University of Pittsburgh

Swanson School of Engineering
ELECTRICAL & COMPUTER
Spring 2022

ECE 2195/1170:
Algorithms for Complex System Design and Modeling

Syllabus

DESCRIPTION: This course discusses the important algorithms and tools that, although at the core of the Computer-Aided Design (CAD) field, are also widely applied in many emerging domains such as microfluidics, synthetic and systems biology, as well as in machine learning methods and other domains that model or design circuits (including biological circuits). These algorithms are used in design steps, starting from a circuit description, translating it into functions such as Boolean equations, discrete functions, weighted sums, all the way to circuit layout on a chip. We focus on mathematical models, algorithms, and data structures. We begin with a review of Boolean algebra, and computational methods that replace manual drawing of Karnaugh maps. Next, we discuss algorithms for 2-level and multi-level logic synthesis, that transform Boolean equations and finite state machine descriptions into optimized logic, and verification methods that determine whether the logic we built does the same thing as the specification we started with. We learn about algorithms that are used to determine component partitioning, placement, and wire routing. We look at timing verification methods in order to determine if the signal through our circuit propagates fast enough. The students will write programs to implement these methods, and experiment with existing algorithm implementations. While we will be learning about these algorithms using the circuit design case study, last several lectures are dedicated to demonstrations of the use of the algorithms in other fields, with guest lectures given by experts from industry and academia.

INSTRUCTORS

Dr. Natasa Miskov-Zivanov
Office: Schenley Place 320, 4420 Bayard Street
Email: nmzivanov@pitt.edu
Phone: 412-624-0509
Office Hours: (tentative) Thursdays 5:30-6:30pm, via Zoom

TA: Gaoxiang Zhou
Office: Schenley Place 315, 4420 Bayard Street
Email: GAZ11@pitt.edu
Office Hours: TBD

LECTURES Time: 4-5:15pm; Location: 241 Crawford Hall

Zoom info for first few weeks: Link: https://pitt.zoom.us/j/98628658956 Meeting ID: 986 2865 8956, Passcode: ECE2195

PREREQUISITES Senior (ECE 302) or Graduate Standing

TOPICS COVERED

- Boolean algebra
- Algorithms for 2-level and multi-level logic synthesis and minimization
- Verification and SAT algorithms
- Graph and geometric layout algorithms for partitioning, placement, and routing
- Timing verification algorithms
- Applications of algorithms in: ML, AI, systems and synthetic biology, etc.

READING *Lecture notes and reading material (research papers) will be available on Canvas*

GRADING

Homeworks	54%
Project	41%
Participation	5%

HOMEWORK Six homeworks will be assigned throughout the semester, approximately released every two weeks, each worth 9% of the overall grade. Homework due dates will be listed in the published homework on Canvas, and any changes to due dates will be communicated via announcements on Canvas. Homework problems involve mathematics, a few proofs, algorithm design and analysis. Additionally, homeworks will often require writing, running and reporting results from small/medium programs that illustrate ideas from the class. Discussions about homework in small groups are strongly encouraged. However, you are required to do your own homework.

PROJECT There will be a semester long project, worth 41% of the grade. Projects can be done individually or in teams of two (preferred). Project topics will be distributed at the beginning of semester and there will be one lecture in each month dedicated to project updates and discussions. Approximate schedule for project updates:

January: Project proposals (5%) - short presentation (~5 min.) and report
February: Project milestones 1 (10%) - presentation of updates (~10 min.) and report
March: Project milestones 2 (10%) - presentation of updates (~10 min.) and report
April: Final project report (16%) – final presentation (~15 min.) and report

Details about the format of presentations and reports, and due dates will be provided in class and on Canvas

PARTICIPATION Attending lectures and participating in class discussions. Asking questions during lectures and others' project presentations.

Tentative schedule:

