Engineering Tripos Part IIB, 4M26: Algorithms and Data Structures, 2023-24

Module Leader

Dr S Albanie [1]

Lecturers

Dr S Albanie & Prof Per Ola Kristensson [2]

Timing and Structure

Lent term. 16 lectures (including 3 examples classes).

Aims

The aims of the course are to:

- Introduce the principles behind algorithm and data structure design and evaluation.
- Cover key topics including elementary and advanced data structures, sorting algorithms, graph algorithms, etc.
- Provide an extensive hands-on understanding of the aforementioned topics via coding-focused computerised examples papers and exam.

Objectives

As specific objectives, by the end of the course students should be able to:

- Analyse computational efficiency of most algorithms.
- Re-implement and debug algorithms taught under time constraints.
- Correctly choose the right algorithmic solution and data structures for the problem encountered.
- Understand relative theoretical and practical advantages and disadvantages of various methods.
- Devise and implement new algorithms or modify existing algorithms to solve previously unencountered tasks.

Content

- **Introduction (1L)**
  - Algorithms and Data Structures: what are algorithms, why study algorithms and how? Introduction of the coding platform and other resources. Applications.
- **Fundamentals of Algorithms (2L)**
  - Elementary data structures - stacks and ques, linked-lists, arrays, dictionaries. Algorithmic complexity. Strategies for algorithmic design: divide and conquer, dynamic algorithms, greedy algorithms.
- **Advanced Data Structures (2L)**
  - Hash tables, binary search trees, red-black trees, B-trees.
- **Sorting Algorithms (2L)**
  - Sorting algorithms - Heapsort, Quicksort, sorting in linear time.
- **Graph Algorithms (3L)**

    - Graph algorithms - shortest path (BFS, DFS, Dijkstra, Bellman-Ford), topological sorting, strongly connected components, maximum flow (Ford-Fulkerson), minimum spanning trees (Kruskal's, Primm's).
- **Further Topics (2L)**
    - Parallel algorithms, NP-completeness
- **Recent Developments (1L)**
    - Large language models for code generation.
- **Example classes (3L)**
    - Discussion of examples papers and past examination papers.

Booklists

Introduction to Algorithms (3rd ed) *by Cormen, T., Leiserson, C., Rivest, R., Stein, C. The MIT Press. ISBN:978-0-262-03384-8.*

Also, please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

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