ECE 590 Topics in Bioengineering: Biomedical Signal Processing
ECE 699 Advanced Topics in Biomedical Signal Processing
Fall 2008

Credits 3
Tuesdays, 7:20 pm – 10:00 pm, Room: Science and Tech II, 260

Instructor:
Siddhartha Sikdar, PhD
Assistant Professor
Department of Electrical and Computer Engineering
Volgenau School of IT&E
Office: Science and Tech II, Room 207B
Email: ssikdar@gmu.edu
Phone: 703-993-1539
Office hours: Tuesdays 2:00-4:00 pm and by appointment

Course description (ECE 590 and ECE 699):
Our modern healthcare system relies critically on the analysis of physiological signals from electronic sensors and instruments to save lives and monitor the health of patients in a wide variety of applications and settings. Examples include automatic cardiac defibrillators commonly found in many public places, which automatically deliver a life-saving electric shock to a patient; Doppler ultrasound instruments in the hospital that noninvasively measure blood flow inside the body; or the heart-rate monitor on the treadmill at the local gym. Biomedical signals are typically nonstationary, have complex features, and the clinically relevant information is often masked by noise and other interfering signals. This course will provide an introduction to the characteristics of biomedical signals, describe applications involving the analysis of these signals, and discuss several signal processing and analysis methods with specific biomedical examples. The students will get hands-on experience in applying the methods learnt in class to real-world problems. A course project will provide the opportunity to individually or collaboratively explore current problems in biomedical signal analysis.

ECE 699 (Advanced Topics) option:
This course also has an ECE 699 option for students desiring 600-level credits. The course content, homework and exams for ECE 699 would be the same as that for ECE 590. Students taking ECE 699 would be expected to do a more advanced project demonstrating in-depth understanding and critical assessment of methods from recent research literature and would be required to submit a project report.

Learning objectives:
At the end of the course the student should be able to:

1. Describe the characteristics of biomedical signals and the need for their analysis.
2. Demonstrate an appreciation of physiological processes underlying the production of biomedical signals and their measurement.
3. Apply filtering, spectral estimation, signal modeling and nonstationary analysis techniques for processing biomedical signals.
4. Design signal-processing algorithms to solve real-world problems involving biomedical signals.

Prerequisites:

1. Familiarity with MATLAB
2. Signal processing (ECE 535 or equivalent) or permission of instructor.
3. Random processes (ECE 528 or equivalent) or permission of instructor.

Resources:

Course home page:

The course material distribution, assignments grading, announcements and discussion boards will be managed using BlackBoard CE6. To access the course home page, log in using your email ID and password on http://courses.gmu.edu. If you have difficulties using this system, please speak with the instructor and appropriate accommodations will be considered.

Required readings:

The lecture slides will be the basis of material covered in lectures and will be posted before the class. Additional reading and reference material will be distributed to students through the course web site periodically.

Textbook (recommended):


Additional textbooks for reference:


Course structure:

The course will consist of weekly lectures, homework assignments, two exams, a final project and a final presentation (details below). In addition, ECE 699 students will be required to submit a written project report. The exams will be closed book and closed notes.
Grade:
Midterm exam 25%
Final exam 25%
Placement exam 25%
Final project and presentation 25%

Final Project (ECE 590):
The final project will involve hands-on experience with developing or implementing signal-processing algorithms for solving a particular biomedical signal analysis problem. Students should select a topic, discuss with the instructor, and get approval within the first five weeks of class. Students can select one of the following approaches:
1) Implement a specific algorithm for biomedical signal processing from recent literature, demonstrate its uses using real data and suggest avenues for improvement.
2) Develop a signal processing algorithm for solving a specific problem involving biomedical signals. Available functions from MATLAB toolboxes can be used where appropriate, and the final result should be demonstrated using real data.

Students with similar interests can choose to work together on a more complex project (the contribution of each student should be clearly defined). An annotated bibliography of relevant literature sources should be submitted to the instructor for approval by the seventh week of class.

At the end of the semester, students will be expected to make a 20-min presentation/demonstration of their final project. Your classmates will grade the final presentation. Grades for the presentation and the final report will be based on: clarity of introduction, quality of results, depth of analysis and discussion.

Project deliverables:
1. Annotated bibliography of literature sources (due by 7th week)
2. Weekly progress reports (starting from the 10th week)
3. Working MATLAB or C/C++ code and properly documented results
4. Project presentation

Final Project (ECE 699):
The final project for students taking ECE 699 will involve hands-on experience with developing or implementing signal-processing algorithms for solving a particular biomedical signal analysis problem as well as exposure to the recent research literature. The project should involve an in-depth study and critical assessment of one or more methods from recent literature. Students should select a real-world problem involving biomedical signals, discuss with the instructor, and get approval within the first five weeks of class. By the seventh week, the students are expected to do a thorough literature search and identify methods that have been proposed to solve the problem. Based on this literature review, students can choose either to:
1) Implement a specific algorithm for biomedical signal processing from recent literature, demonstrate its uses using real data and suggest avenues for improvement.
2) Critically compare two or more methods and discuss the pros and cons of each method.