Date	Lecture Topic	HW, Project	Instructor
January			
01/11	Introduction		NMZ
01/13	Advanced Boolean Algebra 1	HW1 out	NMZ
01/18	Advanced Boolean Algebra 2		NMZ
01/20	Algorithms on Decision Diagrams 1: BDD/ADD Representation		NMZ
01/25	Algorithms on Decision Diagrams 2: BDD/ADD Implementation	Project proposal due	NMZ
01/27	*Project – proposal*	HW2 out	all
February			
02/01	Formal Verification	HW1 due	NMZ
02/03	Satisfiability Algorithms 1		NMZ
02/08	Satisfiability Algorithms 2		NMZ
02/10	Algorithms for 2-Level Logic Minimization	HW3 out	NMZ
02/15	Algorithms for Multi-Level Logic Minimization and Modeling 1	HW2 due	NMZ
02/17	Algorithms for Multi-Level Logic Minimization and Modeling 2		NMZ
02/22	Don't cares – why they can be useful and what do we do with them?	First project report due	NMZ
02/24	*Project – milestone 1*	HW4 out	all
March			
03/01	Algorithms for Sensitivity, Controllability, Observability	HW3 due	NMZ
03/03	*Application examples*: sensitivity, controllability, observability		GZ
03/08	*Spring break – **no class***		
03/10	*Spring break – **no class***		
03/15	Algorithms for Technology Mapping		NMZ
03/17	Graph Algorithms: Placement 1		NMZ
03/22	Graph Algorithms: Placement 2	HW5 out	NMZ
03/24	Graph Algorithms: Routing	HW4 due	NMZ
03/29	*Project – milestone 2*	Second project report due	all
03/31	Algorithms for Timing Analysis 1		NMZ
April			
04/05	Guest lecture – applications of algorithms in ML and ML for improving algorithms	HW6 out	EF
04/07	Applications of DA algorithms in AI	HW5 due	TBD
04/12	Guest lecture – application of timing analysis in Systems Biology		KS
04/14	Guest lecture – applications of DA algorithms in Synthetic Biology		TBD
04/19	*Project – final presentations*		all
04/21	*Project – final presentations*	HW6 due	all
TBD		Final project report due	

Communication

The instructors will send announcements on Canvas, which may include a summary of plans, due dates, reading material and notes about lectures.

Academic Integrity

All students and faculty are expected to adhere to the standards of professional conduct and academic honesty. Any student engaged in cheating, plagiarism, or other acts of academic dishonesty would be subject to disciplinary action. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the SSOE Academic Integrity Policy found at: https://www.engineering.pitt.edu/Academic-Integrity-Guidelines/.

Disability Services

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Statement on Classroom Recording

To address the issue of students recording a lecture or class session, the University's Senate Educational Policy Committee issued the recommended statement on May 4, 2010: "***To ensure the free and open discussion of ideas, students may not record classroom lectures, discussion and/or activities without the advance written permission of the instructor, and any such recording properly approved in advance can be used solely for the student's own private use.***"

Student Opinion of Teaching Surveys

Students in this class will be asked to complete a *Student Opinion of Teaching Survey*. Surveys will be sent via Pitt email and appear on your Canvas landing page during the last three weeks of class meeting days. Your responses are anonymous. Please take time to thoughtfully respond, your feedback is important to your instructors. Read more about *Student Opinion of Teaching Surveys*.

Religious observance

The observance of religious holidays (activities observed by a religious group of which a student is a member) and cultural practices are an important reflection of diversity. In this class, we are committed to providing equivalent educational opportunities to students of all belief systems. At the beginning of the semester, you should review the course requirements to identify foreseeable conflicts with assignments, exams, or other required attendance. If at all possible, please contact the instructor within the first two weeks of the semester to allow time to discuss and make fair and reasonable adjustments to the schedule and/or tasks.

Diversity and Inclusion

The University of Pittsburgh does not tolerate any form of discrimination, harassment, or retaliation based on disability, race, color, religion, national origin, ancestry, genetic information, marital status, familial status, sex, age, sexual orientation, veteran status or gender identity or other factors as stated in the University's Title IX policy. The University is committed to taking prompt action to end a hostile environment that interferes with the University's mission. For more information about policies, procedures, and practices, see: http://diversity.pitt.edu/affirmative-action/policies-procedures-and-practices.

We ask that everyone in this class strive to help ensure that other members of this class can learn in a supportive and respectful environment. If there are instances of the aforementioned issues, please contact the Title IX Coordinator, by calling 412-648-7860, or e-mailing titleixcoordinator@pitt.edu. Reports can also be filed online: https://www.diversity.pitt.edu/make-report/report-form. You may also choose to report this to a faculty/staff member; they are required to communicate this to the University's Office of Diversity and Inclusion. If you wish to maintain complete confidentiality, you may also contact the University Counseling Center (412-648-7930).

COVID-19 Statement

During this pandemic, it is extremely important that you abide by public health regulations and University of Pittsburgh health standards and guidelines. While in class, at a minimum, you must wear a face covering that covers your nose and mouth; other requirements may be added by the University during the semester. These rules have been developed to protect the health and safety of all community members. Failure to comply with these requirements will result in you not being permitted to attend class in person and could result in a Student Conduct violation. For the most up-to-date information and guidance, please visit coronavirus.pitt.edu and check your Pitt email for updates before each class.

Communication to Instructor Pertaining to Illness

As in any situation regarding class absence (remote or in person), a student who becomes ill (albeit COVID-19 related or not) is responsible for communicating with the instructor regarding course absences. ***Please contact the instructor and provide documentation when absences affect quizzes/exams. This should be done via email as soon as possible***.