ECE4782 Biosystems Analysis **Spring 2027**

Instructor: Professor Omer T. Inan, Office Location: TSRB 417, inan@gatech.edu

Office Hours: Weekly (1 hour) TBD

1. Course Summary

Signal processing and modeling tools are presented for analyzing biomedical signals, with a particular focus on physiologic monitoring for human health and performance. Fundamentals of digital signal processing, and probability and statistics are reviewed. Physiology concepts are introduced and developed together with examples of feature extraction, noise reduction, event detection, and signal modeling approaches used in commercially available devices and academic research. Students will complete a final project in small teams, including a short written proposal, presentation to the class and industry or physician guests, and a written report. This course aims at developing both knowledge and critical thinking in the field of physiologic monitoring, with a particular emphasis on systems used outside of clinical settings (e.g., m-health or extreme environment monitoring). No prior knowledge of physiology or biology is needed.

2. Course Information

Lectures: Tuesdays and Thursdays

3. Textbook and Optional References

No textbook is required.

The optional reference textbooks are as follows:

- Sornmo and Laguna, *Bioelectrical Signal Processing and Modeling*
- Oppenheim and Schafer, *Digital Signal Processing*
- Hayes, *Statistical Digital Signal Processing and Modeling*
- Guyton and Hall, *Textbook of Medical Physiology*
- Despopoulus, *Color Atlas of Physiology*

4. Course Requirements and Grading

Requirements:

- Homework assignments every one to two weeks. Homework will normally be assigned on Thursdays and due the following Thursday in class. **Late homework will not be accepted.** You may work on the homework in small groups, but you must write up your own homework.
- Three in-class quizzes covering material from the lectures or homework. **The lowest quiz grade will be dropped.**
- Final project. You will be grouped into small teams, and will propose (written) a research project related to biosignal processing and modeling in consultation with the professor. The project consists of an original design of biosignal processing related topics (scientific, engineering, commercial, etc.). At the end of the term, you will then present to the class

your results in a 10-12 minute presentation, and provide a project write-up (7 pages maximum length). Grading is typically based on depth of coverage, correctness, originality and quality of the analysis, and the overall clarity of the paper and presentation. It is possible that these presentations will occur during the last week of class before final exams OR during the final exam time slot, so please keep both open.

- Attendance is optional (though highly suggested) but **required for all presentations to pass the class.**

Grading:

Homework	20%
Quizzes	30%
Final Project Proposal	10%
Final Project Presentation	15%
Final Project Write-Up	25%

5. Prerequisites

ECE 2026 [min C] or BMED 3510 [min C] or CHBE 4411 [min C] or ME 3015 [min C]. No prior knowledge of physiology or biology is needed. Ask if you are unsure.

6. Tentative Outline

A. Current and future applications of biosignal processing and modeling
B. Digital signals and systems
    a. Linear Systems, Discrete Time Systems, Sampling, Convolution
    b. Fourier Analysis, FFT, Digital Filters (IIR, FIR)
    c. Basics of Feature Extraction and Classification Algorithms
C. Statistical Signal Processing and Modeling
    a. Power Spectral Density Estimation
    b. Signal Modeling Techniques
    c. Prediction
D. Physiologic monitoring
    a. Cardiovascular and Pulmonary Physiology and Signals
    b. Wakefulness: Activity, Behavior, and Exercise
    c. Nervous System and Neurological Disorders
    d. Biomechanics: Posture, Balance, and Movement
    e. Acoustic Signals: Speech, Heart Sounds, Snoring
    f. Sleep Monitoring: Apnea, Sleep Quality
    g. Trauma, Hemorrhage and Other Acute Monitoring
E. Special Topics in Biosignal Processing and Modeling
    a. Cuffless Blood Pressure
    b. Pediatric IV Infiltration
    c. Extreme Environment Challenges

Other Course Expectations & Guidelines

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Course Outcomes – Upon successful completion of this course, students should be able to:

1. Design and implement pre-processing algorithms for reducing noise and artifacts from biosignal recordings
2. Describe challenges in real-world biomedical signal processing problems such as motion artifacts and low signal-to-noise ratio
3. Develop strategies for mitigating these real-world challenges including through the design of multi-modal signal processing and machine learning techniques
4. Communicate the design of biosignal processing algorithms to a diverse audience of engineers and / or clinicians via written and oral presentation

Student Outcomes - In the parentheses for each Student Outcome, "P" for primary indicates the outcome is a major focus of the entire course, “M” for moderate indicates the outcome is the focus of at least one component of the course, but not majority of course material.

1. (P) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. (P) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. (P) an ability to communicate effectively with a range of audiences

5. (M) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives