USC Viterbi
School of Engineering

CSCI 499: Foundations of Multi-Agent Systems
Units: 4.0
Spring 2024 — MonWed — 5:00-6:50PM

Location: TBD

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Office Hours: TBD
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Catalogue Description

Overview of some foundations for building intelligent multi-agent systems, including distributed optimization, game theory, learning, communication, social choice, mechanism design, and auctions.

Course Description

Multi-agent systems are systems of autonomous entities (often called agents) that interact with each other and might have different objectives or available information. Such systems are now becoming ubiquitous due to the increasing fielding of software agents and hardware agents (aka cyber-physical systems, including robots). It is therefore not surprising that the area of multi-agent systems is one of the fastest-growing areas in computer science, engineering, and business applications. Allowing such systems to use the data available to them or acquired by them (for example, from communication with other agents) for making good decisions requires foundations from different disciplines, including computer science, engineering, operations research, and economics. This course will provide an overview of some of these foundations as well as their interplay and applications, with some focus on the game-theoretic analysis of multi-agent systems in which agents cannot be guaranteed to behave cooperatively. It will discuss methods such as distributed constraint satisfaction; distributed optimization; multi-agent planning and learning; cooperative and non-cooperative game theory; social choice (including voting), auctions, and other mechanisms; logics of knowledge and belief; and other methods. Students do not need to be familiar with multi-agent systems, economics, game theory, auctions, or mechanism design, but must be comfortable with formally stated algorithms and reasoning about their properties.

Learning Objectives

Students will be able to demonstrate knowledge of the foundations of multi-agent systems, appreciate trade-offs in the design of such systems, and be able to suggest appropriate methods for building multi-agent systems for specific applications.

Recommended Preparation

An understanding of concepts from artificial intelligence (at the level of CSCI 360). A solid understanding of data structures (at the level of CSCI 104), algorithms and elementary complexity theory (at the level of CSCI 170), programming in C/C++ and Python, and high-school mathematics (such as probability theory); the ability to understand and construct formal proofs.

Course Notes

Students can take the course for a letter grade or pass/no pass. The course will use different delivery mechanisms for the course material, such as in-person lectures by the instructor, videotaped lectures by other researchers, flipped classrooms, seminar-like presentations by students, and exercises presented by teaching assistants. Existing material, such as slides or videos, by the instructor and others will be made available to the students for review, where such material exists.

Technological Proficiency and Hardware/Software Required

Students will need to have access to a laptop or PC and be able to program in C/C++ and Python.

Required Readings and Supplementary Materials

Y. Shoham and K Layton-Brown, Multiagent Systems – Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge, 2008 (short: MAS). Free version available from:

http://www.masfoundations.org/download.html.

The supplementary material will change yearly and be available to students via web links.

Optional Readings and Supplementary Materials

M. Wooldridge, An Introduction to MultiAgent Systems, 2nd edition, Wiley, 2009.

D. Fudenberg and Tirole, Game Theory, MIT Press, 1991;
M. Osborne and A. Rubinstein, A Course in Game Theory, MIT Press, 1994.
V. Krishna, Auction Theory, Second Edition, Elsevier, 2009.

Description of Assignments and How They Will Be Assessed

The assignments test the understanding of the course material. There will be four graded two-week-long assignments. Some of the assignments might involve programming in addition to theoretical questions. All of them must be done individually. Each assignment focuses on testing concepts not yet tested in previous assignments.

There is a grace period of 48 hours for handing in the solutions and then a linearly increasing penalty for late submissions so that submissions that are late by 96 hours (or more) after the original deadline will receive no credit. So, for example, if an assignment is due on Monday at midnight and a) a student hands in the solutions on Wednesday at midnight, then their maximum score is 100 percent; b) they hand them in on Thursday at midnight, then their maximum score is 50 percent; and c) they hand them in on Friday at midnight, then they receive no credit for it.

