CSI 758: Visualization and Modeling of Complex Systems

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E-mail: acroitor@gmu.edu
Office Hours: M 10:00-11:00am
Office: Research Hall 253

Course website: Blackboard
Class Hours: R 4:30-7:10pm
Class Room: Innovation Hall 233

Course credits: 3

Course Description

This course covers elements of modeling and analysis for scientific applications. Concentrates on sample projects and student-initiated projects to use visualization, image and graphical analysis as they apply to modeling of complex data sets and systems. Reviews methods of creating and generating analysis and visualization packages. Data sets from multiple sources will be used. Modeling and analysis accompanied by appropriate readings from current literature. (source: **University Catalog 2021–2022**)

This course is structured around two key learning activities: **Weekly class meetings** and independent student work. In class meetings we will review, discuss, explore, and gain experience with the various course materials. Class meetings will also provide students opportunities to explore the level of their understanding and skill with the various topics covered. **Independent student work** will be in two forms: homework assignments and course project. Assignments will typically focus on specific topics from the weekly class meetings, and will provide an opportunity to gain first-hand experience with modeling, analysis, and visualization of complex systems. The project component will allow students to study a problem or a challenge using the knowledge and skills they gained in a scientific research setting.

Prerequisites/Co-requisites

Prerequisites: The course has no formal prerequisites per the university catalog. While not strictly required, it is **highly recommended** that students in the course will have some prior knowledge/experience with:

- **Basic** programming skills – Python (preferred) or another programming language (e.g., R, Matlab, Fortran, C/C++, etc.).

- **Basic** knowledge of calculus, linear algebra, and probability theory.

If you do not have any experience with topics these please consult with the course instructor about how you could address the situation.

Required Materials

The course materials includes three primary components:

- **Textbook**: "Introduction to the Modeling and Analysis of Complex Systems" by Hiroki Sayama (2015), ISBN: 978-1-942341-06-2. An electronic version of this textbook is available through **the Mason Library**).
- **Course notes**: will be made available on the course's website on Blackboard.
- **Supplementary resources**: additional curated reading resources (e.g., scientific articles, technical documentation, book chapters, online resources, etc.) will be provided from time to time to supplement the course materials.

Course Objectives & Learning Outcomes

The overarching objective of this course is to introduce students to the study of complex systems, loosely defined as systems made of large amount of lower-level components interacting with each other in a non-simple way. We'll review and discusses basic mathematical concepts and tools for formulating and understanding their characteristics (e.g., mean-field approximation, scaling, bifurcation, chaos, and pattern formation). In conjunction, the course will introduce several computational modeling frameworks (e.g., cellular automata, including agent-based models, evolutionary models, etc.). Beyond theory, the course aims to provide hands-on experience with modeling, analyzing, and visualizing complex systems. Towards that goal, Python will be used as a primary computing environment in this course. Given these characteristics, the **course objectives** are to:

1. Review of basic ideas, theories, and approaches for studying complex systems.
2. Introduce analytical techniques and tools that are used for complex systems modeling, analysis, and visualization.
3. Enable students to gain hands-on experience with applying complex systems tools in the context of various domains (e.g., natural, social, and artificial domains)

In view of these objectives, each student is expected to be able to achieve the following **learning outcomes** by the end of the course :

1. Articulate key ideas, theories, and approaches in the study of complex systems.
2. Evaluate the advantages and limitations of such ideas, theories, and approaches.
3. Given a problem or task, design, integrate, and appropriately implement a solution for complex systems modeling, analysis, and visualization.

4. Effectively communicate the approaches, methods, and tools used, as well as analysis results and their significance.

Assessment

Homework

Homework assignments will typically be provided weekly on the same day class meetings are held. Each assignment will contain one or more tasks and have a specific due date and deliverables. Each assignment will also be assigned a relative weight that will be used for calculating the homework score component in the final grade.

Project

The course project provides an opportunity for each student to perform a methodological study of a topic or problem related to complex systems and the course topics. The project topic, which will be selected in consultation with the course instructor, should allow students to perform a "deep dive" study of the topic using scientific research methodology. Students are particularly encouraged to work on a topic related to their thesis or dissertation work.

