Course Information

Course Number:	AERO 437/637
Course Title:	Foundations of Aerospace Autonomy
Section:	437 (500), 637 (600, 700)
Time:	TR 12:45pm-2:00pm (synchronous for distance education students)
Location:	ZACH 261 (TBC) for on campus students; Zoom for distance education students
Credit Hours:	3

Instructor Details

Instructor:	Daniel Selva Valero
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Office Hours:	On campus students: F 8-9:30 (TBC) or by email appointment in office or Zoom Distance education: F 3-4:30 (TBC) or by email appointment on Zoom

Course Description

This course introduces students to the mathematical and computational foundations of aerospace systems autonomy. The necessary basic concepts to undertake the study of aerospace autonomous and intelligent systems (data structures, algorithms, probability theory, and optimization) are covered. Classical artificial intelligence topics are covered including search, constraint satisfaction, and logical and probabilistic reasoning. Example applications are autonomous planetary rovers, smart space habitats, and UAV swarms.

Course Prerequisites

For undergraduate students in AERO 437-500: grade C or better in AERO 401, or concurrent registration; for graduate students in AERO 637-600/700: graduate classification.

Special Course Designation

Stacked course. Synchronous Distance Education (700) section available to MENG students.

Course Learning Outcomes

At the end of the course, students will be able to:

1. Formulate a sequence of autonomous decisions by an aerospace system as a state space graph search problem; evaluate the size of the state space; use search and constraint satisfaction algorithms to solve the problem; compare the complexity of different algorithms.

2. Formulate an autonomous decision by an aerospace system as an optimization problem; assess the type of problem; identify and implement an appropriate algorithm to solve it.
3. Create a model of the deterministic behavior of an autonomous aerospace system and its environment using propositional logic; use appropriate deterministic inference algorithms to infer new knowledge using logical reasoning.
4. Create a model of the stochastic behavior of an autonomous aerospace system and its environment using Bayesian networks; use appropriate probabilistic inference algorithms to reason under uncertainty.

In addition, graduate students at the end of this course will be able to:

5. Conduct original or bibliographical research in a topic within aerospace autonomy.

Textbook and/or Resource Materials

The following are recommended but not required textbooks. They are all available in the library.

- S. J. Russell and P. Norvig*, Artificial Intelligence: A Modern Approach,* Pearson, 2021 (4th edition). 2nd and 3rd editions are also OK.

- S. Miller and D. Childers, *Probability and Random Processes*, Elsevier, 2012. (2nd ed.) Also available as ebook through TAMU library.

- F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, 2015 (4th ed.) Previous editions are also OK.

Grading Policy

The deliverables for this course are as follows:

- **Homework assignments (50%)**: 5 homework assignments on the topics listed above. Graduate students answer additional questions compared to undergraduate and distance education students. These questions may require deeper understanding of the material or they may cover advanced topics (e.g. questions on complexity, optimality, and completeness of search and inference algorithms)
- **Programming assignments (30% grade)**: 2 programming-heavy assignments, focusing on search and constraint satisfaction and logical reasoning respectively.
- **Undergraduate students: Take-Home Exam (20% grade)**: A take-home exam with problems similar to those of the math assignments, focusing on the material related to probabilistic reasoning, but also including questions on searching and logical reasoning.
- **Graduate and distance education students: Research Paper (20% grade)**: Graduate and distance education students complete a research paper describing the the application of search, logical and probabilistic reasoning techniques to an aerospace system.

All assignments will be administered through Canvas. Students must upload each assignment in pdf format to the canvas site by the assignment's deadline. No paper copies will be accepted.

Approximate Letter Grading Scale
A = 90-100
B = 80-89
C = 70-79
D = 60-69
F = <60

Late Work Policy

Late submission of assigned homework and take-home will incur a penalty according to the following schedule:

- Less than 24 hours late: -10%
- 24 to 48 (exclusive) hours late: -20%
- 48-72 hours late: -30%.
- No late submissions will be accepted after 72 hours past due.

The policy above applies to undergraduate, graduate, and distance education students.
Work submitted by a student as makeup work for an excused absence is not considered late work and is exempted from the late work policy (Student Rule 7).

Course Schedule

Distance education students can choose to follow the course synchronously or asynchronously. All lectures will be streamed live through Zoom for distance education students and also recorded and posted on Canvas.

Week	Lecture Topics	Reading	Deliverables
1	Introduction, Intelligent agents	Rus 1-2	
2	Data structures, algorithms		
3	Search algorithms	Rus 3-4	
4	From Search to Constraint Satisfaction	Rus 6	HW 1 on Weeks 1-3
5	Intro to optimization, Linear Programming	Hil 3-4	PA 1 on Search and CSP
6	Linear programming, Integer Programming	Hil 4-6	
7	Integer Programming, Convex optimization	Hil 12	HW 2 on Weeks 5-6
8	Convex optimization, Meta-heuristics	Hil 13	
9	Propositional logic		HW 3 on Weeks 7-8
10	Logical reasoning, logical agents	Rus 7	HW 4 on Week 9
11	Intro to probability, random variables	Mil 2-3	
12	Multiple random variables	Mil 4-5	PA 2 on Logical reasoning
13	Sums and sequences, Probabilistic Reasoning	Mil 6-7	HW 5 on Weeks 11-12
14	Bayesian networks	Rus 13	Take-home exam/research papers due
15	Advanced topics: Planning and learning	Rus 16	

Abbreviations in reading refer to textbooks as follows: Rus: Russell and Norvig, Mil: Miller and Childers; Hil: Hilliers

University Policies

Attendance Policy

The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to Student Rule 7 in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to Student Rule 7 in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" (Student Rule 7, Section 7.4.2).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See Student Rule 24.)

