CSE 5311-001: ADVANCED ALGORITHMS

Summer 2014: TR 10:30 - 12:20, ERB 130

Instructor: Bob Weems, Associate Professor
Office: 627 ERB (`weems@uta.edu`, http://ranger.uta.edu/~weems/)
Hours: MW 3:00 - 4:00, TR 12:30 - 1:30

GTA: Information will be posted on web page

Prerequisites: Algorithms & Data Structures (CSE 2320)
Theoretical Computer Science (CSE 3315)

Objectives: Deeper study of algorithms, data structures, and complexity classes.

Outcomes:

1. Exposure to more sophisticated analysis techniques, e.g. amortized complexity.
2. Exposure to specialized data structures and algorithms.
3. Exposure to models of algorithm design.

Textbook: Cormen, Leiserson, Rivest, Stein, *Introduction to Algorithms*, *3rd ed*., MIT Press, 2009. (Henceforth known as CLRS)

References: S. Baase and A. Van Gelder, *Computer Algorithms, Introduction to Design and Analysis*, *3rd ed*., Addison-Wesley, 2000.

M. de Berg et.al., *Computational Geometry: Algorithms and Applications, 3rd ed*., Springer-Verlag, 2010.

A. Borodin and R. El-Yaniv, *Online Computation and Competitive Analysis*, Cambridge Univ. Press, 1998.

S. Dasgupta, C. Papadimitriou, and U. Vazirani, *Algorithms*, McGraw-Hill, 2006

E.D. Demaine and J. O'Rourke, *Geometric Folding Algorithms: Linkages, Origami, Polyhedra*, Cambridge Univ. Press, 2007.

P. Flajolet and R. Sedgewick, *Analytic Combinatorics*, Cambridge Univ. Press, 2009, http://algo.inria.fr/flajolet/Publications/AnaCombi/

L. Fortnow, *The Golden Ticket: P, NP, and the Search for the Impossible*, Princeton Univ. Press, 2013.

M.R. Garey and D.S. Johnson, *Computers and Intractability: A Guide to the Theory of NP-Completeness*, Freeman, 1979.

G. Gonnet and R. Baeza-Yates, *Handbook of Algorithms and Data Structures, 2nd. ed*., Addison-Wesley, 1991.

R.L. Graham, D.E. Knuth, and O. Patashnik, *Concrete Mathematics*, Addison-Wesley, 1989.

C.M. Grinstead and J.L. Snell, *Introduction to Probability*,
http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/amsbook.mac.pdf

D. Gusfield, *Algorithms on Strings, Trees, and Sequences: Computer Science and Computational Biology*, Cambridge Univ. Press, 1997.

D.S. Hochbaum, ed., *Approximation Algorithms for NP-Hard Problems*, PWS, 1997.

E. Horowitz and S. Sahni, *Fundamentals of Computer Algorithms*, Computer Science Press, 1978.

J. Kleinberg and E. Tardos, *Algorithm Design*, Addison-Wesley, 2006.

D.E. Knuth, *The Art of Computer Programming*, Vols. 1-4, Addison-Wesley.

R. Motwani and P. Raghavan, *Randomized Algorithms,* Cambridge Univ. Press, 1995.

J. O'Rourke, *Computational Geometry in C, 2nd ed.,* Cambridge Univ. Press, 1998.

C.H. Papadimitriou, *Computational Complexity*, Addison-Wesley, 1994.

R. Sedgewick, *Algorithms in C*, *Parts 1-5, 3rd ed*., Addison-Wesley, 2003.

R. Sedgewick and P. Flajolet, *An Introduction to the Analysis of Algorithms, 2nd ed*., Addison-Wesley, 2013.

T. Standish, *Data Structure Techniques*, Addison-Wesley, 1980.

A. Stepanov and P. McJones, *Elements of Programming*, Addison-Wesley, 2009.

C.J. Van Wyk, *Data Structures and C Programs*, Addison-Wesley, 1988.

N. Wirth, *Algorithms + Data Structures = Programs*, Prentice-Hall.

Homework: Two assignments - NOT GRADED

Grade: Your grade will be based on the following weights:

Exams: 80% (Test 1: 40%; Test 2: 40%, August 12, 10:30 - 12:20)
Labs: 20% (Three labs, equal weight)

Policies:

1. Attendance is not required, but is highly encouraged. Consult me in advance if you must miss class for a good reason. The lectures are being recorded and will have a link on the web page, but no availability guarantee is made (e.g. this is not a "distance" course).

