The BioEngineering Technical Interest Group

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• ECE’s bioengineering group is on the leading edge of developing physical and mathematical concepts and techniques that are applied to medicine and biology. Specific applications include feature extraction in cardiac imagery, MEMS devices for direct interfacing with biological systems, modeling of biological sensory and motor systems, and the development of sensors for the detection of cancer cells.
Outline

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What is the ECE BioEngineering Technical Interest Group?

- TIGs are groups of professionals, aligned by common technical interests, who come together in a community to share information and ideas, discuss topics of interest, and answer questions posed by other community members.

- They can participate in discussions, share documents with other members, and many other functions (depending on the specific TIG).

- Bioengineering is concerned with the application of engineering principles to the study and control of biological processes. In this area, mathematical models and physical systems are developed and subsequently applied to medicine and biology.
Undergraduate Courses Offered by the BioEngineering TIG

1. **ECE 1750 - Introduction to Bioengineering**
   An introduction to the field of bioengineering, including the application of engineering principles and methods to problems in biology and medicine, the integration of engineering with biology, and the emerging industrial opportunities.

2. **ECE 4020 - Bioengineering Design**
   Students will work in teams on bioengineering design projects. Course lectures will address topics related to the art of the design process and the practical design issues facing the bioengineer.

3. **ECE 4781- Biomedical Instrumentation**
   A study of medical instrumentation from a systems viewpoint. Pertinent physiological and electro-physiological concepts will be covered. Crosslisted with CHE and ME 4781.

4. **ECE 4782- Biosystems Analysis**
   Analytical methods for modeling biological systems, including white-noise protocols for characterizing nonlinear systems. Crosslisted with CHE and ME 4782.

5. **ECE 47XX- Introduction to Medical Image Processing**
   A study of methods for enhancing, analyzing, interpreting and visualizing information from two- and three-dimensional data obtained from a variety of medical imaging modalities. Cross-listed with BMED 47xx

6. **ECE47XX – Bioelectricity**
   An introduction into electrophysiology and the instrumentation used to analyze electrophysiological signals.
Graduate Courses Offered by the BioEngineering TIG

1. **ECE 6787 - Quantitative Electrophysiology**
   A quantitative presentation of electrophysiological systems in biological organisms, emphasizing the electrical properties and modeling of neural and cardiac cells and systems. Cross-listed with BMED and PHYS 6787.

2. **ECE 6788 - Legal Issues in Biomedical Engineering**
   Study and analysis of US government and law applicable to the development and clinical use of biomedical engineering technology. Cross-listed with BMED, CHE, ME, and MGT 6788.

3. **ECE 6789 - Technology Transfer in Biomedical Engineering**
   Team discussion and case studies in biomedical engineering technology transfer, including licensing, financial capital, safety and efficacy studies, clinical trials and strategic planning. Cross-listed with BMED, CHE, ME, and MGT 6789.

4. **ECE 86xx - Biomedical Applications of MEMS**
   Introduction into the use of microsystems technology to design and fabricate advanced bio-analysis instrumentation. The course includes a process design component and a application design component.

5. **ECE 86xx - Biosensors**
   Introduction into the field of biosensors including discussion on basic sensing mechanisms and methods for designing biosensor systems.

6. **ECE 86xx - Neural Dynamics**
   Advanced electrophysiology and instrumentation for analysis of electrophysiological signals.