Description of Exams

The final tests the understanding of the course material. It has to be solved individually in class. No makeup will be provided. The final will be open textbook ("Multiagent Systems – Algorithmic, Game-Theoretic, and Logical Foundations" only) and open printed or hand-written (but not electronic) notes. Students must bring a calculator and their USC ID to all exams. Using computers, cell phones, or similar equipment is not allowed, not even to access electronic textbook versions.

Grading Breakdown

Assessment Tool (assignments)	% of Grade
Student presentations	30%
Four assignments	10% each
Final	30%
Helping others on the discussion forum	up to 5% extra credit
TOTAL	100%

Helping others on the discussion forum is the only opportunity for extra credit.

Grading Scale

The intended grading scale is as follows:

95% - 100%: A+ (only in spirit since USC allows for an A only)
90% - 95%: A
85% - 90%: A-
80% - 85%: B+
75% - 80%: B
70% - 75%: B-
65% - 70%: C+
60% - 65%: C
55% - 60%: C-
50% - 55%: D+
45% - 50%: D
40% - 45%: D-
00% - 40%: F

The instructor reserves the right to adjust the grading scale.

Assignment Submission Policy
Assignment solutions must be submitted electronically.

Course-Specific Policies
Students are encouraged to post their technical questions on the discussion forum to see whether someone can help them. If this approach does not generate the desired result, then the TAs will be happy to help them in person.

Students must check the correctness of the grading and the posted scores immediately after the scores have been announced. They must let the instructor or TAs know about any grading issue with an assignment or exam within 7 days of the posting of the scores for that assignment or exam. After that time, the instructor will no longer entertain requests for score changes. If students have a grading issue, they must discuss it with the TAs. If no consensus is reached, the students can appeal the grading issue to the instructor. The TAs and the instructor might check assignments or exams completely for other grading issues and adjust their scores up or down as appropriate.

The instructor will assign grades from A to F if warranted. There will always be some students who are very close to grade boundaries. There is nothing that the instructor will do about that. Grades are based on performance, not need or personal circumstances, and the instructor does not negotiate grades. Thus, students should not take the course (or take it completely at their own risk) if they need a certain grade, for example, because it is important for their graduation.

The instructor will not accept excuses unless students present evidence of the issue and inform the instructor about the issue IMMEDIATELY WHEN IT AROSE (not: after it has already affected their performance in class). The instructor accepts only true emergencies as excuses, such as sickness.

Attendance
Students must attend the final and at least 75% of the lectures and seminar/exercises to pass the course. The course will be neither taped nor streamed. If students miss a class, it is their responsibility to find out what was discussed in class, including which announcements were made.

Academic Integrity
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Unless otherwise noted, this course will therefore follow the expectations for academic integrity as stated in the USC Student Handbook. The general USC guidelines on Academic Integrity and Course Content Distribution are provided in the subsequent "Statement on Academic Conduct and Support Systems" section.

In this course, students are expected to submit work that demonstrates their individual mastery of the course concepts. Unless explicitly stated otherwise, all assignments and exams must be completed individually. Students must cite all resources they relied on for their answers, including people, web pages, publications, and other write-ups. They are not allowed to discuss with others how to solve the assignments. They are also not allowed to use code or code snippets of others (that is, that they did not write themselves) unless they were provided as part of the assignments. Submitting code written by, or otherwise obtained from, others is considered plagiarism.

If found responsible for an academic violation, students may be assigned university outcomes, such as suspension or expulsion from the university, and grade penalties, such as an "F" grade on the assignment, exam, and/or in the course.

Students should ask the instructor if they are unsure about what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students may not record this course or any part of it without the express permission of the instructor and all other students in the course. The distribution of any notes, recordings, exams, or other materials from a university course or lectures — other than for individual or course group study — is prohibited without the express permission of the instructor.