Grading Policy

Final course grades will be provided according to the graduate grading scale (letter grade), as defined in **Academic Policy 3.2**. I reserve the right to "curve" the scale dependent on overall class performance at the end of the semester if I determine that such a grading approach is appropriate. If such a grading approach is used it will not be applied when it negatively affects the letter grade. In order to determine the letter grade a numerical score will be calculated according to the following proportions:

Coursework	Quantity	Points	Max Score
Assignments	13*	varying	75
Attendance & Participation	14	5	5
Project	1	20	20
Total			**100**

Table 1: Table 1: Course grade composition.

* Please note that the number of assignments is tentative and will be adjusted as necessary during the semester. Any changes will be announced in class.

Course Schedule

The planned course schedule is provided in Table 2 below. Please note that the list of topics and homework assignments and their order in this table are tentative and are subjected to change at the discretion of the instructor (any changes will be announced in class before they take effect).

Meeting	Date	Topic	HW (due)	Test	Project
1	Jan. 27	Introduction			
2	Feb. 3	Intro. to Models	1		
3	Feb 10	Discrete time modeling & analysis	2		
4	Feb. 17	Continuous time modeling & analysis	3		
5	Feb. 24	Bifurcation & Chaos	4		
6	Mar. 3	Cellular automata modeling	5		
7	Mar. 10		6		
–	Mar. 17	Spring recess (no class)			
8	Mar. 24	Cellular automata analysis	7		
9	Mar. 31	Continuous filed modeling	8		
10	Apr. 7	Continuous field analysis	9		
11	Apr. 14	Dynamical networks: Modeling	10		Topic selection
12	Apr. 21	Dynamical networks: Analysis	11		Draft 1
13	Apr. 28	Intro. to agent-based modeling	12		Draft 2
14	May 5	Summary & conclusion	13		

Table 2: Tentative course schedule and important dates.

In case of any discrepancy between the course schedule and Mason's academic calendar, Mason's calendar and announcements takes precedence. If the campus closes or class is canceled due to weather or other concern, students should check Blackboard as well as the Mason website for updates on how to continue learning and information about any changes to events or assignments. As a student you are expected to be familiar with the important dates in the academic calendar.

Computing requirements

The course requires access to a standalone computer (i.e. a desktop or a laptop) for various learning activities, including homework assignments and the course project (generally, a mobile device such as a smartphone, a tablet, or a "Chromebook" is insufficient for this course). Mason provides students access to on-campus general computing labs as well as virtual computing services that have the required hardware and software. If you prefer to use your own computer for course activities please make sure that it meets the following minimum requirements:

Hardware

- An Intel-based processor that supports 64-bit system architecture with at least two cores (4 or more recommended).
- At least 4GB of memory (8 or more recommended)

- An integrated or dedicated graphics card that supports 800 x 600 resolution (16bit) or more
- At least 5GB of free disk space
- A high-speed network card (wired/wireless)
- A stable Internet connection with a consistent 1.5 Mbps download speed or higher
- A microphone
- A webcam (optional)

Software

- A 64-bit operating system (Windows 10 or higher / Mac OS 10.13 or higher)
- A user account with appropriate account privileges for installing software. If you are using an employer-provided computer for this class it is your responsibility to verify with the computer owner/administrator that you will be able to install the necessary applications and that the computer's security settings will allow you to access and use any electronic course content that is provided.
- A supported up-to-date web browser (you can check which browsers are supported by Blackboard)
- A simple text editor (e.g., Notepad, Visual Studio Code, etc.)
- Adobe Acrobat Reader (free download)
- Zoom videoconferencing tool (see Mason's support page on Zoom for details on how to install and use this software)

Please note that during the course we may use various additional software environments and tools. Information about installing and using such tools will be provided along with the course materials.

Course Policies

Attendance & participation

While attendance is not strictly enforced, students should attend all class meetings and actively participate in them. Such participation essential to the success of the course as well as to the individual and collective learning process. During class meetings we will often engage in hands-on activities in order to develop an understanding of theory and methodology as well as the skills to implement it. These guided hands-on experiences will also serve as an introduction to assignments.

