EC754 – Computer-Aided Verification and Synthesis
Fall 2020

Course Description:
This course will introduce the fundamental theory in computer-aided verification and synthesis for building provably dependable computing systems. The topics covered include logic specifications, modeling formalisms, verification techniques, and inductive synthesis strategies. A special focus of this course is on the interplay between deductive reasoning (logical inference and constraint solving) and inductive inference (learning from data). We will also survey applications of these techniques to a wide range of problems in hardware, software, cyber-physical systems, robotics and biology.

Prerequisites:
Familiarities of propositional logic, basic probability theory and basic graph algorithms, and experience with one programming language (e.g., C++, Python) are assumed. An undergraduate course in algorithms (e.g., EC330 or equivalent) is required. If you are unsure whether you have sufficient background for the course, please contact the instructor.

Instructor: Wenchao Li <wenchao@bu.edu>

Course Schedule: Two lectures per week. Each lecture will be approximately 1.5 hours.

Mode of Instruction: The course will be offered entirely online via Zoom this semester. You will receive a calendar invitation with details of the Zoom meeting.

Office Hours: We will have ad hoc office hours this semester due to the relatively small class size. Email the instructor with a subject line starting with “EC754:” to arrange for a Zoom meeting if you have questions on any aspect of the course materials and assignments.

Grading (tentative): Homework (30%), Seminar Presentation (20%), Participation (10%), Project (40%).

Course Topics (tentative):
Specification/Logic: (2.5 weeks)
- Review of propositional and first-order logic
- Temporal logic (LTL, CTL, PCTL, STL, etc.)
- Hyperproperties
- Specification mining and inference

Model/Automata: (2.5 weeks)
- Finite-state automata
- Timed automata
- Probabilistic automata and Markov chains
- Automata learning

Constraint solving with SAT and SMT: (3 weeks)
- SAT solving
- Satisfiability Modulo Theories (SMT)
- $\exists \forall$ problems
Model Checking: (4 weeks)
- Explicit-state model checking
- Symbolic model checking
- Abstraction; Refinement; Interpolation
- Probabilistic model checking

Synthesis: (3 weeks)
- Syntax-guided synthesis and learning strategies
- Game-theoretic formalisms and techniques

Applications: (spread out across the course)
- Cyber-physical systems
- Robotics and control
- Computer security
- Software engineering
- Networked and distributed systems
- CAD for integrated circuits
- Synthetic biology
- A.I. safety

Reference Books:
There is no required textbook for this course. The following books are recommended references. Copies of relevant chapters will be provided.

Assignments and Grading:
There will be a total of 3 homework assignments each worth 10% of your grade. Homework assignments will be posted on Blackboard. They must be turned in online on Blackboard. You will be given one ‘late day’ which you must use as a whole. This is intended to handle a contingency that you might have. If you want to use this ‘late day’, you must write it clearly at the beginning of your submission. Other than this ‘late day’, no late homework will be accepted, except for legitimate excuses backed by written and dated documentation.

Seminar Presentation:
In this course, we will survey state-of-the-arts in several topics of interest. Each student will be assigned a topic and a “seed” paper to study, and asked to organize the materials into a seminar-style in-class presentation. The presentation will be followed by an in-class Q&A. Details of these seminar presentations will be announced in class and on Blackboard later in the semester.

Class Participation:
You are required to attend your classmates’ seminar presentation and prepare questions for the Q&A. For the latter, you will need to read the “seed” paper before the presentation.
Project:
The project will be a theoretical and/or experimental investigation related to topics covered in class. A list of suggested project topics will be announced towards the middle of the semester. You are also encouraged to pick topics of your own, but you will need to consult with the instructor. The projects should be done individually. Projects will culminate in a final paper, presentation, and possibly a demo.

Policy on Collaboration
All homework assignments are supposed to be individual assignments. You may discuss the problems with your classmates but you must write the answers on your own and you may not share code with your classmates. In addition, if you use textbooks, web sources or other references, you must clearly acknowledge all sources in your homework. When in doubt, you should consult BU’s Academic Conduct Code:
https://www.bu.edu/academics/policies/academic-conduct-code/.