
Cog356 Syllabus, 2022

Cog356 is officially called **Formal Systems and Abstract Machines**, but is loosely referred to as **The Generative Processes Course**, since class examples, exercises, and assignments tend to feature the generation of various phenomena by means of instantiating particular formal systems and abstract machines.

Instructor - Class Meetings - Office Hours

Classes for the 2022 edition of Cog356 will be offered in **face-to-face / in-person mode**, rather than any sort of remote or hybrid mode, so long as the college is not required to go remote, once again, due to the pandemic or some other unforeseen circumstance.

- Instructor: Craig Graci, Computer Science & Cognitive Science
- Class meetings: Monday, Wednesday & Friday 9:10am-10:05am - **face-to-face / in-person**
- Office Hours: Monday, Wednesday & Friday 7:30am-8:30am - **Google Meet**

Text

The **required** text serves to describe various aspects of formal systems in a coherent, accessible manner. Most notably, the text features Doug Hofstadter's take on Post production systems. In the process presenting the systems, Hofstadter provides a great many insights into the nature of formal systems, and important tips for working with formal systems.

- Hofstadter, D. (1979). *Godel, Escher, Bach: an Eternal Golden Braid*. New York: Basic Books.

Other components of the course will be presented by means of lectures and the electronic distribution of additional materials.

Course Description

Post production systems: Definition, Hofstadter's MIU system, his pq-, tq-, and TNT (typographical number theory) systems. **Formal systems:** Basic concepts, working within the system vs working outside of system system, the inherent reciprocal processes of recognition and generation. **Context free grammars:** Definitions, derivations, limitations, applications to cognitive science. **L-systems:** Biological roots, definition, generations, applications to the generation of graphical images with Turtle Graphics and musical melodies with Clay. **Other conceptions of fractals:** Descriptions, renderings, applications of classical mathematical self-similar sets. **Cellular automata:** Von Neumann's seminal ideas, John Horton Conway's game of Life, an introduction to the field of A-Life. **Logic for problem solving:** Knowledge representation in Prolog, Robinson's resolution principal and unification as foundational elements of Prolog. **Church's lambda calculus:** Abstraction, computation, the role of lambda calculus in computer programming language design and specification. **Turing machines:** Mechanism, the role of Turing machines in the theory of computation. **Finite state machines:** Basic concepts, applications to cognitive science. **Markov processes:** The Markov property, Markov processes and applications to cognitive science. **Evolutionary programs:** Genetic algorithms, genetic programs, applications to the modeling of cognitive phenomena.

Learning Outcomes

Upon successful completion of this course, it is expected that you will be able to do most of the following things in a satisfactory manner:

1. Distinguish clearly between operating in “mechanical mode” and “intelligent mode” (Hoftsadter) when engaging with formal systems.
2. Generate theorems from axioms and rules in the context of Post production systems, particularly Hofstadter’s Post production systems.
3. Model simple phenomena (e.g., linguistic forms, musical melodies) with Markov models.
4. Perform derivations of sentences in languages defined by context free grammars, model simple formal languages by using context free grammars, and explore the possibilities inherent in variants of context free grammars which incorporate nondeterminism, hierarchy, or both.
5. Model simple phenomena (e.g., linguistic forms, musical melodies) with L-systems and, perhaps, some other fractals.
6. Define complex systems and discuss the concept of emergence.
7. Discuss Robinson’s resolution principle as an inference rule that subsumes modus ponens and modus tollens, and as the mechanism that unleashes the power of Prolog.
8. Describe Alonzo Church’s lambda calculus, and discuss its role in the design and specification of computer programming languages.
9. Define the structure and operation of finite state machines, use them for purposes of recognition and generation, discuss limitations of finite state machines, and characterize their role in cognitive modeling.
10. Describe the Turing machine as a computational concept, perform computations on simple Turing machines, and articulate the relationship between Universal Turing machines and modern day computers.
11. Describe the basic elements of a genetic algorithm and discuss the application of genetic algorithms to cognitive science.
12. Define the concept of cellular automata, run a few iterations of some simple cellular automata, and discuss basic ideas associated with the field of artificial life (A-life).

Teaching Model

In order to effectively learn something, it is helpful to rely on a suitable model of learning to guide your progress. In college, your professors generally establish some constraints on your engagement with course materials which will, in turn, constrain whatever model of learning you might establish for yourself. For the present course, these are the principle constraints of engagement:

1. **Classroom Presence:** Come to class, prepared (1) to share material pertaining to the various learning activities in which you are expected to engage, and (2) to contribute something meaningful when asked for a contribution of some sort, perhaps to conjure up an example of some kind, or to express an opinion, or to critique an idea.
2. **Problem Sets:** Throughout the semester you will be asked to produce documents in response to a number of assignments that are classified as “problem sets”. Some of these are based on chapters of Douglas Hofstadter’s “Godel, Escher, Bach: The Eternal Golden Braid”. Other problem sets will be based on lectures pertaining to one formal system or another.
3. **Midterm Exam:** There will be a 1 hour in-class exam given during one of the week 10 class days (either Mar 28 or Mar 30 or Apr 1). The exam will be formally announced one week prior to the exam date.

