

CMPM 146 (Game AI)

***Meeting Times*

Online course: Mixed asynchronous and synchronous lectures, Synchronous lab sessions

Prof. Daniel Shapiro
Summer 2023

COURSE INFORMATION

This class examines the use of Artificial Intelligence (AI) in games. It covers AI technologies for search, control, and learning, while exploring a wide variety of roles that AI has played and can play in games. We will examine the use of AI in multiple commercial games, while discussing the broader application of AI for character control, level design, difficulty adjustment, play testing, player tutorials, drama management, interactive narrative, novel experiences, and more.

The course requires 6 one-week long programming assignments (done in teams of two), readings, a midterm, and a final project (done in teams of four). Through this work, students will gain familiarity with multiple AI metaphors, and learn how selected AI techniques can be applied to improve game design, game development and game play.

INSTRUCTOR INFORMATION

Prof. Shapiro, dgs@ucsc.edu

My research currently focuses on the use of machine learning to enable novel interactive experiences, like translating touch into lyric poetry. I worked for 30 years in general theories of cognition, which was the original dream of AI; brain in a box, human level capabilities for planning, problem solving, and acting in a machine. I came to UCSC's CM department because games are a natural customer for cognitive systems.

LEARNING OUTCOMES

By the end of this class students should be able to:

1. identify a core set of AI techniques relevant to game development tasks,
2. implement and/or apply those techniques to address game development tasks,
3. creatively employ AI techniques to accomplish a novel purpose in games, and
4. explain how AI has been employed in a variety of existing games.

In addition, students will develop skills for:

5. remote collaboration on design and programming tasks,
6. defining a prototype that efficiently illustrates a novel purpose in games, and
7. reviewing and constructively commenting on projects pursued by other students.

More broadly, students will develop an appreciation for the breadth of possible AI applications in games, which will provide them with a novel, and valuable perspective on work in game studies and in the game industry.

PREREQUISITES/COREQUISITES

Students need a basic facility with programming and data structures to complete this class. As a result, we list Computer Science 101 (or equivalent) as a prerequisite.

Experience using Python is a plus, but not required. No prior exposure to AI is required.

Students with a design emphasis are welcome, and there will be opportunities to employ design skills, especially in the final project.

REQUIRED MATERIALS, TEXTBOOKS AND TECHNOLOGY

This class has no textbook, but it makes extensive use of readings available on the web. The readings include blogs, videos of game play, conference talks, and primary research articles.

Students will need access to a computer capable of running a zoom session, ideally *with* a camera input to enhance interaction in the lab sessions.

COMMUNICATION

The course activities consist of lectures, a weekly 1-hour lab session attended by the instructor and TAs, office hours, a discussion forum, and homework assignments. All activities will be online.

Most lectures are asynchronous, some are synchronous. Students can absorb the asynchronous lectures at their own pace, but the content is necessary for completing the weekly assignments during the first half of the class. The introductory class, the midterm review session, the final project proposal review sessions, and guest lectures are all synchronous.

The lab sessions are synchronous. They focus on:

- Q&A regarding readings and lecture content,
- assistance with weekly programming assignments,
- collaboration and constructive review of work in progress, and
- group discussion of topics suggested by class materials, e.g., the role of AI in games, the role of AI adversaries in games, how to design effective prototypes, and brainstorming project ideas.

I will hold 4 office hours each week. I *strongly* encourage students to make use of office hours. It's one of the things I most enjoy as a professor, and I have noticed that students who inhabit office hours routinely do better in the class.

The TAs are responsible for alternate programming assignments and will hold 9 office hours during “on” weeks (for assignments they grade), and 2 office hours on “off” weeks (while the other TA is “on”).

Students can contact me, or the TAs by email outside of office hours. It generally takes us a day to respond.

The class employs Slack for course announcements and Q&A, and Discord as an unmonitored discussion forum.