Students with similar interests can choose to work together on a more complex project (the contribution of each student should be clearly defined).

At the end of the semester, students will be expected to make a 20-min presentation/demonstration of their final project. Your classmates will grade the final presentation. Grades for the presentation and the final report will be based on: clarity of introduction, quality of literature review, quality of results, depth of analysis and discussion.

In addition, ECE 699 students are expected to submit a written project report (5-10 pages) with separate sections for Introduction, Methods, Results and Discussion.

Project deliverables:
1. Annotated bibliography of literature sources (due by 7th week)
2. Weekly progress reports (starting from the 10th week)
3. Working MATLAB or C/C++ code and properly documented results
4. Project presentation
5. Project report

Homework:
There will be assigned homework throughout the semester. The homework will involve processing and analysis of real signals, and will involve programming in MATLAB. Homework submitted after the due date will be penalized (15% penalty for each day late). No homework will be accepted after one week from the due date.

5 points of the homework grade is reserved for class participation. One student will be assigned each week on a rotating basis to take the lead on compiling a summary of the discussions in class. The student should compare notes with other students and post their summary on the discussion board on the class home page. These summaries should be used as a supplement to the lecture slides in preparing for examinations. The class participation grade will be based on the quality of these discussion summaries.

Exams:
The midterm and final exams will be closed book and notes. They will consist of a mixture of essay-type and multiple-choice type questions. Absence from exams must be notified ahead of time and alternative arrangements made with the instructor.
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<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topic</th>
<th>Important deadlines</th>
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<tbody>
<tr>
<td>1</td>
<td>8/26/08</td>
<td>Introduction; nature of biomedical signals and instruments; why do we need biomedical signal analysis?</td>
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<tr>
<td>2</td>
<td>9/02/08</td>
<td>Examples of biomedical signals and the underlying physiological processes.</td>
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<tr>
<td>3</td>
<td>9/09/08</td>
<td>Review of random processes, stationarity and ergodicity, noise.</td>
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<td>4</td>
<td>9/16/08</td>
<td>Signal characteristics: autocorrelation, crosscorrelation, covariance, power spectral density, cross-spectral density, coherence.</td>
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<tr>
<td>5</td>
<td>9/23/08</td>
<td>Filtering biomedical signals: FIR and IIR filters, ensemble averaging, frequency domain filtering.</td>
<td>Paper topic approval due</td>
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<tr>
<td>6</td>
<td>9/30/08</td>
<td>Filtering biomedical signals: trend removal, artifact removal, noise reduction.</td>
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<td>7</td>
<td>10/07/08</td>
<td>Event detection: correlation, matched filtering, coherence analysis.</td>
<td>List of literature sources due</td>
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<td>8</td>
<td>10/14/08</td>
<td>No class: Columbus day recess</td>
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<td>9</td>
<td>10/21/08</td>
<td>Mid-term Exam</td>
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<td>10</td>
<td>10/28/08</td>
<td>Biomedical signal modeling: Fourier series, basis functions.</td>
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<td>11</td>
<td>11/04/08</td>
<td>Biomedical signal modeling: parametric modeling, Yule-Walker equations, AR, MA and ARMA processes.</td>
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<td>13</td>
<td>11/18/08</td>
<td>Nonstationary signal analysis: short-time fourier transforms.</td>
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<td>14</td>
<td>11/25/08</td>
<td>Nonstationary signal analysis: time-frequency methods, wavelets.</td>
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<td>15</td>
<td>12/02/08</td>
<td>Examples of feature extraction and computer-aided diagnosis. Course wrap up.</td>
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<td>16</td>
<td>12/09/08</td>
<td>Final presentations.</td>
<td>Project report for ECE 699 due.</td>
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<td>16</td>
<td>12/16/08</td>
<td>Final exam.</td>
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Academic Honesty and Collaboration:

The integrity of the University community is affected by the individual choices made by each of us. GMU has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment, ask for clarification. No grade is important enough to justify academic misconduct.

With collaborative work, names of all the participants should appear on the work. Collaborative projects may be divided up so that individual group members complete portions of the whole, provided that group members take sufficient steps to ensure that the pieces conceptually fit together in the end product. Other projects are designed to be undertaken independently. In the latter case, you may discuss your ideas with others and conference with peers; however, it is not appropriate to give your work to someone else to review. You are responsible for making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.

Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, or endnotes. Paraphrased material must also be properly cited. A simple listing of books or articles is not sufficient. Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please see the instructor.

Relevant Campus and Academic Resources

Disability Services
Any student with documented learning disabilities or other conditions that may affect academic performance should: 1) make sure this documentation is on file with the Office of Disability Services (SUB I, Rm. 222; 993-2474; www.gmu.edu/student/drc) to determine the accommodations you might need; and 2) talk with the instructor to discuss reasonable accommodations.

Office of Diversity Programs and Services
SUB 1, Rm. 345; 993-2700; www.gmu.edu/student/msaf/index.html

Writing Center
Robinson A116; 993-1200; writingcenter.gmu.edu.