4. **Take Home Final Exam:** A take home final exam will be distributed sometime during week 13 of the semester.

My role as teacher will be to (1) orchestrate these learning activities, and (2) choreograph classes in a manner that integrates various aspects of these learning activities with phenomena surrounding formal systems and abstract machines.

Requirements

You are required to regularly **attend class** and to engage in all **classroom activities**. The first prerequisite for engaging in classroom activities is that you be present for them. The second prerequisite is that you be prepared to engage in the activities, if preparation is in order. Doing work is good! But it should not be considered a substitute for participating in classroom interactions that pertain to the discussion of assignments or other activities.

You are required to complete all **assignments**, and to submit them, in the specified manner, in a timely fashion.

You are required to take a **midterm exam**, which will take the form of a 1 hour, in-class exam. No cognitive artifacts, beyond blank paper and writing stick, will be allowed for this exam.

You are required to complete a **final exam**, which will take the form of a “take home” exam.

Grading

Your grade will be determined on the basis of your performance on the following nonexclusive activities:

1. The class attendance (10 percent)
2. The classroom activities (20 percent)
3. The assignments (40 percent)
4. The midterm exam (10 percent)
5. The final exam (20 percent)

Furthermore, I will adhere to the typical process for allocating grades. Thus, with respect to overall percentages, 90 or above will map to A, 80s will map to B, 70s will map to C, 60s will map to D, and other numbers will map to E.

Important Notes

1. This is an in-person, face-to-face class. I intend to teach the course accordingly, and to adhere to the admonition of my dean:
 - CLAS Dean (August 4, 2021): Faculty should continue to plan to teach their courses as posted in the schedule. **Please don't make individual exceptions to allow students to participate remotely in face-to-face courses. We know how disruptive that is to both faculty and students.**
2. Statement precluding the student use of cell phones or laptops or other electronic communication devices in the classroom: **Students will not be permitted to use cell phones or laptops or other communication devices while class is in session.** If you should need to check your phone for extraordinary reasons, please just quietly remove yourself from the classroom and check your cell for communications in the hallway. In the case of an emergency or other unexpected exigency, tend to your emergency or unexpected exigency. Otherwise,

please simply quietly return to class immediately after checking your phone.

3. In consideration of lingering COVID consequences, I will generally distribute significant documents, including assignments, by posting them to the course web site.
4. In the event that the college should need to go remote, as it did starting in March, 2020, I plan to use a teaching model that I developed for use at that time and that served me and my students well for the 2+ semesters that in-person teaching was so severely limited. If the need should arise, I will send you an email with a description of the model. With luck, that unfortunate situation will not recur this semester.
5. The course web page is located at:
http://www.cs.oswego.edu/~blue/course_pages/2022/Spring/Cog356/
6. Generally speaking, I will be processing student email this semester twice each week, on Monday from 2:00pm-3:00pm and on Friday from 2:00pm-3:00pm. Please expect my response to any email that you might send my way to be timed accordingly.
7. Generally speaking, I will be holding three office hours each week, on Monday, Wednesday, and Friday from 7:30am-8:30am. I plan to conduct my office hours solely via Google Meet this semester. If you would like to meet with me during an office hour, please send me an email. I will process requests for office hour appointments during my email processing hours at 2pm on Monday and Friday. Generally speaking, if you send me an email request for an office hour appointment by 2pm on a Friday, I will book you for the following Monday morning. If you send me an email request for an office hour appointment by 2pm on Monday, I will book you for the following Wednesday or Friday, whichever you prefer. If you have a preferred time to meet during my office hours, I will do my best to accommodate your preference. Otherwise, I will schedule on a “first-come/first-served” basis, allocating the next office hour “slot” that is available.
8. Requests to make up exams will rarely be considered unless accompanied by a written medical excuse for your absence.
9. It is intended that you complete your work by yourself. You are, of course, welcome to ask specific technical questions of others and converse over conceptual issues, but you should be doing your own work. Compelling evidence that someone other than you contributed conspicuously to the completion of required work will result in a “maximum negative” grade for that assignment, failure in the course, or worse.
10. College Intellectual Integrity Statement: SUNY Oswego is committed to Intellectual Integrity. Any form of intellectual dishonesty is a serious concern and therefore prohibited. You can find the full policy online at <http://www.oswego.edu/integrity>.
11. College Disability Statement: “If you have a disabling condition, which may interfere with your ability to successfully complete this course, please contact the Office of Accessibility Services.”
12. Clery Act/Title IX Reporting Statement: SUNY Oswego is committed to enhancing the safety and security of the campus for all its members. In support of this, faculty may be required to report their knowledge of certain crimes or harassment. Reportable incidents include harassment on the basis of sex or gender prohibited by Title IX and crimes covered by the Clery Act. For more information about Title IX protections, go to <https://www.oswego.edu/title-ix/> or contact the Title IX Coordinator, 405 Culklin Hall, 315-312-5604, titleix@oswego.edu. For more information about the Clery Act and campus reporting, go to the University Police annual report: <https://www.oswego.edu/police/annual-report>.