7. **ECE 86xx - Hybrid Neural Microsystems**
   Application of microsystems technology to the field of neuroscience. The course includes a review of conventional analytical tools and an in depth discussion on the use of microsystems technology to realize enabling neuro interfacing / analysis systems.
Research

BioEngineering TIG Faculty – Core Faculty

Butera, Robert J.
- instrumentation development, electrophysiology
DeWeerth, Stephen P.
- neural interfaces, circuitry
Frazier, A. Bruno, Chairperson
- microsystems, BioMEMS
Hunt, William D.
- microsystems, acoustic biosensors
Koblasz, Arthur
- medical instrumentation
Tannenbaum, Allen R.
- image processing
Vachtsevanos, George J.
- signal analysis, biocontrols
Yezzi, Anthony J.
- image processing
Research

BioEngineering TIG Faculty - Affiliated ECE Faculty

Allen, Mark G.
- microsystems, microfabrication

Benkeser, Paul J.
- image processing

Clements, Mark A.
- digital signal processing

Hasler, Paul E.
- neuro interfaces, circuitry

Verriest, Erik I.
- biocontrols

Zhou, Guotong
- digital signal processing

Adjunct Faculty:

Brummer, Marijn
- Emory, BME
- image processing

Lee, Robert
- GaTech, BME
- electrophysiology

Skrinjar, Oskar
- GaTech, BME
- image processing

Wang, May
- GaTech, BME
- image processing
Description
The goal is to improve the navigational accuracy for placement of the permanent stimulator in the midbrain for deep brain stimulation surgery (for movement disorders like Parkinson’s disease). Funded by NIH.

Results
• Initial non-rigid image registration algorithm
• Initial intra-operative brain deformation compensation strategies

Existing Collaborations
• Dr. Mewes, Neurology, Emory
• Dr. Puzrin, CEE, Georgia Tech

Potential Collaborations
• Dr. Gross, Dr. Abosch, Neurosurgery, Emory U.
Responsive Neurostimulation

Overall Architecture for Epilepsy Research

Professor George J. Vachtsevanos
Research

• Seizure Detection and Prediction
  – Determine spatial and temporal course of seizure precursors
  – Pre-Processing: including differential mode (bipolar analysis) and Notch Filter
  – Feature Extraction and Selection: including Pre-selection, Extraction and Optimal Feature Vector Selection
  – Classification and Validation: including Classifier design, Performance Metric Definition and Validation

• Deep Brain Stimulation
  – Effective stimulation parameter set selection
  – Performance metric for the effect of stimulation
  – Mechanisms of deep brain stimulation
  – Close the loop between seizure detection/prediction and stimulation paradigms
Overall Architecture for Cardiac Arrhythmia Research

Professor George J. Vachtsevanos
Research

- Data Management
- Data Preprocessing: including Baseline drift removal and Power line removal
- Feature extraction and selection: including potential feature extraction based on ECG and Heart Rate Variability (HRV) signal and Optimal Feature Selection
- Classification: including Classifier Design, Performance Metric and Validation
- Risk Stratification: Stratify patient at high risk for cardiac arrhythmia
- Cardiac Arrhythmia Prediction: including precursor identification, and the relationship between the temporal and spatial distribution of precursors and cardiac arrhythmia
- Heart Modeling: including the establishment of the computer heart model and the study of the cardiac arrhythmia mechanism

Professor George J. Vachtsevanos
Industry Opportunities

• Biomedical instrumentation is a rapidly growing market sector driven by the need for better clinical diagnostic / monitoring tools and instruments with novel analysis capabilities.
• There are many small, medium & large size companies developing biomedical instrumentation in the United States and abroad.
• Many opportunities for employment in Georgia. The Georgia Biomedical Partnerships, Inc. is a central source for Georgia Biomedical industry activities.
• Several GaTech start-up companies developing new products for the market.
• Example applications: Imaging systems, pacemakers, catheters, EKG systems, cancer diagnostic equipment, drug discovery tools, neural monitoring systems, hybrid computing systems, nanosystems, biosensors
Educational Opportunities

• Georgia Tech Bioengineering undergraduate students have multiple options for pursuing graduate degrees in ECE, Biomedical Engineering, as well as Medical School.

• Numerous ECE faculty are members of the interdepartmental Bioengineering Graduate Program. Thus, students entering ECE who want to pursue an M.S. or Ph.D. in Bioengineering can matriculate either as traditional ECE students with a focus in Bioengineering or into the interdepartmental Bioengineering program with ECE as their home school.