

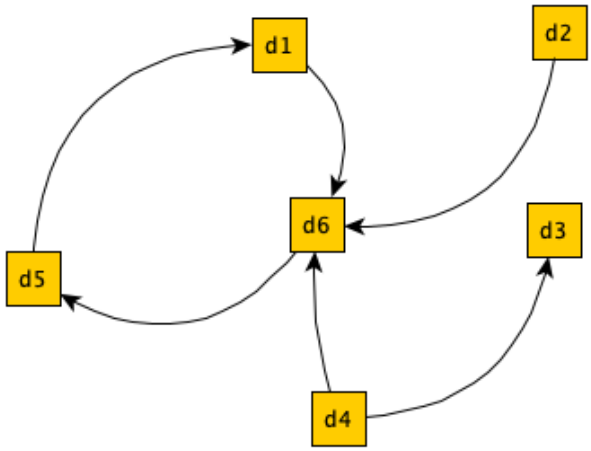
(iv) What effect on the results would you see if you had used stemming for this corpus?

[15 marks]

[Total 35 marks]

Question 3:

(a) The link structure of some web pages is shown below. There are six web pages shown (d1, d2, d3, d4, d5 and d6), and the arrows show links between the pages (e.g. d4 contains links to d3 and d6).



Show a worked example of how *PageRank* scores are calculated for these documents. Use a damping factor of 0.8 and show at least 3 iterations.

[14 marks]

(b) Compare the *MAP*, *bpref* and *NDCG* evaluation metrics. In your answer, outline any advantages or disadvantages of each. For each metric, suggest a situation where it is more appropriate than the others.

[9 marks]

(c) Below is a set of results and relevance judgments for a query:

Retrieved = d_{13}, d_{21}, d_{19}, d_{12}, d_6, d_{24}, d_{11}, d_1, d_3, d_{17}, d_9, d_{23}, d_{10}, d_{14}

Relevant = {d_2, d_3, d_7, d_9, d_{12}, d_{15}, d_{17}, d_{23}}

Calculate the following metrics:

(i) Mean Average Precision (MAP)

(ii) Recall

(iii) R-Precision

[12 marks]

[Total 35 marks]

Question 4:

(a) The *Rocchio Algorithm* uses a *modified query vector* to achieve relevance feedback. Explain why this is effective in improving the effectiveness of an Information Retrieval system, and how this modified query vector can be calculated.

[10 marks]

(b) The table below shows results from three search engines in response to the same query. Each set of results consists of a ranked list of unique document identifiers (DocID), along with the ranking score. Complete the following tasks, showing your workings for each.

(i) Calculate the ranking score that document D6 would have using *CombSum*.

(ii) Calculate the ranking score that document D10 would have using *CombMNZ.*

(iii) Calculate the ranking score that document D5 would have using *Borda Fuse*.

Engine A

DocID	Score
D10	0.60
D9	0.57
D12	0.48
D11	0.46
D8	0.41
D1	0.37
D6	0.26
D7	0.19

Engine B

DocID	Score
D5	971
D1	936
D11	860
D2	516
D8	414
D6	300
D4	153
D10	99

Engine C

DocID	Score
D12	9.23
D1	9.00
D2	7.88
D6	6.69
D7	5.03
D8	4.22
D5	3.63

[9 marks]

(c) Different levels of *corpus overlap* can influence the design of a data fusion algorithm. Explain why this is the case.

[10 marks]

(d) Briefly describe *three* sources of synonyms for use in *query expansion*.

[6 marks]

[Total 35 marks]