

CS 6501-002 / SYS 6582-002**CPS: Formal Methods, Safety, Security, Spring 2020**

Instructor: Lu Feng (lu.feng@virginia.edu)

TAs:

- Ingy ElSayed-Aly (ie3ne@virginia.edu)
- Josephine Lamp (jl4rj@virginia.edu)

Lecture: Monday/Wednesday 5-6:15 PM, Thornton Hall E303

Office Hours:

- Monday 10:30-11:30 AM, Rice 442 (TA: Josephine Lamp)
- Tuesday 12-1 PM, Olsson 271 (Instructor)
- Wednesday 2:30-3:30 PM, Rice 442 (TA: Josephine Lamp)
- Thursday 12:30-1:30 PM, Rice 442 (TA: Ingy ElSayed-Aly)
- Friday 10:30-11:30 AM, Rice 442 (TA: Ingy ElSayed-Aly)

Description

Welcome! Cyber-physical systems (CPS) are smart systems that include co-engineered interacting networks of physical and computational components. Examples of CPS include medical devices, automotive cars, robots, internet of things, smart cities. Increasingly, such systems are everywhere. It becomes more and more important to assure the safety and security of CPS, since many CPS applications are safety-critical and life-critical. This course will give you the required skills to analyze the CPS that are all around us, so that when you contribute to the design of CPS, you are able to understand important safety and security aspects and feel confident designing and analyzing CPS systems. The overall goal of this course is to enable you to learn not only the fundamental knowledge of CPS and formal methods, but also important skills of creative thinking, collaborative working, and continuing learning of new techniques after the course is over. It will provide an excellent foundation for students who seek industry positions and for students interested in pursuing research.

Prerequisites

This course has substantial elements of mathematics and logic. You should have taken the following classes (or their equivalents):

- Discrete Mathematics
- Probability
- Linear Algebra
- Calculus

Assessment & Grading

The overall course grade will be determined by the following assessment:

- **Homework (25%):** There will be 5 homework assignments hosted online, which are meant to help you reinforce and practice with concepts covered in class. The homework will be automatically graded for correctness, and you can submit as many times as you like up to the deadline. You are encouraged to work until you have fully solved the homework.
- **Programming assignments (20%):** You will learn to use the probabilistic model checking tool PRISM and complete a set of assignments using the tool.
- **Paper reviews (20%):** We will teach you how to read a research paper effectively and critically in class. We will discuss 20 research papers in the second half of the semester. You will read each paper and write a review summarizing its strengths and weaknesses *before* the class.
- **Paper presentation (5%):** You will present one of the 20 papers in class. Depending on the class size, each paper may have around 3 students who collaborate on presenting the paper and leading the in-class discussion.
- **Final course project (25%):** You will team up in groups of up to 4 students to work on a final course project. It can be a theoretical and/or experimental investigation related to topics covered in class. You are encouraged to pick topics of your own and consult with the instructor. The key point is that there should be some new research in your project: either a new application of existing formal methods, or a new formal technique, or both. Projects that are simply surveys of existing papers without any input of new ideas will not be acceptable. The project deliverables include:
 - 1-2 pages proposal (5%)
 - 3 minutes video demo (5%)
 - In-class project presentation (5%)
 - 5-10 pages final report (10%)
- **Quizzes and participation (5%):** We will randomly pick 5 classes to do a short quiz of 1-2 questions to test your understanding of the course material. These quizzes are not meant to be onerous, but are meant to ensure that you actively engage in the class and/or paper discussion. Each quiz will be graded with a check.

Grades are on the following fixed scale:

A	[90 – 100]%
A-	[85 – 90)%
B+	[80 – 85)%
B	[75 – 80)%
B-	[70 – 75)%
C+	[65 – 70)%
C	[60 – 65)%
C-	[55 – 60)%
D+	[50 – 55)%
D	[45 – 50)%
D-	[40 – 45)%
F	[0 – 40)%

Course Materials

- There is no required textbook for this course. Recommended readings will be announced in lectures and UVACollab.
- You are strongly encouraged to participate in discussion, ask questions, and answer other students' questions through Piazza. The instructor and TAs will also monitor the Piazza site closely to answer questions in time.

Course Topics and Schedule (Tentative: Subject to change!)