2. You are expected to have at least skimmed the new material by the day we start that material in class. The material will be covered in the order given later.

3. Homeworks, with solutions, are available from the web page.

4. CHEATING - YOU ARE EXPECTED TO KNOW UNIVERSITY POLICIES. All cases of plagiarism will be processed through University channels outside the CSE department.

   http://www.uta.edu/conduct/

5. Any request for special consideration must be appropriately documented **in advance**. (Special consideration does not include giving a higher grade than has been earned.)

6. Late labs are penalized 30% per day, i.e. up to 10:15 a.m. After the due date neither I, nor the GTA, will provide assistance.

7. Each student will have available *one* 48-hour no-penalty extension that may be applied to *one* of the lab assignments. To use your extension you must send an email to the grader *before* the due time.

8. If you require a reasonable accomodation for a disability, please contact me no later than the second week of this semester. Further details are available at http://www.uta.edu/disability/

9. Occasional class-wide email messages (e.g. weather situations, clarifications) may be sent to the addresses recorded by MyMav. These will also be archived on the course web page.

Course Outline

Starred (*) topics are not in CLRS

0. Selective review of dynamic programming (CSE 2320 notes 7)
1. Mathematical Preliminaries
   - Recurrences - Master Method (4.5-4.6.1)
   - Probability and Randomized Algorithms (5)
2. Binary Search Trees
   - Red-Black Trees - Review (13)
   - AVL Trees*
   - Treaps (problem 13-4)
   - Augmenting Data Structures (14)
3. Amortized Analysis (17)
4. Self-Organizing Linear Search (Computing Surveys*, problem 17-5)
5. Trees
   - Optimal Binary Search Trees (15.5)
   - Self-Adjusting Binary Search Trees (Splay trees/amortized analysis) (JACM)*
6. Skip Lists*

7.a. Priority Queues - Review (6.5)
   - Binary Trees, Binary Heaps, d-heaps*, Leftist Heaps*
   - Binomial Heaps (problem 19-2)
   - Fibonacci Heaps (19)

7.b. van Emde Boas Trees (20)

8. Disjoint Sets (union-find trees) (21)
9. Hashing
    - Review (11.2-11.4)
    - Brent's Rehash*, Cuckoo Hashing*
    - Perfect Hashing (11.5)
    - Optimal Hashing*
    - Bloom Filters*
10. Medians/Selection (9.3)

TEST 1

11. Minimum Spanning Trees (23)
    - Brief review of Prim
    - Review of Kruskal's Algorithm and extension to detecting non-unique MST
    - Boruvka's Algorithm*
12. Max-Flow/Bipartite Matching (26)
    - Ford-Fulkerson - review, maximum capacity* paths
    - Push-relabel methods
    - Vertex and edge connectivity*
18. Intractability (34, 35)
    - Sample Intractable Problems
    - Complexity Classes
    - Reductions
    - Polynomial-Time Approximation
16. Matrices
    - Strassen's Matrix Multiplication (4.2)
    - Binary Matrix Multiplication and Four Russians Trick*
17. Computational Geometry (33)
    - Fundamental Predicates
    - Closest Pairs
    - Convex Hulls
    - Sweepline Algorithms
15. Sequences
    - Pattern Preprocessing Search
        - Rabin-Karp Algorithm (32.2)
        - Gusfield's Z Algorithm*
        - Knuth-Morris-Pratt Algorithm (32.4)
    - Text Preprocessing - Suffix Arrays*
    - Longest Common Subsequences
        - Dynamic Programming - Review and Linear Space* Version
        - Four Russians for LCS*
        - Longest Strictly Increasing Subsequence Approach*

TEST 2

Calendar - with subject numbers from course content

June				July/August			
3	Syllabus/0.	5	1.	1		3	No Class
10	2.	12	3./4.	8	9./10.	10	11.
17	5.	19	6./7.	15	Exam 1	17	12.
24		26	8.	22	18.	24	
				29	16.	31	17.
				5	15.	7	
				12	Exam 2		

Thursday, July 17 is the last day to withdraw.