PURDUE UNIVERSITY

WELDON SCHOOL OF
BIOMEDICAL ENGINEERING

BIOMEDICAL SIGNAL PROCESSING
BME 595B - FALL 2008

Biomedical Signal Processing - 12652 - BME 59500 - 001

Time: Tuesday/Thursday 4:30-5:45
Room: SC G030
Credits: 3

Biomed Signal Processing Lab - 34827 - BME 59500 - 007

Time: Monday 3:30-5:30
Room: MJIS 1061
Credits: 1

Professor: Michael G. Heinz, Ph.D.
Asst. Professor of Biomedical Engineering
Asst. Professor of Speech, Language, and Hearing Sciences
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Office Hours: by appointment (Mon 2-3pm preferred)

Teaching Asst: Ananth Chintanpalli
Email: cananthk@purdue.edu
Office Hours: M 11-12:30; (MJIS 1084)
W 1:30-3;
F 1:30-3

Lab Teaching Asst: Pooja Rajdev
Email: prajdev@purdue.edu
Office Hours: T 2:30-4:15; (MJIS 1061)
W 11-1;
TH 2:30-4:15

Course Description: An introduction to the application of digital signal processing to practical problems involving biomedical signals and systems. Topics include: overview of biomedical signals; filtering to remove artifacts; event detection; analysis of waveshape and waveform complexity; frequency domain characterization; modeling biomedical signal-generating systems; analysis of non-stationary signals; pattern classification and diagnostic decision. MATLAB is used throughout to apply the theory and techniques discussed to biomedical signals. A laboratory component provides experience in using a real-time DSP hardware system for biomedical applications.

Prerequisites: ECE 301 and ECE 302 (or permission of instructor). Familiarity with MATLAB.

Required Text: Rangayyan , R.M., Biomedical Signal Analysis : A Case-Study Approach, Wiley-IEEE Press, 2001. (ISBN: 0471208116)

Required Software: MATLAB (see below for options for accessing MATLAB)
MS Office (Word and PowerPoint)

Supplemental References:

1) Bruce, E., Biomedical Signal Processing and Signal Modeling, Wiley-Interscience, 2000. (ISBN: 0471345407).
2) Oppenheim, A.V., Schafer, R.W., and Buck, J.R., Discrete-Time Signal Processing, 2nd Edition, Prentice Hall, 1999. (ISBN: 0137549202).
3) Papoulis, A. and Pillai, S.U., Probability, Random Variables and Stochastic Processes, 4th edition, McGraw-Hill Science, 2001. (ISBN: 0072817259).
4) Chassaing, R. and Reay, D. Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK, 2nd edition, Wiley-IEEE Press, 2008 (ISBN: 0470138661).

Blackboard: Materials and grades for both the lecture and labs parts of the course will be posted on the Blackboard page for BME59500-001 (Note: the Blackboard page for BME59500-007 will not be used). Announcements will be made via regular email.

Grading: Plus/minus grading will be used. Separate grades will be given for the lecture and lab parts of the course. Lab grades will be based on both oral and written evaluation of the 6 assigned labs by the Lab TA. Lecture grades will be based on:

Problem Sets (5)	30%
Midterm Exam	20%
MATLAB Project	20%
Final Project	30%

Problem Sets and Project Submissions:
Submitted work will consist of both written and electronic files. All assignments are due by the beginning of class on the due date. No late assignments will be accepted (except in extenuating circumstances, discussed with Dr. Heinz prior to the due date). Written material will consist of derived solutions and/or MS Word (*.doc) text with inserted MATLAB figures (TIFFs recommended). Written work should be handed in at the beginning of class. Electronic material will consist of your *.doc file, and any scripts or functions you have written, as well as any *.wav files you have generated. The *.doc file must have a list of every electronic file submitted with the assignment, with a brief description. Every figure in your *.doc file should be generated by the code you submit, i.e., we should be able to run your code and see your figures appear with no effort. All electronic files should be submitted as a ZIP file, which should be emailed to Ananth (cananthk@purdue.edu) prior to the start of class.