Date	Topic
1/13 Mon	Lecture: Introduction
1/15 Wed	Lecture: Formal Modeling 1
1/20 Mon	No class (MLK holiday)
1/22 Wed	Lecture: Formal Modeling 2
1/27 Mon	Lecture: Formal Specification 1
1/29 Wed	Lecture: Formal Specification 2
2/3 Mon	Lecture: Formal Verification and Synthesis 1
2/5 Wed	Lecture: Formal Verification and Synthesis 2
2/10 Mon	Lecture: Formal Verification and Synthesis 3
2/12 Wed	Lecture: DTMC Model Checking 1
2/17 Mon	Lecture: DTMC Model Checking 2
2/19 Wed	Lecture: MDP Model Checking 1
2/24 Mon	Lecture: MDP Model Checking 2
2/26 Wed	Lecture: PRISM Model Checker
3/2 Mon	Lecture: SAT & SMT Solving
3/4 Wed	Lecture: How to read and review a paper?
3/9 Mon	No class (spring recess)
3/11 Wed	No class (spring recess)
3/16 Mon	Medical CPS: Safety (paper presentation & discussion)
3/18 Wed	Medical CPS: Security (paper presentation & discussion)
3/23 Mon	Automotive CPS: Safety (paper presentation & discussion)
3/25 Wed	Automotive CPS: Security (paper presentation & discussion)

3/30 Mon	Smart cities & smart homes: Safety (paper presentation & discussion)
4/1 Wed	Smart cities & smart homes: Security (paper presentation & discussion)
4/6 Mon	Human-in-the-loop CPS: Safety (paper presentation & discussion)
4/8 Wed	Human-in-the-loop CPS: Security (paper presentation & discussion)
4/13 Mon	Machine learning enabled CPS: Safety (paper presentation & discussion)
4/15 Wed	Machine learning enabled CPS: Security (paper presentation & discussion)
4/20 Mon	Lecture: Concluding Remarks & Research Frontiers Overview
4/22 Wed	Final project presentation
4/27 Mon	Final project presentation

Policies

- Extensions for assignments are generally granted only if you have a medical or family-related emergency; the default extension is 3 days, and you can request more if necessary. Please email the instructor for any extension request.
- Late submissions & slip days: You will have a total of 5 slip days for late submission of assignments, and may use up to 2 days for each assignment. Note that this policy is meant to deal with cases like internet issues while submitting, forgetting about the deadline, emergency situations, joining the class late, etc. For medical or family-related emergency, please refer to the previous policy regarding extension request.

Honor Code

We trust every student in this course to fully comply with all of the provisions of the University's Honor Code. By enrolling in this course, you have agreed to abide by and uphold the Honor System of the University of Virginia, as well as the following policies specific to this course.

- All graded assignments must be pledged.
- **Collaboration:** Homework, programming assignments, and paper reviews must be completed on your own. The final course project is encouraged to be completed in groups of up to 5 students.
- **Ethics:** Submissions should acknowledge all collaborators and sources consulted. All code and written responses should be original. We trust you to submit your own work, but to protect the integrity of the course from anyone who doesn't play by the rules, we will actively be checking for code plagiarism.

All suspected violations will be forwarded to the Honor Committee, and you may, at the instructor's discretion, receive an immediate zero on that assignment regardless of any action taken by the Honor Committee.

Please let the instructor know if you have any questions regarding the course Honor policy. If you believe you may have committed an Honor Offense, you may wish to file a

Conscientious Retraction by calling the Honor Offices at (434) 924-7602. For your retraction to be considered valid, it must, among other things, be filed with the Honor Committee before you are aware that the act in question has come under suspicion by anyone. More information can be found at <http://honor.virginia.edu>. Your Honor representatives can be found at: <http://honor.virginia.edu/representatives>.

Accessibility

The University of Virginia strives to provide accessibility to all students. If you require an accommodation to fully access this course, please contact the Student Disability Access Center (SDAC) at (434) 243-5180 or sdac@virginia.edu. If you are unsure if you require an accommodation, or to learn more about their services, you may contact the SDAC at the number above or by visiting their website at <http://studenthealth.virginia.edu/student-disability-access-center/faculty-staff>.

It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements. If you have questions or concerns about academic accommodations for religious observance or religious beliefs, you may contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200.

Accommodations do not relieve you of the responsibility for completion of any part of the coursework missed as the result of a religious observance.