CSC (791/495)-011: Parameterized Algorithms & Complexity

Blair D. Sullivan

Fall 2017

github.com/bdsullivan/ParameterizedAlgorithms-Fall2017

E-mail: blair_sullivan@ncsu.edu
Office Hours: TBD
Office: 3280 EBII

Web: **csc.ncsu.edu/faculty/bdsullivan**
Class Hours: Friday, 9:35am-12:20pm
Class Room: 1005 EBI

Course Description

This research-oriented course will introduce the fundamentals of parameterized complexity and algorithms (including kernelization, branching, dynamic programming, intractibility, and approximation), along with a selection of advanced techniques used in the recent literature. Students will also gain hands-on experience in theoretical computer science research from literature review and problem selection through active research, collaboration, and presentation of results and future directions.

Learning Outcomes

1. Understand and apply fundamental concepts in parameterized algorithms and complexity.
2. Write clear, complete, concise proofs; critically evaluate proposed solutions for these properties.
3. Identify open problems and research opportunities in relevant scientific literature.
4. Contextualize & present theoretical computer science research in oral and written formats.

Course Structure

Each class period will mix lecture material with small-group problem solving.

Each week, students will be responsible for writing up a complete, polished proof of one of the in-class exercises (referred to as **weekly problem writeups**). These will be graded primarily for clarity and presentation. Additional suggested problems for each topic will not be graded, but form the basis for the **proof review exercises**. Each review exercise will require students to verify (for correctness) and critically evaluate (for clarity and presentation) "proofs" for 2-4 problems related to already-covered material. CSC791 students will additionally be required to correct any errors

found (or provide an alternative correct proof). Finally, the course has two group projects, which are outlined below.

1. **Opportunity Identification Project**: Teams of two will identify an "interesting" open problem from the literature, and present it to the class in two ways. First, students will produce a 1-2 page description of the problem along with its context and related work in the literature, and suggestions for potential avenues of attack. Second, they are responsible for preparing a mini-poster and "pitching" the problem to their classmates during an in-class poster session. Poster guidelines will be provided with the team assignments. Posters will be graded on both visual clarity of presentation and students' ability to answer questions. The most promising proposed problems may be available as topics for the final research project.

2. **Final Research Project**: Teams of approximately 4 students (including both CSC495 and CSC791 enrollees) will work together on an open problem. The final report will be formatted like a typical CS conference paper (details on template, length requirements, and mandatory sections will be provided with team assignments). CSC495 students will give a lightning talk during the last week of class, and CSC791 students will give a conference-style oral presentation during the final exam period.

Students must keep a **research log** on their github repository for the course, with weekly updates required as soon as pairs are assigned for the first project (anticipated in Week 5), and continuing throughout the rest of the semester.

Course Policies

This course will make extensive use of LaTeX and version control (git). Each student will be responsible for creating and uploading all individual assignments (including their research notebook entries) to a private github repository that the teaching staff have read/write access to (this allows us to commit feedback directly). Further, each team will have a separate project repository, which will be used to submit deliverables (e.g. reports, source for posters, presentations) and enable collaborative editing. Specific instructions on repository naming, including mandatory directory and file structure will be provided. Repository commit logs may be considered when determining individuals' contributions to group projects for grading purposes.

All problem writeups, proof reviews, and reports must be completed using LaTeX, and source must be committed to the appropriate repository. Figures must be professionally presented (e.g. typeset with tikz, drawn in Inkscape, or created with matplotlib, depending on content). Presentations and posters may be created using LaTeX (suggested; templates will be provided) or software such as Microsoft PowerPoint (PDF must be available). Posters may be printed on the departmental printer (see Carol Allen); please be sure to allow enough advance time for printing.

Attendance

Attendance is required.

Prerequisites

CSC333 is required for enrollment in CSC495. An equivalent course, or upper-level undergraduate training in algorithms and complexity theory is required for CSC791.

Course Materials

Textbook

There is no textbook purchase required for this course. Much of the material covered in this class can be found in the text *Parameterized Algorithms* by Cygan et al, freely available at:
https://www.mimuw.edu.pl/ malcin/book/parameterized-algorithms.pdf
Any additional required readings will be made available through the course github repository.

