CAS 570: Fundamentals of Complex Adaptive System Science

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Fall 2023 — Mondays 3:00 to 5:45, ECA 120

Course Description

Many phenomena of critical relevance to human society are dynamic systems that change over individual and evolutionary time scales, and are highly interactive, both within and between systems. That is, they are complex adaptive systems (CAS). As a consequence, many social and natural systems share isomorphic properties like near-decomposability, hierarchical organization, scale-free networks, self-organized criticality, and emergence that are inherent to the structure, operation, and dynamics of CAS. The spread of epidemics, healthy and diseased states of the human brain, impacts of agriculture on land degradation, the scaling of human innovation with urban growth, and social responses to natural disasters all involve CAS.

Fundamentals of CAS Science explores the diverse, interdisciplinary applications of a complex adaptive systems across the social, behavioral, and life sciences. The course includes a laboratory in which students will practice using state-of-the-art computational tools.

Student Learning Outcomes

Upon completion of this course, students will have acquired:

- a broad appreciation of the potential for applying concepts and methods for complex adaptive systems across a wide array of scientific fields;
- an understanding of how research informed by complex systems concepts can lead to new insights about diverse real-world phenomena;
- knowledge of the kinds of methods most useful to studying the dynamics of complex social and biological systems.

Readings

Readings are current journal and book chapters that represent up-to-date accounts of ongoing complexity related research across multiple disciplines. These will be posted on Blackboard.

As a comprehensive introductory reference, we suggest Melanie Mitchell's book *Complexity: A Guided Tour*.

Assignments and Grading

Grades will be based on student participation (40%) and a computational project (60%).

The computational project will consist of a simple quantitative model connected to the research of each student's interest that connects to concepts in complexity theory and modeling. It requires (1) a clear question and (2) a modeling strategy. The goal of the project is for you to familiarize yourself with the technical aspects of model building and address any unexpected challenges it presents. The end result will be a well-documented Jupyter notebook (or similar algorithmic output), with a particular focus on result reproducibility.

Each class session will end with an hour devoted to group discussion of student projects. These discussions will involve technical aspects and sharing code. Two class sessions will focus solely on these aspects (LAB 1 & 2).

Relevant ASU Academic Policies

Academic Integrity

All students are required to read and act in accordance with university and Arizona Board of Regents policies, including:

- the Arizona Board of Regents Code of Conduct (ABOR Policies 5-301 through 5-308),
- ASU's policies on academic integrity, and
- ASU's Computer, Internet and Electronic Communications Policy

If you fail to meet the standards of academic integrity in any of the criteria listed on the university policy website, sanctions will be imposed by the instructor, school, and/or dean. Academic dishonesty includes borrowing ideas without proper citation, copying others' work (including information posted on the internet), and failing to turn in your own work for group projects. If you follow an argument closely, even if it is not directly quoted, you must provide a citation to the publication, including the author, date and page number. If

you directly quote a source, you must use quotation marks and provide the same sort of citation for each quoted sentence or phrase.

You may work with other students on assignments. However, all writing that you turn in must be done independently by you. If you have any doubt about whether the form of cooperation you contemplate is acceptable, ask the instructor in advance of turning in an assignment. Any work submitted for credit in this class may be scanned to compare it against everything posted on the Internet, online article/paper databases, newspapers and magazines, and papers submitted by other students.

Disability Policy

Disability Accommodations: Qualified students with disabilities who will require disability accommodations in this class are encouraged to make their requests to me at the beginning of the semester either during office hours or by appointment. Note: Prior to receiving disability accommodations, verification of eligibility from the Disability Resource Center (DRC) is required. Disability information is confidential.

Establishing Eligibility for Disability Accommodations: Students who feel they will need disability accommodations in this class but have not registered with the Disability Resource Center (DRC) should contact DRC immediately. Their office is located on the first floor of the Matthews Center Building. DRC staff can also be reached at: 480-965-1234 (V), 480-965-9000 (TTY). For additional information, visit: www.asu.edu/studentaffairs/ed/drc. Their hours are 8:00 AM to 5:00 PM, Monday through Friday.

Course Schedule

Week 1 (Aug 21) – **Introduction** to Complex Adaptive Systems Science

Week 2 (Aug 28) – **Networks** (Enrico Borriello)

Week 3 (Sept 4) *Labor Day, No Class*

Week 4 (Sept 11) – **Collective Behaviors** Pt 1 – Scaling & Coarse graining (Bryan Daniels)

Week 5 (Sept 18) – **Collective Behaviors** Pt 2 – Emergence & Function (Bryan Daniels)

Week 6 (Sept 25) – **Evolutionary Biology** (Manfred Laubichler)

Week 7 (Oct 2) – Modeling **Dynamics** Pt 1 – Deterministic component (Enrico)

Week 8 (Oct 9) *Fall Break, No Class*

Week 9 (Oct 16) – **Agent Based Models** (Michael Barton)

Week 10 (Oct 23) – **Information Theory** (Enrico Borriello)

Week 11 (Oct 30) – **LAB** Pt 1

Week 12 (Nov 6) – **Statistics and Dimensionality Reduction** (Bryan Daniels)

Week 13 (Nov 13) – Modeling **Dynamics** Pt 2 - Stochastic component (Enrico Borriello)

Week 14 (Nov 20) – **Computation** (Bryan Daniels)

Week 15 (Nov 27) – **LAB** Pt 2