ASSIGNMENTS & ASSESSMENT

Game AI is a project-oriented course. The class structure backchains from this goal. I introduce a variety of AI techniques in the first 6 weeks of the class (via lectures, readings, and programming assignments) so that students can draw on that base to select and pursue a creative project in the last 4 weeks. The class requires:

- 6 one-week long programming assignments done in teams of two (30% of grade),
- 12 readings with Q&A (10% of grade)
- a midterm (30% of grade),
- a final project done in teams of four (30% of grade)

Several programming assignments and readings offer opportunities for extra credit.

The asynchronous lectures present a great deal of information about AI metaphors, algorithms, and their use in games. Students will need to study this material in order to complete the weekly programming assignments.

The weekly programming assignments and final project are major course activities. The programming assignments are thought provoking, and require students to internalize, understand and implement/apply AI metaphors (addressing learning outcomes 1 and 2). The final project addresses the objective to creatively employ AI in games (learning outcome 6). The weekly two-person assignments and the team project both develop collaboration skills (outcome 5).

The asynchronous lectures, synchronous lab sessions, and readings support this work. The lecture content and readings address the goals to communicate AI techniques and their use in existing games (outcomes 1 and 4). Lab discussions and breakout sessions help students understand, implement and creatively apply AI techniques in games (outcomes 2 and 3), hone their design/implementation prototype (outcome 6), and exercise constructive review and collaboration skills (outcome 7). The class emphasizes on teamwork, applications of AI, and remote interaction all mirror common game industry settings, and develop student skills requisite for job environments (learning outcome 5).

The programming assignments include a series of success tests and are graded against those standards. Program clarity (comments and style) play a role only when partial credit is required. The readings employ multiple choice and short answer questions.

Final project evaluation is based on a proposal, a short final writeup, and a c. 10-minute group presentation given during the finals slot allocated to the class. We provide a final project presentation template and urge students (strongly) to rehearse their talks. Chief evaluation criteria are the clarity of that presentation, the technical difficulty, and the technical achievement of the work. Peer assessments of those features contribute to a project's score, as does its selection as a class top-3 favorite (and separately, a staff top-3 favorite). Student reviews of other projects contribute to the reviewer's final project grade.

Students will be able to look up their grade (in progress) on Canvas at any time. Students are welcome to discuss their grade and their work with the course staff at any time.

GRADING POLICY

The late policy for this class is designed to keep students (and their programming partners) from falling further behind as each weekly assignment is due and the next is released.

- Unexcused late work (any category of work) receives a 20% deduction.

I will grant 1-day extensions *only* with prior discussion. Two-day extensions are exceedingly rare.

If you encounter health issues, emergencies, or similar difficulties, come talk to me. The late policy is there to prevent avoidable problems, not to create new ones.

We intend to provide one-week turnaround on programming assignments and two-week turnaround on the midterm so students will have up-to-date feedback on their work. We provide feedback on final project proposals within one week.

STUDENT HOURS FOR COURSE

Students should be aware that Game AI is a hard course. The pace during the first 6 weeks is fast. The lectures communicate a great deal of material (augmented by the readings), while the programming assignments have taken c. 15 hours of work per student per week in the past. The lab sessions serve as a forum for discussing the current assignment and reducing that total. The pace decreases in the second half of the term; the programming assignments end, the readings mostly end, and the lectures address topics of interest. A few synchronous lectures will feature guest speakers. There is no final, so viewing lectures past the midterm is functionally optional. The goal is to give students time to collaborate on final projects.

INSTRUCTOR FEEDBACK

Students are always encouraged to come to office hours (mine or the TAs) to discuss course concepts and obtain feedback on their work.

The readings primarily evaluate automatically, while the TAs and graders will evaluate programming assignments. Programs that do not pass the automatic acceptance checks will be individually examined by the TAs, commented on, and receive partial credit.

Final project ideas, proposals, and work in progress will receive detailed commentary from the professor in class, lab sessions, and in office hours. In some cases, I will ask teams to attend office hours to clarify their planned work.

The rubric for grading the final project (the breakdown of points by subtask and the criteria for assigning points) will be available to students at the time the final project is assigned.

STUDENT FEEDBACK

At the end of the quarter, you will be asked to complete a Student Experience of Teaching survey for this course. SETs provide an opportunity for you to give valuable feedback on your learning that is honest and constructive. This anonymous feedback will help me consider modifications to the course that will help future students learn more effectively. For example, I introduced the lab session in response to feedback requesting more discussion of the weekly assignments and readings.

COURSE SCHEDULE

Week	Lectures	Discussion section	Readings	Programming Assignments	Games discussed	Deliverables
1	Course Administration and Themes Forward Search Path Planning Meets World Models	Python Intro P1 Readings Games to unpack	R1: Can you read me? R2: Amit Patel's Introduction to A*	P1: Navmesh Pathfinding	Pong, Rome II, Façade	Readings Q&A
2	Photoshop of AI Monte Carlo Tree Search Constraint Solving	P2 Readings One AI to rule them all?	R3: The Photoshop of AI Debate R4: MCTS in AlphaGo R5: Dungeon Feng Shui	P2: Infinite TicTacToe	AlphaGo, Mario Sudoku, Alcazar, Infinite Refraction	Readings Q&A P1
3	Agent Control via Finite State Machines Reactive Control with Behavior Trees Rule Based Control	P3 Readings	R6: Domain Specific Languages R7: (extra credit) Harel on HFMSs R8: How Behavior Trees Work R9: PromWeek Unpacked	P3: Planet Wars	PacMan HALO 2 Prom Week	Readings Q&A P2
4	ABL (A Behavior Language) Goal Oriented Action Planning in F.E.A.R. Advanced Planning	P4 Readings Infinite TicTacToe competition results	R10: Structuring Content in Façade R11: GOAP	P4: Minecraft Planning	Façade F.E.A.R. KillZone 2	Readings Q&A P3
5	Utility models Procedural Content Generation Deep Learning	P5 Planet wars competition results		P5: PCG Level Generation	Drivatars	P4
6	Review Deep Learning II Acquiring Strategies from Players	P6	MIDTERM (Take home, 5 days)	P6: Deep Learning	Black & White	P5
7	Invited speaker: Craig Reynolds "Steering behaviors and camouflage" Creative Projects Introduction Unpack game (class choice)	P7 Brainstorming project ideas		P7: Creative project		Midterm P6
8	Creative Project Proposals I Creative Project Proposals II No Man's Sky unpacked	Building successful prototypes				Creative Project Proposals
9	Versu & Left4Dead unpacked Personality simulation in the Sims unpackd Social Interaction with Virtual Agents	Creative project progress	R12: Turing Tantrums R13: Player's Want Smart AI		Versu, Left4Dead Sims 1 - 3 Immerse	Readings Q&A
10	Invited Speaker: Rez Graham "10 Things All AI Devs Need to Know" Crowd Sourced Program Verification Deep Synesthesia	Do <i>you</i> want smart AI? Brainstorming the future for AI in games			Xylem, Binary Fission	
Creative Project Presentations in Finals Slot						Creative Project Writeup

FINAL EXAM DATE AND TIME

CM 146 does not have a final exam. We use the final exam period for presentations of final team projects.

ACCESSIBILITY

UC Santa Cruz is committed to creating an academic environment that supports its diverse student body. If you are a student with a disability who requires accommodations to achieve equal access in this course, please affiliate with the DRC. I encourage all students to benefit from learning more about DRC services to contact DRC by phone at 831-459-2089 or by email at drc@ucsc.edu. For students already affiliated, make sure that you have requested Academic Access Letters, where you intend to use accommodations. You can also request to meet privately with me during my office hours or by appointment, as soon as possible. I am happy to discuss how we can implement your accommodations in this course to ensure your access and full engagement.

TITLE IX/CARE ADVISORY

UC Santa Cruz is committed to providing a safe learning environment that is free of all forms of gender discrimination and sexual harassment, which are explicitly prohibited under Title IX. If you have experienced any form of sexual harassment, sexual assault, domestic violence, dating violence, or stalking, know that you are not alone. The Title IX Office, the Campus Advocacy, Resources & Education (CARE) office, and Counseling & Psychological Services (CAPS) are all resources that you can rely on for support.

