BIOM 7904: Ultrasound Imaging Technology (Syllabus)

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Course Description
This course will introduce students to a variety of current and emerging methods in ultrasound imaging. Concepts will be grounded in fundamental physical principles (acoustic waves, piezoelectric transduction, diffraction, scattering) and progress to methods of array beamforming, k-space representation, and imaging system architecture. Ultrasound nonlinearity, bioeffects, safety metrics, as well as Doppler (flow), harmonic, contrast-enhanced, and elastography imaging methods will also be introduced. Students will have the opportunity to observe ultrasound experiments and perform ultrasound imaging on an abdominal phantom. Projects for 7904 will involve thorough review of academic literature on a specific sub-topic; for further credit, the project will also entail design/development aspects, involving simulating and/or processing data (e.g., relevant to the student’s own graduate research).

Pre-requisite course: BIOM 4801/6801 strongly recommended. Familiarity with Fourier Transforms and Matlab will be helpful, but not required.

Required Textbook

Suggested Supplemental Texts:


Course Learning Outcomes/Objectives
Upon completion of this course, students will be able to:
-explain the origin, transmission, and reception of ultrasound waves
-model and discuss the tradeoffs of different beamforming strategies
-describe how ultrasound B-mode images are formed
-discuss the principles and utility of other ultrasound-based clinical imaging modes

Course Methodology
Composite Grade Weighting:
Attendance & Participation 10%
Homework Assignments 30%
Midterm Exams 15%
Final Exam 25%
Final Project 20%
Grading Scale:
A: 91-100
B: 81-90
C: 71-80
D: 61-70

Tentative Schedule
Week 1: Fourier Transform & Linear Systems Review, Mechanics of Solids
Week 2: Acoustic Waves, Wave Equations & Modeling, Attenuation
Week 3: Electromechanical Transducers, Piezoelectric Effect, Electroacoustic Impedance
Week 4: Diffraction Physics, Array Beamforming Basics
Week 5: Tissue Bioeffects & Safety, Scattering & Coherence
Week 6: Speckle Statistics, Reduction, Tracking
Week 7: Concept Review, Midterm Exam
Week 8: Ultrasound Imaging System Components & Architecture, Processing Strategies
Week 9: k-space Representation, Advanced Beamforming Approaches
Week 10: Doppler Imaging Modes, Phase-shift Estimators, Vector Flow and Functional Imaging
Week 11: Elastography, Acoustic Radiation Force-based Imaging Approaches
Week 12: Nonlinear Acoustics, Harmonic Imaging, Contrast-enhanced & Molecular Imaging
Week 13: Clutter Noise, Phase Aberration, and Correction Strategies; Concept Review
Week 14: Midterm Exam, Project Presentations/Demonstrations, Final Exam Review