Use of Generative AI in this Course

Since creative, analytical, and critical thinking skills are part of the learning outcomes of this course, all assignments should be prepared by the students working individually or, if explicitly allowed for an assignment, in groups. Students may not have another person or entity complete any portion of the assignment. Developing strong competencies in multi-agent systems will prepare students for a competitive workplace. Therefore, using AI-generated tools is prohibited in this course, will be identified as plagiarism, and will be reported to the Office of Academic Integrity.

Course Evaluations

It is very important to the instructor that students voice concerns about any aspect of the course as soon as they arise. Students can e-mail the instructor or talk to the instructor in person. The instructor will accept anonymous notes (either on paper or via email from any free "on-the-fly" email account) and treat them seriously, as long as they are sincere and constructive.

The instructor will ask students to complete anonymous questionnaires for different reasons, for example, because the instructor wants to learn a bit more about them so that the course can be tailored toward their skills and expectations; because the instructor wants to evaluate certain features of the course, or because the instructor wants to improve future courses. In addition, the instructor will ask students to complete the USC course evaluations at the end of the semester.

Course Schedule

The course topics and schedule will change as the instructor gains more experience teaching the material to undergraduate students, as new textbooks become available, as new research results become available, and as the topical focus of the course broadens or otherwise changes over time.

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Introduction to Multi-Agent Systems; Swarms	---	
Week 2	Case Study: Multi-Agent Path Finding 1	R. Stern et al. Multi-Agent Pathfinding: Definitions, Variants, and Benchmarks [Position Paper]. Symposium on Combinatorial Search (SoCS), 151-159, 2019.	
Week 3	Case Study: Multi-Agent Path Finding 2	Additional readings made available via weblinks	
Week 4	Distributed Constraint Satisfaction	MAS, Chapter 1	Assignment 1 out
Week 5	Distributed Optimization	MAS, Chapter 2	
Week 6	Cooperative Auctions	S. Koenig et al. The Power of Sequential Single-Item Auctions for Agent Coordination. In AAAI Conference on Artificial Intelligence (AAAI), 1625-1629, 2006.	Assignment 1 due
Week 7	Introduction to Noncooperative Game Theory: Games in Normal Form	MAS, Chapter 3	Assignment 2 out
Week 8	Computing Solution Concepts of Normal-Form Games	MAS, Chapter 4	
Week 9	Games with Sequential Actions: Reasoning and Computing the Extensive Form	MAS, Chapter 5	Assignment 2 due
Week 10	Richer Representations: Beyond the Normal and Extensive Forms	MAS, Chapter 6	Assignment 3 out
Week 11	Learning and Teaching, Communication	MAS, Chapters 7 and 8	
Week 12	Aggregating Preferences: Social Choice	MAS, Chapter 9	Assignment 3 due
Week 13	Protocols for Strategic Agents: Mechanism Design	MAS, Chapter 10	Assignment 4 out
Week 14	Protocols for Multi-Agent Resource Allocation: Auctions	MAS, Chapter 11	
Week 15	Logics of Knowledge and Belief	MAS, Chapter 13	Assignment 4 due
FINAL	**Final Exam**		Due on the university-scheduled date of the final exam. Refer to the final exam schedule in the USC *Schedule of Classes* at classes.usc.edu.

Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recordings Policies
USC has policies that prohibit the recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university course without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university courses or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the course, whether obtained in class, via email, on the internet, or via any other media. (Living our Unifying Values: The USC Student Handbook, page 13).

Students and Disability Accommodations:
USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each

course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - *(213) 740-9355 – 24/7 on call*
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - *988 for both calls and text messages – 24/7 on call*
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - *(213) 740-9355(WELL) – 24/7 on call*
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - *(213) 740-5086*
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - *(213) 740-5086 or (213) 821-8298*
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - *(213) 740-0776*
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - *(213) 740-0411*
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - *(213) 740-2101*
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - *UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call*
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - *UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call*
Non-emergency assistance or information.

Office of the Ombuds - *(213) 821-9556 (UPC) / (323-442-0382 (HSC)*

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - *(323) 442-2850 or* otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.