Please be aware that if you tell me about a situation involving Title IX misconduct, I am required to share this information with the Title IX Coordinator. This reporting responsibility also applies to course TAs and tutors (as well to all UCSC employees who are not designated as “confidential” employees, which is a special designation granted to counselors and CARE advocates). Although I have to make that notification, you will control how your case will be handled, including whether or not you wish to pursue a formal complaint. The goal is to make sure that you are aware of the range of options available to you and that you have access to the resources you need.

Confidential resources are available through [CARE](#). Confidentiality means CARE advocates will not share any information with Title IX, the police, parents, or anyone else without explicit permission. CARE advocates are trained to support you in understanding your rights and options, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and more. You can contact CARE at (831) 502-2273 or care@ucsc.edu.

In addition to CARE, these resources are available to you:

- If you need help figuring out what resources you or someone else might need, visit the [Sexual Violence Prevention & Response \(SAFE\) website](#), which provides information and resources for different situations.
- [Counseling & Psychological Services \(CAPS\)](#) can provide confidential counseling support. Call them at (831) 459-2628.

- You can report gender discrimination and sexual harassment and violence directly to the University's [Title IX Office](#) by calling (831) 459-2462 or by using their [online reporting tool](#).
- Reports to law enforcement can be made to the UC Police Department, (831) 459-2231 ext. 1.
- For emergencies, call 911.

ACADEMIC INTEGRITY

All members of the UCSC community benefit from an environment of trust, honesty, fairness, respect, and responsibility. You are expected to present your own work and acknowledge the work of others in order to preserve the integrity of scholarship.

Academic integrity includes:

- Following exam rules
- Viewing exam materials only when permitted by your instructor
- Keeping what you know about an exam to yourself
- Incorporating proper citation of all sources of information
- Submitting your own original work

The Game AI class emphasizes work in teams. Academic integrity in this context also includes:

- Accurately acknowledging own and partner contributions
- Contributing equitably to group projects
- Not sharing solutions for weekly programming assignments across groups (though discussing approaches at the level of pseudocode is allowed)

Academic misconduct includes, but is not limited to, the following:

- Disclosing exam content during or after you have taken an exam
- Accessing exam materials without permission
- Copying/purchasing any material from another student, or from another source, that is submitted for grading as your own
- Plagiarism, including use of Internet material without proper citation
- Submitting your own work in one class that was completed for another class (self-plagiarism) without prior permission from the instructor.
- Violations of the Academic Integrity policy can result in dismissal from the university and a permanent notation on a student's transcript. For the full policy and disciplinary procedures on academic dishonesty, students and instructors should refer to the [Academic Misconduct page](#) at the [Division of Undergraduate Education](#).

INTELLECTUAL PROPERTY

The materials in this course are the intellectual property of their creators. As a student, you have access to many of the materials in the course for the purpose of learning, engaging with your peers in the course, completing assignments, and so on. You have a moral and legal obligation to respect the rights of others by only using course materials for purposes associated with the course. For instance, you are not permitted to share, upload, stream, sell, republish, share the login information for, or otherwise disseminate any of the course

materials, such as: video and audio files, assignment prompts, slides, notes, syllabus, simulations, datasets, discussion threads. Conversely, any materials created solely by you (for example, your videos, essays, images, audio files, annotations, notes) are your intellectual property and you may use them as you wish.

RELIGIOUS ACCOMMODATION

UC Santa Cruz welcomes diversity of religious beliefs and practices, recognizing the contributions differing experiences and viewpoints can bring to the community. There may be times when an academic requirement conflicts with religious observances and practices. If that happens, students may request reasonable accommodation for religious practices. The instructor will review the situation in an effort to provide a reasonable accommodation without penalty. You should first discuss the conflict and your requested accommodation with your instructor early in the term. You or your instructor may also seek assistance from the [Dean of Students office](#).

ALL-GENDER RESTROOMS

UC Santa Cruz is committed to the well-being of all students and cares about all students feeling safe and welcome, regardless of their gender identity, expression, and/or embodiment. The [Lionel Cantú Queer Center](#) has worked with students and campus staff to create more safe and accessible restrooms for transgender and genderqueer students, staff, faculty, alumni, and UCSC visitors. A [complete list of all-gender restrooms](#) on campus was compiled and is maintained by the Cantú Queer Center.