Assignments

The course includes several mandatory written assignments ("homework") on select topics from the class materials. Assignments may include tasks such as algorithm development and implementation, analysis of data processing results, and discussion/analysis of theoretical concepts and test cases. All assignments are mandatory. Typically, one week will be allocated for every assignment unless noted otherwise (the due date for each assignment will be provided on Blackboard). Submission of assignments should be done only through the Blackboard course website. Please do not email assignments directly to the course team unless explicitly instructed to do so.

Late assignment submission

Assignments submitted up to 5 calendar days past the due date will result in a late penalty of 3 percent of the full assignment score per calendar day. As Work submitted after more than 5 calendar days and up to 14 calendar days past the due date (but before the last day of classes) will result in a late penalty of 25 percent. Submissions after 14 calendar days past the due date will not be accepted. Exceptions to this policy may be made on a case-by-case basis at the discretion of the Instructor. Requests for deferrals must be made in writing (by email) at least 24 hrs before the assignment due date/time. Deferral of course work is a privilege and not a right, and there is no guarantee that a deferral will be granted.

Tests & exams

The course may includes mandatory written tests, as noted in the course schedule. The date/time and the material covered in each test will be announced in class or ob Blackboard prior to the test date. Generally, all students are expected to be available to take a course test at the given date/time. A student who cannot write a course test due to a cause beyond reasonable control (e.g., medical emergency, military deployment, etc.) can request (in writing) to make arrangements to complete a test at a different time. If the request is approved, it is the student's responsibility to make the necessary arrangements with the instructor to complete the test.

Incomplete (IN) grade

An Incomplete grade (IN) grade may be requested by a student who is passing a course but who may be unable to complete scheduled course work due to a cause beyond reasonable control (e.g., medical emergency, military deployment, etc.). Any requests for an incomplete grade must be submitted in writing no later than the last week of classes, and should clearly indicate the reason for the request. If an IN grade is granted, it is your responsibility to contact the instructor at the end of the semester to make proper arrangements for completing any missing work. For further details on the IN grade please visit the Registrar's Office website.

Use of technology during class meetings

We will frequently use the internet as a means to enhance our discussions. We will also be using computers for our in-class writing assignments and you are encouraged to bring a laptop to class if you are able to. Please be respectful of your peers and your instructor and do not use technology to engage in activities that are unrelated to the class. Such disruptions show a lack of professionalism. Similarly, please refrain from using mobile devices (such as cell phones) during class time. When using technology on campus students are expected to follow the university policy number 1301: Responsible Use of Computing.

Email communication

Students must use their Mason email account to send/receive University information, including communications related to this class. I will not respond to messages sent from or send message to a non-Mason email address. Email messages received Monday to Friday will be answered within

36 hours, Email messages received during weekends or university holidays will be generally answered on the following business day.

University policies

Student and faculty names and pronouns

Name and pronoun use: If you wish, please share your name and gender pronouns with me and indicate how best to address you in class and via email. I use "he/him/his" for myself and you may address me as “Arie”, “Dr./Prof. Croitoru” or “Dr. C” in email and verbally.

COVID-19: Safe return to campus

> **Note**: Please check the Safe Return to Campus webpage regularly as these policies may change during the semester.

All students taking courses with a face-to-face component are required to follow the university’s public health and safety precautions and procedures outlined on the university Safe Return to Campus webpage. Similarly, all students in face-to-face and hybrid courses must also complete the Mason COVID Health Check daily, seven days a week. The COVID Health Check system uses a color code system and students will receive either a Green, Yellow, Red, or Blue email response. Only students who receive a “green” notification are permitted to attend courses with a face-to-face component. If you suspect that you are sick or have been directed to self-isolate, please quarantine or get testing. Faculty are allowed to ask you to show them that you have received a Green email and are thereby permitted to be in class.

Students are required to follow Mason’s current policy about facemask-wearing. As of August 11, 2021, all community members are required to wear a facemask in all indoor settings, including classrooms. An appropriate facemask must cover your nose and mouth at all times in our classroom. If this policy changes, you will be informed; however, students who prefer to wear masks will always be welcome in the classroom.

Campus closure or emergency class cancellation/Adjustment

If the campus closes, or if a class meeting needs to be canceled or adjusted due to weather or other concern, students should check Blackboard and their Mason email for updates/instructions on how to continue learning and for information about any changes to events or assignments.

