



COSC 320 – 001 [3-2-0]
Analysis of Algorithms
2022/2023 Winter Term 2
Project Topics

There are a few topics that you can choose to work on as your group project. You are encouraged to read all of them and think about the skills you want to gain out of each project. Discuss these points, and then choose **ONE** project to work on as your term-group-project.

No matter which project you choose, you should complete the following steps:

- 1) Problem formulation:
Formulate the problem as an algorithmic problem.
- 2) Algorithm design and analysis:
There is a straightforward solution to the problem you are trying to solve. Let's name it algorithm A. This algorithm will have at least $O(n^2)$ (or more depending on the project $O(n^3)$, etc).
You are required to design a more efficient algorithm (call it B), prove its correctness, and compare (using the asymptotic notation) the time complexity of the two algorithms.
- 3) Implementation and Empirical Evaluation:
Implement your algorithm B and the algorithm A, and perform simulations to empirically compare their running times. Your implementation shall have a class named ProjectName with two public methods
algorithmAforProject(X)
algorithmBforProject(X)
Both methods shall return the required results.
- 4) Clearly explain your choice of data structure to implement your algorithms. Reason about why you choose this data structure over others and what are the pros and cons. In some projects, you should think of searching with $O(n)$ when one data structure is used, compared to non-linear time using another one.

Note: In all cases, you can download some real datasets and test as an extra step. This can motivate you about the real applications of the course. Finding the proper dataset or generating synthetic dataset is part of the project.

Note 2: You can implement your project in a programming language of your choice: java, python, or C++. Matlab code is not acceptable.

Note 3: All implementations should have clear test sets and plots showing the comparison of the running times of the designed algorithms.

Note 4: If any online resource is used as a helper, you should cite it properly, or the project will receive a 50% penalty immediately.

Note 5: All milestones of the project should be delivered clearly and with proper explanations and rationales.

Note 6: A peer-review will be given at the end, for each group, meaning that all group members should give a grade to all other group members including themselves. This peer-review shows how each person has collaborated to complete the project. If all group members give a low collaboration mark to one person, this indicates the person has not put enough effort to complete the project. In this case, the grade of the individual will be lower than his/her group members significantly. The weight of peer-review marks will be decided later.



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Note 7: Tentative: Consider your projects as a competition or hackathon. There are multiple groups who choose the same topic. We can choose a dataset for each topic and run all the designed algorithms to compare their run time.

Evaluations:

20 points for problem formulation, a pseudo-code description of the algorithms.

20 points for the formal analysis (including correctness proof and running time).

20 points for the choice of data structure and analyzing/reasoning about it over other options.

40 points for implementation (correctness and efficiency). Your implementation will be tested on your TAs laptops. Your algorithm will be executed for various number of inputs, from 1,000 records to half a million (at least). Your implementation should handle all cases within a few seconds/minutes.

Milestones:

Project proposal (5 marks): You should describe your problem in more details (include an example that shows your understanding), edge cases, and any expected complexities. You also need to describe your plans of obtaining a real dataset or generate a dataset which enables you to test your dataset. Your choice of programming language, timelines, and the separation of tasks among all group members are part of this delivery. Note that for some topics, you should think about the operations that should be done. Try to divide the work including analysis and design among all group members equally, meaning that all members design and analyze the algorithms and work on the implementation and testing.

First milestone: problem formulation and pseudo-code for your algorithms. This also includes the analysis of the algorithms, proof the correctness and running time of at least one of the algorithms.

Second milestone: Includes the analysis of the second algorithm, correctness and run time proofs. Note that at this point you should have submitted the algorithm analysis for both algorithms. Description of the data structures that you will choose and the rationales.

Third milestone: Implementation of the first algorithm. You need to submit the test cases and plots showing how it runs as the input grows.

Fourth delivery: Implementation of the second algorithm, all tests, and plots. This is the final delivery of your project. You also need to include a 10-minute video showing your choices, designed algorithms, and running your implementations.

Hacking:

An implementation without a clear and formal formulation, design, and analysis, is only worth 40% of the total marks, even if your program runs well.

An implementation that crashes will get a 30% penalty.



Project Topics

Topic 1) Keyword replacement in a corpus: In text analytics, often it is required that a set of keywords are replaced with a given set for the documents in hand. For example, on Twitter, people write a lot of abbreviations. When one requires to analyze the tweets, (s)he should find all the abbreviations in a given list of abbreviations (e.g. ASAP, won't) and replace all these brief terms in the tweets with its proper phrase/keywords (e.g. ASAP -> As soon as possible, or won't -> will not). Your job is to design an algorithm that finds all of the keywords that are in the abbreviation list in each tweet, and then replace them with the appropriate given keyword/phrase. The number of tweets can be millions and the list of keywords can be hundreds. A naïve approach is that for each tweet, your algorithm checks for all of the elements in the abbreviated list and replaces them. Other than the naïve approach, design a better algorithm and apply the required four steps explained in the first page.

Topic 2) String Matching is a problem used in many applications such as plagiarism detection. In this project, you are required to implement a plagiarism detector. Your algorithm will receive a corpus of existing documents and a potentially plagiarized document as input. The output should be the set of documents from which the document was plagiarised from. You should implement the KMP, LCSS, and Rabin-Karp fingerprints algorithms. You need to read about some of these algorithms if we don't discuss them in class.

a) KMP : Treat each sentence in the test file as a potential pattern. Search for the pattern in the existing documents and find the matches.

b) LCSS : Run the LCSS algorithm for each paragraph from the test file and existing corpora.

c) Rabin-Karp fingerprints: Implement Rabin-Karp algorithm for multipattern matching. You can use the language libraries for converting string to hash.

The definition of plagiarism and threshold are left to your discretion.