PRINCIPLES OF COMMUNITY

The University of California, Santa Cruz expressly prohibits students from engaging in conduct constituting unlawful discrimination, harassment or bias. I am committed to providing an atmosphere for learning that respects diversity and supports inclusivity. We need to work together to build this community of learning. I ask all members of this class to:

- be open to and interested in the views of others
- consider the possibility that your views may change over the course of the term
- honor the unique life experiences of your colleagues
- appreciate the opportunity that we have to learn from each other
- listen to each other's opinions and communicate in a respectful manner
- keep confidential discussions that the community has of a personal (or professional) nature
- ground your comments in the texts we are studying. Refer frequently to the texts and make them the focus of your questions, comments, and arguments. This is the single most effective way to ensure respectful discussion and to create a space where we are all learning together.

Because the Game AI class emphasizes group work, it is important to establish principles for those collaborations. I ask all members of this class to:

- Respond promptly to your teammates, and stay in contact with them
- Proactively discuss any issues that may prevent or delay your full cooperation
- Collaborate constructively to complete assignments
- Do your share of the work
- Communicate respectfully with your teammates
- Listen and learn from one another while performing the work

- Assume that your teammates have good intentions when attempting to resolve any collaboration difficulties

DIFFICULT CONVERSATIONS

In our online discussions and interactions for the Game AI class, we will have the opportunity to examine and comment on work in progress. This includes partially formed ideas, design sketches, and partially implemented systems. It is important for all of us to approach those conversations in a positive and constructive manner. Be aware that people care about their work and may take harsh criticism poorly. Developing constructive review skills is a learning objective of the class.

The Game AI class emphasizes work in teams, which offers many opportunities to learn from each other and utilize each other's skills. Teamwork also involves personalities, and students may encounter difficult conversations while conducting collaborative assignments. If this occurs, it is important to maintain respect for each other's ideas, experiences, and perspective. The effort will ultimately deepen our understanding of others and allow us to make the most of working within a diverse community. Developing effective collaboration skills is a learning objective of the class.

REPORT AN INCIDENT OF HATE OR BIAS

The University of California, Santa Cruz is committed to maintaining an objective, civil, diverse and supportive community, free of coercion, bias, hate, intimidation, dehumanization or exploitation. The Hate/Bias Response Team is a group of administrators who support and guide students seeking assistance in determining how to handle a bias incident involving another student, a staff member, or a faculty member. To report an incident of hate or bias, please use the following form: [Hate/Bias Report Form](#).

STUDENT SERVICES

Counseling and Psychological Services

Many students at UC Santa Cruz face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

Student Success and Engagement Hub

The Division of Student Success provides campus-wide coordination and leadership for student success programs and activities across departments, divisions, the colleges, and administrative units.

Tutoring and Learning Support

At Learning Support Services (LSS), undergraduate students build a strong foundation for success and cultivate a sense of belonging in our Community of Learners. LSS partners with faculty and staff to advance educational equity by designing inclusive learning environments in Modified Supplemental Instruction, Small Group Tutoring, and Writing Support. When

students fully engage in our programs, they gain transformative experiences that empower them at the university and beyond.

Slug Support Program

College can be a challenging time for students and during times of stress it is not always easy to find the help you need. Slug Support can give help with everything from basic needs (housing, food, or financial insecurity) to getting the technology you need during remote instruction.

To get started with SLUG Support, please contact the [Dean of Students](#) Office at 831-459-4446 or you may send us an email at deanofstudents@ucsc.edu.

Slug Help/Technology

The ITS Support Center is your single point of contact for all issues, problems or questions related to technology services and computing at UC Santa Cruz. To get technological help, simply email help@ucsc.edu.

On-Campus Emergency Contacts

For all other help and support, including the health center and emergency services, Click here to go to UCSC's [Emergency Services](#) page. Always dial 9-1-1 in the case of an emergency.