Access to MATLAB:
This course will require access to MATLAB and MS Office in order to complete the problem sets and projects. It is each student's responsibility to find a reliable environment in which to do the work for this course. This should be worked out within the first week of class. MATLAB CDs are available from ITAP for students to install (free of charge) on their own machine (laptop or at home – internet access required to run license). MATLAB should also be available on all ITAP machines on campus. Three MATLAB tutorials are posted on Blackboard for reference. Also, numerous TA office hours are available to supplement you existing familiarity with MATLAB. *PLEASE take advantage of the TA office hours – it is very easy to get stuck as you are learning to use MATLAB, and the TA can often get you unstuck very quickly (e.g., if you don't know the right command or syntax).*

MATLAB Project: (2.5 weeks). This research-oriented project will be done in groups of two students, with individual project reports due from each student.

Simulation of Cochlear Implant Processing: Filter bank simulations of cochlear-implant processing will be implemented to estimate how many frequency channels are needed to understand speech (Shannon et al, 1995). The filter-bank analysis will then be extended to create chimaeric sounds using the envelope from one sound (speech or music) and the fine-time structure from another sound. This processing will be used to determine the salient types of information (envelope or fine-time structure) required for the perception of speech and/or music as a function of the number channels used (Smith et al., 2002).

Shannon, R.V., Zeng, F.G., Kamath, V., Wygonski, J., and Ekelid, M. "Speech recognition with primarily temporal cues," *Science*, 270, 303–304, 1995.

Smith Z.M., Delgutte B., Oxenham A.J. "Chimaeric sounds reveal dichotomies in auditory perception," *Nature*, 416, 87-90. 2002.

Final Project: (final ~5 weeks)

An independent project will apply signal processing to a research question of interest to each student. This project can either be related to ongoing research in a lab or can be the replication of a published study. It can involve MATLAB or the real-time DSP boards, or both. The final projects are intended to be quite extensive as they will hopefully be in an area of direct interest and familiarity to each student. Projects will be presented to the class during the final week of the semester (modeled after a ~15 minute conference talk) and will be written up in a final report (modeled after a conference proceedings paper, ~6-10 pages). Grading will based on 1/3 content, 1/3 oral presentation, and 1/3 written presentation. Note: content will be judged based on what you accomplish by the time you submit your written report (Thursday of exam week), i.e., if you don't finish everything you want by your oral presentation, you are welcome to keep working and include a more complete version in your written report.

Statement on Collaborative Work:

The skills to be learned in this class rely on each student doing and understanding the assignments themselves. However, collaboration is encouraged in ways that help to avoid students getting stuck and not being able to complete an assignment (e.g., discussion of underlying concepts and theory, not knowing the name of a specific MATLAB command, etc …). However, in no case should solutions, code, or text be copied from another student. Each student is expected to write their own code, solutions, and text. Violations of this expectation will receive 0 credit and may be referred to the BME department and/or Dean of Students for disciplinary action.

Students with Disabilities

Students with disabilities must be registered with Adaptive Programs in the Office of the Dean of Students before classroom accommodations can be provided. If you have a disability that requires academic adjustments, please make an appointment with me to discuss your needs as soon as possible.

Course Flexibility in the Case of Unexpected Emergencies

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course. Blackboard Vista web page, my email address: mheinz@purdue.edu, and my office phone: 496-6627. Additional suggestions for best practices in the case of a campus emergency are available at: http://www.itap.purdue.edu/tlt/faculty/.

