Leon H. Charney
School of
Marine
Sciences
UNIVERSITY
OF HAIFA

Course title:

Prof. Roee Diamant
Basics of Underwater Acoustic Signal Processing- 229.4003

Course scope:

14 meetings: 28 hours

Target skills and knowledge:

The course will provide tools for basic signal processing analysis of underwater acoustic signals. The student will become familiar with types of acoustic systems and will experiment working with acoustic projector, hydrophones, and sonar. Through understanding physical acoustic characteristics, topics learned will include: acoustic ranging, acoustic classification, acoustic communication, and acoustic detection. Part of the course will take place in a wet lab to aquire hands-on experience.

Evaluation method:

Two homework assignments (50%), lab assignment (50%).

Assessment criteria:

The ability to design underwater acoustic systems employing detection, ranging, and classification while taking into account the impact of the channel noise and impulse response. Part of the course will be a lab assignment to obtain hands-on experience in data collection, and in processing underwater acoustic data collected from past sea experiment.

Course content:

The course covers the following topics: underwater acoustic propagation and noise from the engineering point of view; correlation techniques; probabilistic estimation techniques; spatial filtering; localization techniques; machine learning classification of acoustic signals. The course will focus on the three most important technologies for nowadays underwater acoustic systems: detection of signals, classifications, and position tracking. We will study the challenges related to these three components, describe in details state-of-the art techniques, and learn of ways to formalize these problems and to analyze them. During the course, the students will perform a lab assignment involving the use of underwater acoustic data obtained from past sea experiments.

Week 1: Introduction to underwater acoustic signals: propagation, noise, Doppler effect, multipath Week 2: Introduction to probability analysis. Experimenting on sea noise
Week 3: Parameter evaluation: least squares, tracking filters
Week 4: Passive detection of acoustic signals: energy detection. Experimenting on dolphin's signals
Week 5: Active detection of acoustic signals: matched filter. Experimenting on active sonar
Week 6: Filtering. Experimenting with filter design

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Week 7: Ranging. Experimenting with finding the direct path
Week 8: Localization. Trilateration and under-ranked localization. Experimenting on tracking tagged sharks.
Week 9: Underwater simulations. Bellhop.
Week 10: Signal classification – kmeans, hierarchical, SVM. Experimenting with noise transients Week 11: Object detection in sonar images. Experimenting with data from synthetic aperture sonar Week 12: Acoustic hardware – characteristics and specifications.
Week 13: Performing recordings in department's pool
Week 14: presentation of projects.

Textbooks:

- Fundamentals of Statistical Signal Processing, Volume 2: Detection Theory, by Steven M. Kay, Prentice Hall 1998.
- Harry L. Van Trees, Detection, Estimation, and Modulation Theory, Part I, II, III, IV
- H. Vincent Poor, Introduction to Signal Detection and Estimation
- Boyd and Vandenberghe, Convex Optimization

Preliminary requirements:

Probability/statistics, Infinitesimal Calculus 2, Matlab programming