Instructor: Professor Yariv Ephraim
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Office Hours: Monday: 5:00-6:00 pm; Thursday: 3:20-4:20 pm

Course Credit: 3 credit hours
Time: Thursday 4:30-7:10 pm
Place: Aquia Building, Room 219
Final Exam: Final exam on 12/17, 4:30-7:15pm.
Mid-term exam: 10/29.
Exams Policy: Exams are open books and notes. Electronic devices of any kind are not allowed.
Grading: 1st test 40%; 2nd test 50%; homework 10%.
Prerequisites: ECE 528 or equivalent.

Text Book:

Other References:
- Current Literature.

Course Description:
This course covers the fundamentals of linear estimation, and provides an introduction to parameter estimation. We develop the Wiener and Kalman filters, as well as more modern subspace-based estimation approaches, for stationary and non-stationary signals. The main themes is estimation from the innovation
process (Gram-Schmidt) using the orthogonality principle. In parameter esti-
mination we introduce the maximum-likelihood approach and its implementation
through the expectation-maximization algorithm. We demonstrate the work-
ings of the EM algorithm in positron emission tomography (PET). This course
is recommended for students interested in communication theory, control theory,
and signal processing.

Prerequisites: ECE-528 or instructor permission.

Course Outline:

• Introduction (week 1)
  1. The scope of estimation theory
  2. Linear and Nonlinear estimation
  3. Course overview

• Deterministic least squares problems (Chap. 2, weeks 1-2)
  1. The deterministic least-squares criterion
  2. Orthogonality condition and geometric interpretation
  3. Regularized least-squares problems
  4. The QR method
  5. Updating and Downdating least-squares solutions

• Stochastic least squares problems (Chap. 3, weeks 3-4)
  1. Normal Equations
  2. Orthogonality condition
  3. Linear models

• The innovations process (Chap. 4, week 5)
  1. Estimation of stochastic processes
  2. The innovations process
  3. The exponentially correlated process

• Innovations for stationary processes (Chap. 6, week 6)
  1. Innovations via spectral factorization
  2. Canonical spectral factorization
  3. Scalar rational z-spectrum

• Wiener theory for scalar processes (Chap. 7, week 7)
  1. The discrete-time Wiener smoother
2. The Wiener-Hopf filtering equation and its solution
3. Important special cases and examples (prediction, white noise)

• The Kalman filter (Chap. 9, weeks 8,10)
  1. The standard state-space model
  2. The Kalman filter recursions for the Innovations
  3. Recursions for predicted and filtered state estimators
  4. Approximate non-linear filtering (the extended Kalman filter)

• The multi-stage Wiener filter (current literature, week 11)

• Maximum Likelihood Parameter Estimation (current literature, week 12)

• The EM algorithm and Positron Emission Tomography (current literature, week 13-14)

Attendance and homework:

1. Students are encouraged to attend all lectures and to submit all homework assignments.

2. Practicing the material taught in class, by working out the homework problems, is crucially important to your success in this class. Homework will be assigned weekly, and will be due in class the week following their assignment. Graded homework will be returned in class the week following their due date.

3. Students are encouraged to type their homework submissions in Latex. You may use the Latex editor Texmaker and the Latex compiler MikTex which are available for free on the Internet. A Latex template will be provided upon request.

4. Late homework submission will not be graded. No exceptions except for medical emergencies.

5. You are encouraged to discuss the material and homework problems with other classmates, but you must submit your OWN solutions.

6. Copying solutions for homework assigned problems, from any source, constitutes a violation of the university honor code. See the paragraph on Academic Integrity below.

7. Electronic devices of any kind are not allowed (and will not be needed) during exams.

8. Audio taping, video taping, or picture snapping, during lectures, are not allowed.
9. Students must use their MasonLive email account to receive important University information, including messages related to this class. See http://masonlive.gmu.edu for more information. Homework assignments and other course material will be emailed to your MasonLive email account. Please make sure that your mail box is not full at any time during the semester. Also, when you send me an email, please write ece528 on the subject line.

10. Students who cannot attend an exam due to religious holidays and observations should contact me as soon as possible to arrange for an alternative date.

Support Resources: A list of support resources on campus may be found in: http://ctfe.gmu.edu/teaching/student-support-resources-on-campus/

University Policies: The University Catalog, http://catalog.gmu.edu, is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other policies are available at http://universitypolicy.gmu.edu/. All members of the university community are responsible for knowing and following established policies.

Academic Integrity: GMU is an Honor Code university; please see the University Catalog for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else’s work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

Office of disability services: If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Services (ODS) at 993-2474. All academic accommodations must be arranged through the ODS. http://ods.gmu.edu

Other useful campus resources:

- Writing center: A114 Robinson Hall; (703) 993-1200; http://writingcenter.gmu.edu
- University libraries: “Ask a Librarian” http://library.gmu.edu/mudge/IM/IMRef.html
- Counseling and psychological services (CAPS): (703) 993-2380; http://caps.gmu.edu