AE 8803: Optimization-Based Learning Control and Games
Course Syllabus

Instructor:	Dr. Kyriakos G. Vamvoudakis
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Time & Location:	
Office Hours:	
Course Web Page:	-

Suggested Texts:	F. L. Lewis, D. Vrabie, and V. L. Syrmos. *Optimal Control*, John Wiley & Sons, 2012 (ISBN: 978-0-470-63349-6) Preliminary version is provided by author in
	http://www.uta.edu/utari/acs/FL%20books/Lewis%20optimal%20control%203rd%20edition%202012.pdf
	D. Liberzon, *Calculus of variations and optimal control theory: a concise introduction*, Princeton University Press, 2012 (ISBN: 978-0-691-15187-8) **(good reference on calculus of variations).** Preliminary version is provided by author in: http://liberzon.csl.illinois.edu/teaching/cvoc.pdf
Additional Texts:	D. Vrabie, K. G. Vamvoudakis, F. L. Lewis, *Optimal Adaptive Control and Differential Games by Reinforcement Learning Principles*, Control Engineering Series, IET Press, 2012 (ISBN: 978-1-84919-489-1) **(good reference on RL and optimal control)**
	T. Basar, G. J. Olsder, *Dynamic noncooperative game theory*, Vol. 23. Siam, 1999 (ISBN: 978-0-89871-429-6) **(good reference on game theory)**

Required Software:	Student Edition of Matlab

Course Description: This course will cover analysis and design techniques in optimal control systems and differential games.

Course Topics:	I. Static and Dynamic Optimization
	A. Unconstrained Optimization and Efficient Algorithms, e.g. steepest or gradient descent methods
	B. Constrained Optimization with Lagrange Multipliers (First-Order Necessary Conditions) and Second-Order Conditions
	II. Calculus of Variations
	A. Motivation Examples
	B. Hamiltonian Formalism and Mechanics
	C. First and Second-Order Conditions

D. Specification of Performance Indices

III. Optimal Control of Discrete-Time Systems
    A. Solution Concept
    B. Linear Quadratic Regulator (LQR) and Matrix Equations
    C. Steady-State Closed-Loop Control
    D. Advanced Topics

IV. Optimal Control of Continuous-Time Systems
    A. Solution Concept
    B. LQR and Matrix Equations
    C. Steady-State Closed-Loop Control
    D. Advanced Topics

V. Extensions of LQR
    A. Cross Terms in the Cost Functional
    B. Servo and Tracking Problems

VI. Final- Time-Free and Constrained Input Control
    A. Constrained Minimum-Time Problem (Bang-Bang Control)
    B. Constrained Minimum-Fuel Problem (Bang-Off-Bang Control)
    C. Constrained Minimum-Energy Problem

VII. Dynamic Programming
    A. Bellman's Principle of Optimality
    B. Continuous versus Discrete-Time
    C. Hamilton-Jacobi-Bellman (HJB) Equation
    D. Brief Remarks on Viscosity Solutions

VIII. Differential Games
    A. Pontryagin's Principle and Bellman's Equation
    B. Zero-Sum Games and Hamilton-Jacobi-Isaacs Equation (HJI)
    C. Non-Zero-Sum Games and Nash Equilibrium

IX. Advanced Topics
    A. Reinforcement Learning
    B. Duality of Optimal Control and Optimal Estimation
    C. Motion Planning with Randomized Trees and Optimal Control
    D. Output Feedback
    E. Limited Bandwidth Optimal Control

Tentative Grading Policy: Homework 30%
                                Midterm 35% (Mid-class)
                                Final Project 35% (Please come talk to me to pick a project that is related to your field of interest.)

Homework Assignments:
- Due at the beginning of the class on the due date. Solutions to the homework will be posted on the web at the time that they are due. Therefore, NO LATE HOMEWORK will be accepted.
- Electronic submissions will be accepted before the class starts.

- Late homework will not be accepted without formal documentation of extenuating circumstances (e.g. a note from a Dean, a physician, etc.).

Course Policies: 1. NO CELL PHONES are allowed during lecture. 2. Be on time to class. Tardy is discouraged. 3. No make-up exams/quizzes. If you miss the exam, a zero score will be assigned to the missed exam/quiz. 4. If you miss a class due to personal emergency or medical reasons, please be sure to inform the instructor by e-mail. 5. Homework assignments are to be submitted by the due date. You may discuss homework problems with your classmates, but you are responsible for your own works. 6. After an assignment grade has been posted online, students must see the instructor within one week if they wish to discuss the assignment and their work.

Principles of Community: Students are expected to be polite and professional when interacting with one another and with the instructor. Abusive or insensitive behavior will not be tolerated.

Academic Support: The instructor will provide assistance through normal protocols, such as office hours, but cannot serve as a private tutor.

Special Accommodations: Special accommodations can be made for students with disabilities. Please bring any such issues to the instructor's attention *no later than the second week of class*.

Health and Well-Being: Georgia Tech and the School of Aerospace Engineering understand that many students experience stress through a variety of academic, financial and personal experiences. We value you and want to make you aware of resources available to you should you need them. Your well-being and mental health are important, and we are here for you.

Center for Assessment, Referral and Education (CARE)   https://care.gatech.edu/
Campus Police (any emergency):   404-894-2500   http://www.police.gatech.edu/
Counseling Center: 404-894-2575   https://counseling.gatech.edu/
Dean of Students Office: 404- 894-6367   https://studentlife.gatech.edu/
Georgia Crisis and Access Line: 800-715-4225
National Suicide Prevention Lifeline: 800-273-TALK (8255) https://suicidepreventionlifeline.org/
Crisis Text Line: Text HOME to 741741
VOICE: Victims Survivor Support: (404)   385-4464   (or   4451)
http://healthinitiatives.gatech.edu/well-being/voice
Stamps Health Services https://health.gatech.edu/contact