BME 595B Fall 2008 Lecture and Lab Schedule (Tentative)

Week	Date	Lecture Topic	Reading	Assignments	DSP Lab
1	8/25 (M)				*no meeting*
	8/26 (T)	Introduction; Review: Signals and Systems		PS 1 OUT	
	8/28 (TH)	Intro to Biomedical Signals and Systems	Chapters 1, 2		

2	9/1 (M)				**LABOR DAY**
	9/2 (T)	*Introduction to DSP LAB****	*[*** meet in MJIS 1061: 4:30-5:45pm]*		*LAB 1 intro*
	9/4 (TH)	Filtering for Artifact Removal	Ch 3	PS 2 OUT; **PS 1 DUE**	
3	*9/8 (M)*				*LAB 1 con't*
	9/9 (T)	**No meeting: BME Acoustics Conference (if interested, poster session 1-2:30 in MJIS atrium)**			
	9/11 (TH)	Filtering for Artifact Removal		PS3: OUT; **PS 2 DUE**	
4	*9/15 (M)*	*LAB 2: Data acquisition/Memory use*			*LAB 2 intro; LAB 1 due*
	9/16 (T)	Filtering for Artifact Removal			
	9/18 (TH)	Filtering for Artifact Removal			
5	*9/22 (M)*				*LAB 2 con't*
	9/23 (T)	Event Detection	Ch 4	PS4: OUT; **PS 3 DUE**	
	9/25 (TH)	Event Detection			
6	*9/29 (M)*	*LAB 3: Digital Filter Implementation*			*LAB 3 intro; LAB 2 due*
	9/30 (T)	Event Detection			
	10/2 (TH)	MATLAB PROJECT intro: Cochlear Implants	Shannon et al 1995; Smith et al 2002	PRJ: OUT; **PS 4 DUE**	
7	*10/6 (M)*	*LAB 4: FFT/Adaptive Noise cancellation*			*LAB 4 intro*
	10/7 (T)	Waveshape and waveform complexity	Ch 5		LAB 3 due (anytime this week)
	10/9 (TH)	Waveshape and waveform complexity			
8	10/13 (M)				**OCTOBER BREAK**
	10/14 (T)	**OCTOBER BREAK**			
	10/16 (TH)	Waveshape and waveform complexity			
9	*10/20 (M)*				*LAB 4 con't*
	10/21 (T)	Frequency domain characterization	Ch 6	**MATLAB PRJ DUE**	
	10/23 (TH)	Frequency domain characterization			
10	*10/27 (M)*	*LAB 5: ECG detection*			*LAB 5 intro; LAB 4 due*
	10/28 (T)	Frequency domain characterization		PS5: OUT	
	10/30 (TH)	Modeling biomedical signals and systems	Ch 7		
11	*11/3 (M)*				*LAB 5 con't*
	11/4 (T)	Modeling biomedical signals and systems			
	11/6 (TH)	Modeling biomedical signals and systems		**PS 5 DUE**	
12	*11/10 (M)*	*LAB 6: Real-time analysis of neural signals*			*LAB 6 intro; LAB 5 due*
	11/11 (T)	Modeling biomedical signals and systems			
	11/13 (TH)	Analysis of nonstationary signals	Ch 8	**FINAL PROJECT PROPOSAL DUE**	
13	*11/17 (M)*				*LAB 6 con't*
	11/18 (T)	**MIDTERM EXAM – IN CLASS**			
	11/20 (TH)	Analysis of nonstationary signals			
14	*10/24 (M)*				*LAB 6 due*
	11/25 (T)	Pattern Classification, diagnostic decisions	Ch 9		
	11/27 (TH)	**THANKSGIVING**			
15	12/1 (M)				
	12/2 (T)	Pattern Classification, diagnostic decisions			
	12/4 (TH)	Pattern Classification, diagnostic decisions			
16	12/8 (M)	**Final Project Presentations**			
	12/9 (T)	**Final Project Presentations**			
	12/11 (TH)	**Final Project Presentations**			
17	12/1512/19	**EXAM WEEK (No final)**	**FINAL PAPER DUE: Thursday Dec 18th, by 5pm**		