ENG EC707 Radar Remote Sensing
Spring 2023 Syllabus

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Office: PHO537
Office Hours: Thursdays 11-12

Lecture: MW 12:20-2:05 ET, PHO 207

Prerequisites: Continuous and discrete time signal processing (EC401, EC516, or equivalent), Electromagnetic waves (EC455 or equivalent), or consent of instructor.

Course Description

This course approaches the topic of radar and remote sensing from a combined theoretical, mathematical and practical perspective. Students will develop an intuitive and quantitative understanding of radar systems and radar signal analysis for hard targets, distributed targets, and imaging (synthetic aperture radar) modalities. The successful student will complete the course with an ability to digest primary literature on radar systems and applications, and be prepared to continue with these topics professionally.

EC707 is appropriate for any graduate student with a solid background in mathematics that includes knowledge of analog and discrete-time signal processing and familiarity with electromagnetic waves and Maxwell's equations. Radar is a broad interdisciplinary subject, and not all students will be equally prepared for all topics in the course. The interests of individual students will be cultivated through a semester project based on a research article selected by the student in consultation with the instructor. This exercise will expose graduate students to the process of proposal writing, manuscript preparation, and oral presentation,

Lectures

Lecture attendance is mandatory, as much of the learning will happen through group discussions. Occasional absence due to other commitments is understood.

Texts

The lecture content will be disseminated in a set of slides and readings posted on Blackboard. Most of the fundamental material will be drawn from the following books, which are available through the links below:

- Levanon and Mozeson, *Radar Signals* [link]
- Hysell, *Antennas and radar for environmental engineers* [link]
- Blahut, *Theory of Remote Image Formation* [link]

For prerequisite material on electromagnetics and signal processing, the following books may be helpful:

- Balaji, *Electromagnetics Made Easy* [link]
- Rao, *Signals and Systems* [link]

Grading

The course grade will be based on a set of homework assignments and a final course project with the distribution shown below. The semester project will be discussed in a separate document. Student engagement is a major consideration in the final grade.

60% Homework assignments
20% Final Project: Oral Presentation
20% Final Project: Written Report

Topical Outline (Tentative)

1. **Introduction and Overview**
   History, Radar Modalities, Electromagnetic spectrum, Radar system elements.
2. **Math preliminaries**
   Complex algebra, Euler's identity, complex plane, analytic signal representation
   Essential Fourier analysis for radar
3. **Doppler radar: basic concepts**
   Range determination and resolution
   Doppler frequency shift
   Range-Doppler ambiguity
   The Radar Equation
4. **Electromagnetic waves and media**
   Maxwell's equations for time harmonic fields
   TEM waves, Poynting vector, power flow, polarization
   Reflection, transmission, and attenuation in simple media
   Waves in ionized media, Drude-Lorentz model
5. **Antenna fundamentals**
   The elemental dipole radiator
   Antenna power pattern, Directivity, Gain, Effective Area, Impedance
   Aperture antennas, Array antennas
6. **Radar Cross Section (RCS) and scattering**
   Definition and calculation of RCS
   Scattering regimes: Optical, Rayleigh, Mie
   Bragg scattering, specular vs. non-specular reflection
   Polarization effects and the scattering matrix
7. **Radar Reception and Signal Processing**
   I and Q demodulation, Pulse-Doppler analysis
   Matched filter
   Radar ambiguity function
8. **Pulse compression radar**
   Linear frequency modulation, phase coding, amplitude coding
9. **Noise and Stochastic signals**
   Stochastic signal models, focus on Gaussian processes.
   Optimal filtering
10. **Selected modalities**
    Imaging radar (SAR, ISAR, InSAR)
    Doppler Weather Radar
    Ionospheric Radar
    LiDAR
11. **Selected Advanced topics**
    Sparse sensing
    Cognitive radar
    Micro-Doppler analysis
    Machine Learning in radar
12. **Project presentations**