We recommend *Graph Theory* by Diestel for background information on topics in graph theory, viewable for free online at http://diestel-graph-theory.com. Other useful reference texts might be *Parameterized Complexity Theory* by Flum and Grohe and *Fundamentals of Parameterized Complexity* by Downey and Fellows.

Electronic Resources

This term we will be using Slack to facilitate group project discussions and enable you to get fast, efficient help from classmates, the TA, and myself. Use of Slack is mandatory; it will be used for all out-of-lecture announcements. Students will be also required to use LaTeX to typeset assignments and Github to submit documents (a github user account will be necessary).

Grading

- **20%** of your grade will be determined by weekly problem writeups.
- **10%** of your grade will be determined by proof review exercises.
- **20%** of your grade will be determined by the opportunity identification project:
  - **10%** Report
  - **10%** Poster Presentation
- **40%** of your grade will be determined by the final research project:
  - **5%** Draft of Final Report with full Literature Review and Background/Preliminaries
  - **20%** Final Report
  - **5%** Draft of Slides
  - **10%** Oral Presentation
- **10%** of your grade will be determined by participation (including attendance/research log).

As detailed in Course Structure, there will be no final exam, but final project presentations will be held during the exam period (students in both CSC495 and CSC791 must attend) and the final project report is due during the last week of classes.

Late Policy:

No late assignments will be accepted.

Grade Scale:

$(\infty, 98]$ A+, $(98, 92]$ A, $(92, 90]$ A-,
$(90, 88]$ B+, $(88, 82]$ B, $(82, 80]$ B-,
$(80, 78]$ C+, $(78, 72]$ C, $(72, 70]$ C-,
$(70, 68]$ D+, $(68, 62]$ D, $(62, 60]$ D-,
$(60, 0]$ F

Academic Integrity

Academic Integrity

Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at http://policies.ncsu.edu/policy/pol-11-35-01

Academic Honesty

See http://policies.ncsu.edu/policy/pol-11-35-01 for a detailed explanation of academic honesty. Please ask the instructor if you have any questions about whether your actions/plans for completing assignments may constitute academic dishonesty under these policies - we are more than happy to clarify expectations.

Honor Pledge

Your signature on any test or assignment indicates "I have neither given nor received unauthorized aid on this test or assignment."

Accommodation for Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, student must register with the Disability Services Office (http://www.ncsu.edu/dso, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation at http://policies.ncsu.edu/regulation/reg-02-20-01.

NC State Policies, Rules, and Regulations (PRR)

Students are responsible for reviewing the PRRs which pertain to their course rights and responsibilities. These include:

- http://policies.ncsu.edu/policy/pol-04-25-05 (Equal Opportunity & Non-Discrimination Policy),
- http://oied.ncsu.edu/equity (Office for Institutional Equity and Diversity),
- http://policies.ncsu.edu/policy/pol-11-35-01 (Code of Student Conduct), and
- http://policies.ncsu.edu/regulation/reg-02-50-03 (Grades and Grade Point Average).

Schedule

Week 01 (08/18): Introduction to Parameterized Complexity

Week 02 (08/25): Kernelization

Week 03 (09/01): Branching & Bounded Search Trees

Week 04 (09/08): Unnatural Parameters

Week 05 (09/15): Dynamic Programming & Decompositions

Week 06 (09/22): Intractibility & Lower Bounds

Week 07 (09/29): Randomization & Approximation

Week 08 (10/06): Fall Break (open problem reports due 10/6)

Week 09 (10/13): Open Problem Posters & Special Topics*

Weeks 10-14 (10/20 - 11/17): Special Topics* & Project Collaboration (report draft due 11/10)

Week 15 (11/24): Thanksgiving Break (CSC495 slide draft due 11/22)

Week 16 (12/01): CSC495 Lightning Talks, Wrapup (CSC791 slide draft due 11/29)

Week 17 (12/08): CSC791 Final Presentations (**8:00 - 11:00 am**)

*Special Topics

Special topics covered in the second half of the course may include (but are not limited to):

- Bidimensionality
- Lower Bounds and ETH/SETH
- Sparse Graph Classes
- Advanced Kernelization
- Connections to FO/MSO-Logic
- Iterative Compression
- Matroids
- Hot Topics (new results from the literature)