

**THE UNIVERSITY OF TEXAS AT AUSTIN**  
**The Department of Aerospace Engineering & Engineering Mechanics**

**ASE 381P.7 – Advanced Topics in Estimation Theory**  
**Spring 2018**

**SYLLABUS**

**Unique Number**            12695

**Instructor**                Dr. Renato Zanetti  
Office: WRW 401D, 512-471-5145, [renato@utexas.edu](mailto:renato@utexas.edu)  
Office Hours: M and Th 2:30-3:30

**Class Time:**                MW 8:30-10:00

**Class Location:**            WRW 413

**Web Page:**        Course documents will be posted on the course **Canvas** website.

**Course Objectives:**

This course examines methods of stochastic estimation of nonlinear dynamical systems.

**Prerequisites:**

Statistical Estimation Theory (ASE 381P6)

Completed with at least a B grade

**Computer:**

Solutions to homework problems can be done using a variety of software languages (including MATLAB, Mathematica, Maple, Fortran, C, Java, etc.). Familiarity with MATLAB is desired but not required, although typically all students will use Matlab. In some cases it is required that the student turn in the source code.

**Text:**

Recommended:

Bar-Shalom and Li, *Estimation with Applications to Tracking and Navigation*

**Class Format:**

Traditional lectures and discussion will be held during each class period. Homework assignments will be given approximately every three weeks. There will be one midterm exam and a comprehensive final.

**Class Website:** This class will use Canvas—a Web-based course management system with password protected access at <http://canvas.utexas.edu/> —to distribute course materials, to communicate and collaborate online, to post grades, and for course announcements. You can find support in using Canvas at the ITS Help Desk at 475-9400, Monday through Friday, 8 a.m. to 6 p.m., so plan accordingly.

**Class Topics**

- 0. Random Processes and ECRV
- 1. MMSE and Orthogonality Principle
  - Recursive MMSE
  - FPK equation, mean evolution, covariance evolution
  - LMMSE
- 2. Transformations of Random Variables
  - Exact Solution
  - Taylor Series Approximation
  - Statistical Approximation
  - Polynomial Chaos
- 3. Linear Estimation of Nonlinear Systems
  - Linearization of LMMSE solution (EKF as an LMMSE estimator)
  - Statistical Linearization of MMSE solution – Bayes Filters (EKF vs. UKF vs. GSOE vs. Quadrature Filter vs. Cubature Filter)
  - Process Noise Tuning, Unmodeled Accelerations
  - Residual Edit
  - Ensemble KF (Time Permitting)
- 4. Nonlinear Estimation of Nonlinear Systems
  - State Transition Tensor and Polynomial Update
  - GMM
  - Discretization methods: grids and SIS
- 5. Information, Non-Linear Cramer-Rao Bound, and non-MMSE estimation
  - Entropy and KLD
  - Nonlinear LS (Time Permitting)
  - Hinfinity filter (Time Permitting)
- 6. Observability and Consider Estimation (Time Permitting)

**Grading:**

Homeworks	(~1 per 3 weeks)	10%
In-class midterm 1	(~W Mar 7)	25%
Final Project	(Due Last Day of Class)	35%
Comprehensive Final	(Friday, May 11, 9:00-12:00 noon)	30%

Grades are awarded by merit; not by a predetermined distribution, nor a particular grade range.

The target range for grades are:

A: 90-100

B: 80-90

C: 70-80

D: 60-70

F: 0-60

although the threshold for a particular grade may be shifted downwards (not upwards). Attendance, class participation, and improvement throughout the semester can be (will likely be) considered in borderline grade cases.

**Homework Policy:** Each homework assignment will be posted on Canvas and will be also due electronically on Canvas by the submission deadline. Under typical circumstances, late assignments will not be accepted. The main objectives of the assignments are to gain computer experience and practice problems that will prepare students for exams.

*Format:*

Homework should be concise, legible, professional, and demonstrate all important steps in the solution. Computer generated plots should be legible with axes and important information properly labeled. Always include units.

**Examinations:** The exams will assess the students' understanding of the material covered in class and the homework assignments. We will have 1 midterm exam and 1 comprehensive final exam.

**Attendance:** Regular class attendance is expected. Repeated unexcused absence from class is a justification for a downward adjustment of the student's grade. Medical and professional absences are accepted. In all cases the student should notify the instructor of any planned absences before that class if at all possible. By UT Austin policy you must notify me of your pending absence at least fourteen days prior to the date of observance of a religious holy day. If you must miss a class, an examination, a work assignment, or a project in order to observe a religious holy day, you will be given an opportunity to complete the missed work within a reasonable time after the absence.

**Important Dates:** Refer to <http://registrar.utexas.edu/calendars> for important dates regarding drops, payments, holidays, finals etc.

**Academic Integrity:** The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community.

Each student in this course is expected to abide by the University of Texas Honor Code. [See the UT Honor Code above.] Any work submitted by a student in this course for academic credit will be the student's own work. You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else (hard copy or electronic).

Should copying occur (including plagiarism/copying from internet source or any other source), both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Code

can also be extended to include failure of the course and University disciplinary action. During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

**Course Evaluation:** The Measurement and Evaluation Center forms for the College of Engineering will be used during the last week of class to evaluate the course and the instructor. I will not have access to these evaluations until about one month after the end of the semester.

### **Special Notes:**

**Students with Disabilities:** The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact me or the Office of the Dean of Students at 471-6259, 471-4641 TDD or the College of Engineering Director of Students with Disabilities at 471-4321.