Course materials and student privacy

All course materials posted to Blackboard or other course site are private to this class; by federal law, any materials that identify specific students (via their name, voice, or image) must not be shared with anyone not enrolled in this class. Videoconferencing will be used during this class as needed. Videorecordings – whether made by instructors or students – of class meetings that include audio, visual, or textual information from other students are private and must not be shared outside the class. Live video conference meetings (e.g. Collaborate or Zoom) that include audio, textual, or visual information from other students must be viewed privately and not shared with others in your household or recorded and shared outside the class.

Recording and/or sharing class materials

Some/All of our synchronous meetings in this class will be recorded to provide necessary information for students in this class. Recordings will be stored on Blackboard or other University secure site and will only be accessible to students taking this course during this semester. Photography and/or recording of any kind (audio, video), reuse of course materials, and further dissemination of the course contents is not permitted unless prior written consent of the professor and George Mason University has been given, or if recording is part of a course activity or an approved accommodation plan.

Some kinds of participation in online study sites violate the Mason Honor code: these include accessing exam or quiz questions for this class; accessing exam, quiz, or assignment answers (partial or complete) for this class; uploading of any of the instructor's materials or exams; and uploading any of your own answers or finished work. Always consult your syllabus and your professor before using these sites. You are also encouraged to review a short video on this subject.

Academic Integrity

Mason is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely.

The integrity of the University community is affected by the individual choices made by each of us. Mason has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment, ask for clarification. No grade is important enough to justify academic misconduct. Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, or endnotes. Paraphrased material must also be cited, using the appropriate format for this class. A simple listing of books or articles is not sufficient. Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please see me.

Disability Accommodations

Disability Services at George Mason University is committed to upholding the letter and spirit of the laws that ensure equal treatment of people with disabilities. Under the administration of University Life, Disability Services implements and coordinates reasonable accommodations and disability-related services that afford equal access to university programs and activities. Students can begin the registration process with Disability Services at any time during their enrollment at George Mason University. If you are seeking accommodations, please visit http://ds.gmu.edu/ for detailed information about the Disability Services registration process. Disability Services is located in Student Union Building I (SUB I), Suite 2500. Email:ods@gmu.edu ; Phone: (703) 993-2474. The course team is committed to working with you and disability services to design and provide solutions for supporting your accommodations.

Diversity and Inclusion

Our university is an intentionally inclusive community that promotes and maintains an equitable and just work and learning environment. We welcome and value individuals and their differences including race, economic status, gender expression and identity, sex, sexual orientation, ethnicity, national origin, first language, religion, age, and disability.

Sexual Harassment, sexual misconduct, and interpersonal violence

George Mason University is committed to providing a learning, living and working environment that is free from discrimination and a campus that is free of sexual misconduct and other acts of interpersonal violence in order to promote community well-being and student success. We encourage students who believe that they have been sexually harassed, assaulted or subjected to sexual misconduct to seek assistance and support. University Policy 1202: Sexual Harassment and Misconduct speaks to the specifics of Mason's process, the resources, and the options available to students.

As a faculty member, I am designated as a "Non-Confidential Employee," and must report all disclosures of sexual assault, sexual harassment, interpersonal violence, stalking, sexual exploitation, complicity, and retaliation to Mason's Title IX Coordinator per University Policy 1202. If you wish to speak with someone confidentially, please contact one of Mason's confidential resources, such as Student Support and Advocacy Center (SSAC) at 703-993-3686 or Counseling and Psychological Services (CAPS) at 703-993-2380. You may also seek assistance or support measures from Mason's Title IX Coordinator by calling 703-993-8730, or emailing titleix@gmu.edu.

Other student resources

The university offers a range of services to support students in a variety of ways (a comprehensive list is available available online). Among these services are:

- Counseling and Psychological Services
- The Center for Culture, Equity, and Empowerment
- The Office of Diversity, Integrity, and Inclusion
- Student Support and Advocacy Center
- Student Health services
- The Writing Center

If you are unable to find resource(s) for your specific needs please contact me, your academic advisor, or your home department for help.

Disclaimer: Any typographical errors in this Course Outline are subject to change and will be announced in class. Some information in this syllabus is subject to change.