AE 6511 - OPTIMAL GUIDANCE AND CONTROL
Fall 2021

Instructor Panagiotis Tsiotras
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Time
TTh 3:30–4:45pm; Clough 423

Office Hours
By appointment only. Please send me an email to arrange a one-to-one meeting via BlueJeans or Zoom.

Description
This course is indented as an introduction to the elements of Optimal Control theory and Calculus of Variations. Although the main emphasis will be on applications from aerospace engineering, several examples will be provided on the use of optimal control to other disciplines such as, economics, mechanical systems, human behavior, etc.

Prerequisites
Some familiarity with ordinary differential equations and elementary linear algebra is helpful, but not required.

Tentative Outline

(1) Finite-dimensional optimization problems; minima and maxima of functions
(2) Variational cones; Gâteaux and Fréchet derivatives
(3) Necessary and sufficient conditions
(4) Existence and uniqueness conditions; Weirstrass theorem
(5) Minima and maxima subject to constraints
(6) Lagrange multipliers; Kuhn-Tucker conditions
(7) Infinite-dimensional optimization problems; minima and maxima of functionals
(8) Elements of calculus of variations
(9) Lagrange-Euler necessary conditions
(10) Legendre and Jacobi conditions; conjugate points; Erdmann corner conditions
(11) Optimal control problems with control constraints
(12) Pontryagin Maximum Principle

(13) Legendre-Clebsch condition; bang-bang control

(14) Optimal control problems with state and control constraints

(15) Singular optimal control

(16) Optimal feedback control

(17) Dynamic programming and Hamilton-Jacobi theory

(18) The Linear quadratic control problem; the Riccati equation

(19) Neighboring optimal guidance

(20) Elements of differential games; pursuit-evasion games; $\mathcal{H}_\infty$ control

Textbook

There is no required textbook. A clear, detailed set of lecture notes should be enough. Selected chapters from the book *A Course in Classical Optimal Control* by D. Bernstein and P. Tsiotras (in preparation) will be provided and will be used extensively during the semester. As an additional resource you can use the book *Optimal Control Theory with Aerospace Applications* by J. Ben-Asher, AIAA Publishing, 2010 or *Applied Optimal Control*, by A. E. Bryson, Jr. and Y.-C. Ho, Hemisphere Publishing Corporation, New York, 1975.

References

There exist many excellent books on the subject. Below is a partial list. Please feel free to consult these and any other books you may want that will assist you in comprehending the class material. Additional handouts and selected articles from the literature will be disseminated via the class website. Good reference material is available online, and can be found using google or wikipedia

- D. Liberzon, *Calculus of Variations and Optimal Control Theory: A Concise Introduction*, Princeton University Press, 2012.
- D. Kirk, *Optimal Control Theory: An Introduction*, Prentice Hall, New Jersey, 1970.
- M. Athans and P. L. Falb, *Optimal Control: An Introduction to the Theory and Its Application*, McGraw-Hill, New York, 1965.
- E. B. Lee and L. Markus, *Foundations of Optimal Control Theory*, John Wiley, New York, 1967.
- G. Ewing, *Calculus of Variations with Applications*, Dover, New York, 1985.
- D. Luenberger, *Linear and Nonlinear Programming*, (2nd Ed.), Addison-Wesley, Reading, 1989.
- E. Pinch, *Optimal Control and the Calculus of Variations*, Oxford University Press, Oxford, 1993.

Website

All relevant information on the class will be disseminated electronically via Canvas.

Teaching Assistants

- Josh Pilipovsky (jpilipovsky3@gatech.edu)
- Scott Guan (scott.guan@gatech.edu)

Nominal TA (virtual) office hours are Tue-Thu: 11:00AM - 12:00PM. In addition, please contact the TAs directly for additional available office hours on a case-by-case basis.

Honesty

The School of Aerospace Engineering values honesty and integrity of all members of our community. An important aspect of this value system is the Academic Honor Code. Although you are encouraged to work together to learn the course material, the exams and homeworks are expected to be completed individually unless specified otherwise. All conduct in this course will be governed by the Georgia Tech Honor Code.

Grading Policy

The grades will be determined based on homework assignments, one mid-term, and a final exam/project. The tentative final grade distribution will be as follows:

$$\text{Final Grade} = \text{Homework} \times 20\% + \text{Mid-Term} \times 35\% + \text{Final Exam/Project} \times 45\%$$

Health-Related Considerations

Per the University System of Georgia Fall 2021 guidelines all students are strongly encouraged to receive a Covid-19 vaccine (https://health.gatech.edu/coronavirus/fall-2021-guidelines). Individuals (especially unvaccinated ones) are strongly encouraged to continue wearing a mask or face covering and continue social distancing whenever possible. The CDC issued new interim guidance recommending the use of masks inside public buildings even by fully vaccinated individuals as a precaution given the broad circulation of the highly contagious delta variant of the virus. At Georgia Tech, everyone is encouraged to wear a mask or face covering while inside campus facilities. Please see https://health.gatech.edu/coronavirus/institute-operations. Also, if you feel sick please stay at home. Unvaccinated students who are exposed to someone with Covid-19, will be subject to quarantine per current Georgia Department of Public Health guidelines. This may be disruptive for the whole class. Given the current uncertainty of the course of the pandemic, these guidelines may change in the course of the semester. If so, the attendance guidelines will be updated accordingly.

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
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

Campus Resources for Students

Office of Disability Services
https://disabilityservices.gatech.edu
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