UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
School of Computer Science and Applied Mathematics

COMS3005A
Advanced Analysis of Algorithms
Assignment

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1 Aim

This assignment is intended to give you some exposure to the experimental nature of Computer Science – specifically the concept of measuring the performance of different algorithms that solve the same problem and relating these measurements to the theoretical analysis of the algorithms. This will be accomplished by performing an experiment and preparing a document discussing the design, implementation and evaluation of the experiment.

A second aim of the assignment is to introduce you to a new technique for solving problems more efficiently than the obvious *brute force* approach.

2 Instructions

1. This assignment will be an individual assignment.
2. The assignment will be done in two phases.
3. The first phase will be to develop, code and measure the runtime of a brute force algorithm to solve the given problem. You will be required to do the theoretical analysis of your algorithm and compare that to your runtimes.

   The problem is presented in section 3 below.

   Note that you will be required to develop code to generate your test data as well.
4. The second phase will be to develop an improved solution, do the theoretical analysis of the algorithm, code the algorithm, measure its performance, relate the measured performace to the theoretical analysis and then compare its performance with that of the brute force solution.
5. For each phase of the assignment you will need to code the algorithm into a high level programming language of your choice, ensure that the program works correctly, measure the performance of the program on different input instances, compare the empirical analysis to the theoretical analysis and write up a report of your experiment. In the second phase you will also need to compare the performance of the two approaches.

   Note that the timing approaches and the graph plotting from Laboratory 1 should come in useful here.
6. Your reports (for both phases) should be prepared in LaTeX. Some supplementary material will be made available to you to assist you with this requirement.
7. The submissions will be through the course Moodle site.

Notes:

1. Your document should contain a declaration stating that you know of and understand the University's plagiarism policy (it can be found on the University's web site) and that you have appropriately cited and/or acknowledged any work that you have used in preparing your report.

2. Your document should be written in the form of a laboratory report. You should discuss what you planned to do, why you planned to do it that way and how you actually did it. This means discussing your methodology (designing and implementing your experiment). You should then present your results and discuss how the results you got relate to what you were setting out to measure/verify.

   See the "Empirical Analysis" document for more details on a lab report.

3. The code you develop **must** run on the equipment in the Mathematical Sciences Laboratories and it must be made available to me as part of your submission so that I can run it if necessary.

Please see me if you have any questions about this assignment.

3 The problem

3.1 Determining vertical adjacencies between orthogonal rectangles

In a particular application, it is important to be able to find the adjacencies (shared edges or parts of edges) between a set of orthogonal rectangles in the plane efficiently. An orthogional rectangle is a rectangle whose edges are aligned with the x and y axes.

In determining the adjacencies between the rectangles, horizontal and vertical adjacencies can be treated as separate cases. In this assignment only the case of vertical adjacencies will be tackled. Horizontal adjacencies can be treated analogously. Figure 1 shows a set of adjacent rectangles and their shared vertical adjacencies.

Your tasks in this assignment are to

1. develop a *brute force* or *naïve* algorithm to solve this problem, and then

2. to use knowledge about the problem to develop an improved algorithm.

3.2 Requirements

Any orthogonal rectangle R can be defined by the x and y coordinates of its bottom-left and top-right corners. The input to the algorithm/program will be a list of rectangles plus their coordinates. For example,
1, 0, 0, 20, 30
2, 8, 40, 20, 55
. . .

The algorithm thus requires a data structure which contains the rectangle number and these coordinates as well as the ability to keep track of other information calculated in the algorithm. This other information is the number of rectangles which are adjacent to the right hand side of the rectangle being considered and a list of these rectangles plus the x coordinate and bottom and top y coordinates of the respective adjacencies. These lists of adjacencies (one list per rectangle) are, in fact, the required output from this algorithm and are used later in the application.

For example, for the set of adjacent rectangles in Figure 1 the first list could be something like
1, 3, 3, 20, 0, 8, 4, 20, 12, 16, 5, 20, 22, 30
representing
rectangle 1, 3 adjacent rectangles, rectangle 3, x, yb, yt, rectangle 4, x, yb, yt, rectangle 5, x, yb, yt.

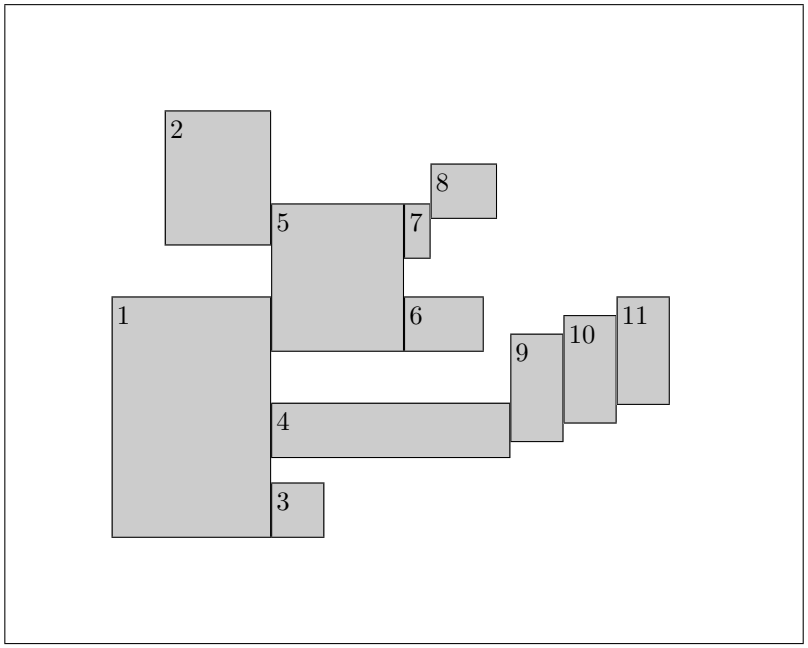

Figure 1: A configuration of adjacent orthogonal rectangles

4 Deadlines

There are two handin deadlines for this assignment — one for the "brute force" experiment and one for the final report.

The first report will be due on Tuesday 18 April 2023.

The final report will be due on Monday 15 May 2023.

The assignment test will be written during the AAA laboratory session on Monday 15 May 2023.

Late submissions will not be accepted – you will be given 0% for that phase of the assignment.

5 Required materials for submission

For each submission you should submit a zip file containing

1. Your report – this should include discussion of your input, sample output, results, graphs, etc.
2. Your programs with instructions on how to run these if required.

6 Assessment

The assessment will be based on the written reports and an *assignment test*.

The aim of the assignment test is to determine whether you understand the work that went into the two reports. The marks for the two reports will therefore be scaled by the mark for the assignment test. The final mark will be calculated as $(R_1/3 + R_2 * 2/3) * T_1$ where T_1 will be either 0 or 1 depending on the result of the assignment test.

This assignment will count 20% of the final mark for the course.

The material of this assignment – empirical analysis, the new technique for solving problems, etc. – is examinable. It may be assessed in the class test and the final examination.