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" (Section 20.1.2.3, Student Rule 20).

You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at aggiehonor.tamu.edu.

Notice of Nondiscrimination

Texas A&M University is committed to providing safe and non-discriminatory learning, living, and work environments for all members of the University community. The University provides equal opportunity to all employees, students, applicants for employment or admission, and the public regardless of race, color, sex (including pregnancy and related conditions), religion, national origin, age, disability, genetic information, or veteran status. Texas A&M University will promptly, thoroughly, and fairly investigate and resolve all complaints of discrimination, harassment (including sexual harassment), complicity and related retaliation based on a protected class in accordance with System Regulation 08.01.01, University Rule 08.01.01.M1, Standard Administrative Procedure (SAP) 08.01.01.M1.01, and applicable federal and state laws. In accordance with Title IX and its implementing regulations, Texas A&M does not discriminate on the basis of sex in any educational program or activity, including admissions and employment. The following person has been designated to handle inquiries and complaints regarding the non-discrimination policies: Jennifer M. Smith, TAMU Associate VP & Title IX Coordinator at YMCA Ste 108, College Station, TX 77843, 979-458-8407, or email civilrights@tamu.edu. For other reporting options, visit https://ocrcas.ed.gov/contact-ocr to locate the address and phone number of the office that serves your area, or call 1-800-421-3481.

Civil Rights, Free Speech, and Title IX Policies

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit discrimination and harassment based on an individual's race, color, sex, (including pregnancy and related conditions), religion, national origin, age, disability, genetic information, veteran status, or any other legally protected characteristic. This includes forms of sex-based violence, such as sexual assault, sexual harassment, sexual exploitation, dating/domestic violence, and stalking.

Students can report discrimination/harassment, access supportive resources, or learn more about their options for resolving complaints on the University's Civil Rights & Title IX webpage.

Students should be aware that all university employees (except medical or mental health providers) are mandatory reporters, which means that if they observe, experience or become aware of an incident that they reasonably believe to be discrimination/harassment alleged to have been committed by or against a person who was a student or employee at the time of the incident, the employee must report the incident to the university.

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact Disability Resources in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu. Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.

Pregnancy Accommodations

Texas A&M provides reasonable accommodations to students due to pregnancy and/or related conditions, such as childbirth, recovery and lactation. Students should contact the University's Pregnancy Coordinator as soon as they become aware of the need for accommodation. Depending on the circumstances, accommodations could include extended time to complete assignments or exams, changes in course sequence, or modifications to the physical classroom environment. Texas A&M will also allow a voluntary leave of absence, ensure the availability of lactation space, and maintain grievance procedures to provide for the prompt and equitable resolution of complaints of sex discrimination. For information regarding pregnancy accommodations, email TIX.Pregnancy@tamu.edu.

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors influencing a student's academic success and overall wellbeing. Students are encouraged to engage in healthy self-care practices by utilizing the resources and services available through University Health Services on its mental health webpage. The TELUS Health Student Support app provides access to professional counseling in multiple languages anytime, anywhere by phone or chat, and the 988 Suicide & Crisis Lifeline offers 24-hour emergency support at 988 or 988lifeline.org.

Students needing a listening ear can contact University Health Services (979.458.4584) 24-hour emergency help is also available through the 988 Suicide & Crisis Lifeline (988) or at 988lifeline.org.

Statement on the Family Educational Rights and Privacy Act (FERPA)

FERPA is a federal law designed to protect the privacy of educational records by limiting access to these records, to establish the right of students to inspect and review their educational records and to provide guidelines for the correction of inaccurate and misleading data through informal and formal hearings. Currently enrolled students wishing to withhold any or all directory information items can do so within howdy.tamu.edu using the Directory Information Withholding Form. The complete FERPA Notice to Students and the student records policy is available on the Office of the Registrar webpage.
Items that can never be identified as public information are a student's social security number, citizenship, gender, grades, GPR or class schedule. All efforts will be made in this class to protect your privacy and to ensure confidential treatment of information associated with or generated by your participation in the class.

Directory items include name, UIN, local address, permanent address, email address, local telephone number, permanent telephone number, dates of attendance, program of study (college, major, campus), classification, previous institutions attended, degrees honors and awards received, participation in officially recognized activities and sports, medical residence location and medical residence specialization.

Optional Syllabus Statements

Artificial Intelligence Statement

According to the Texas A&M University Definitions of Academic Misconduct, plagiarism is the appropriation of another person's ideas, processes, results or words without giving appropriate credit

(aggiehonor.tamu.edu). You should credit your use of anyone else's words, graphic images, or ideas using standard citation styles. Artificial Intelligence (AI) text generators and natural language processing tools (colloquially, chatbots - such as ChatGPT), audio, computer code, video, and image generators should not be used for any work for this class without explicit permission of the instructor and appropriate attribution. This includes, but is not limited to,

i. Creating or revising drafts
ii. Editing your work
iii. Reviewing a peer's work

This excludes pre-existing software additions such as spelling and grammar checkers, which are acceptable.

Note: Some programming assignments will include questions designed to use AI agents for specific things, including programming of tedious aspects of the code supporting but not directly linked to the learning outcomes of this course. These questions will be clearly marked in the assignment. Students will still need to explain how the AI was used and for what.

College and Department Policies

None.