Biomedical Signal and Image Processing

EE 5353-002, CRN-29410
EE 4359-002, CRN-29404
Spring 2022

Syllabus

Department of Electrical & Computer Engineering
The University of Texas at El Paso, El Paso, Texas 79968, USA
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Contents

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Tuesday, January 18, 2022

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Ricardo von Borries
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1 General Information

⇒ **Course ID:** Biomedical Signal and Image Processing
EE 5353-002, CRN-29410
EE 4359-002, CRN-29404

⇒ **Time:** Tuesday and Thursday, 9:00 am – 10:20 am

⇒ **Lecture Room:** Education Building 318

⇒ **Prerequisites:** EE 3353 with a grade "C" or better or instructor permission

⇒ **Textbook:** J. Semmlow and B. Griffel. *Biosignal and Medical Image Processing*. CRC Press, Taylor & Francis Group, Boca Raton, FL, third edition, 2014 [1]

⇒ **Computational Software:** Matlab® and its toolboxes [2, 3, 4]

⇒ **Instructor:** von Borries – rvonborries@utep.edu

⇒ **Office:** Engineering Building 313

⇒ **Office Hours:** Tuesday and Thursday 10:30 am to 11:15 am (room 313 or Blackboard)
Tuesday and Thursday 3:00 pm to 3:45 pm (room 313 or Blackboard)
or by appointment on Blackboard

⇒ **Version:** Tuesday, January 18, 2022

2 Description

Biomedical Signal and Image Processing develops the develops the application of digital signal and image processing techniques to improve clinical diagnostic accuracy. Signals of interest include one- and multi-dimensional data arrays such as ECG, EMG, EEG, EGG,

scintigraphy, and x-ray tomography, recorded with one- or multi-channel acquisition systems. Techniques addressed may include: time-frequency analysis, parametric modeling, noise removal, component extraction, image reconstruction, classification. Computer simulations with signals that are alternatively simulated or from biomedical data banks provide motivation and facilitate understanding of the theory and applications.

3 Textbook and Numerical Computation Software

Biomedical Signal and Image Processing has two required resources: (1) the textbook by J. Semmlow and B. Griffel. *Biosignal and Medical Image Processing*. CRC Press, Taylor & Francis Group, Boca Raton, FL, third edition, 2014; and (2) the software `Matlab`® and its toolboxes for numerical computation and visualization developed by The MathWorks, Inc. [2, `Matlab`® on MathWorks], [3], [4]. If you don't have `Matlab`® installed in your computer, you can get `Matlab`® from the Engineering Technology Center (ETC) at the Engineering building E351D, College of Engineering, located between the Engineering and Classroom buildings on the 3rd floor, `http://etc.utep.edu`, e-mail: `etchelpdesk@utep.edu`. Alternatively, you can have access to `Matlab`® at `https://my.apps.utep.edu/vpn/index.html`.

4 Student Outcomes

Ability to

- ⇒ work with biosignal and medical image file formats and data banks.
- ⇒ identify, characterize, and specify the blocks of biosignal measurement systems (analog amplification and filtering, conversion analog-to-digital, sampling frequency, scalar quantization, windowing).
- ⇒ characterize and analyze Linear-Time Invariant (LIT) signals and systems: linearity, time invariance, causality, superposition, signal and noise variances, signal-to-noise ratio, correlation, covariance, convolution, impulse response.
- ⇒ apply basic signal spectral analysis: Fourier series, Fourier transform, discrete-time Fourier transform, discrete Fourier transform, windowing, power spectrum, spectral averaging.
- ⇒ characterize and design digital filters: FIR and IIR.
- ⇒ implement spectral analysis: parametric and nonparametric.
- ⇒ apply short-time Fourier transform, wavelet transform, wavelet packets.
- ⇒ apply multivariate analysis: principal component analysis and independent component analysis.
- ⇒ apply the Radon transform and filtered back projection.
- ⇒ apply basic classification and clustering techniques: linear support vector machine and k-means clustering.

5 Course Topics

1. Biosignals

- (a) One-dimensional and multi-dimensional sampling
- (b) Analog filtering
- (c) Quantization
- (d) Biomedical data banks

2. Measurements

- (a) Noise
- (b) Signal analysis
- (c) Mean, variance, correlation
- (d) Convolution

3. Basic Spectral Analysis

- (a) Fourier series
- (b) Fourier transform
- (c) Discrete-time Fourier transform
- (d) Discrete Fourier transform
- (e) Power spectrum
- (f) Spectral averaging

4. Noise Reduction and Digital Filters

- (a) Noise reduction
- (b) Z-transform
- (c) Transfer function
- (d) Finite impulse response filters
- (e) Infinite impulse response filters

5. Spectral Analysis

- (a) Parametric methods
- (b) Yule-Walker equations and autoregressive model
- (c) Non-parametric analysis

6. Time-Frequency Analysis

- (a) Spectrogram
- (b) Wigner-Ville distribution
- (c) Choi-Williams distribution

7. Wavelet Analysis

- (a) Continuous wavelet transform
- (b) Discrete wavelet transform
- (c) Filter banks
- (d) Denoising
- (e) Discontinuity detection
- (f) Wavelet packets

8. Multivariate analysis

- (a) Principal component analysis
- (b) Independent component analysis

9. Image Acquisition and Reconstruction

- (a) Imaging modalities: CT, PET, SPECT
- (b) Radon transform
- (c) Filtered backprojection
- (d) Magnetic resonance imaging
- (e) Functional MRI

10. Classification and Clustering

- (a) k-nearest neighbor probability density estimation
- (b) Support vector machines: the linear case
- (c) Support vector machines: the nonlinear case
- (d) k-means clustering

6 Evaluation

Activity	**%**
Participation	10
Midterm Exam	20
Final Exam	20
Homework	30
Projects	20

Note that EE 4359 and EE 5353 are both introductory cross-listed courses on systems and controls: offered at the same time, on the same day, in the same room, with the same instructor, and using the same textbook; however, the content (theoretical level and extension of the material covered; and level and extension of the work required in the assessment of learning) may differ between the two courses and should be compatible with courses at senior undergraduate and first year graduate levels, respectively, EE 4359 and EE 5353.

Formulas are part of the material assessed in EE 4359 and EE 5353, and formula sheets are not allowed during EE 4359 and EE 5353 exams. Two important rules for the exams in the classroom are: (1) closed textbook, notes and homework solutions; and (2) turned off electronic devices: calculator, computer, cell phone, smart watch, headphone, etc.

7 Grading

$A = 100 - 90\%$, $B = 90 - 80\%$, $C = 80 - 70\%$, $D = 70 - 60\%$ and $F = 60 - 0\%$.

8 Missed Exams

If you miss the Midterm Exam or the Final Exam without an acceptable excuse you will receive zero points for the missed exam. You may be excused from a scheduled exam time due to serious illness, funeral attendance, courtroom appearance, or a UTEP athletic participation. In the case of a missed exam, you must communicate and submit the appropriate documentation to me no later than ten days after the date of the missed exam. The make-up exam for either the Midterm Exam or the Final Exam is comprehensive (all the material covered in the course) on the Friday of the finals' week (tentatively, May 14, 4:00 pm to 6:45 pm). Note that there is no make-up exam for more than one missed exam.

9 Grade Assignment for Drops and Withdrawals

If you drop the course before the drop deadline, the grade is "W." However, please note the following regulation stated in the UTEP academic catalog (http://catalog.utep.edu/grad/academic-regulations/registration-and-records/): "... if the student drops after the student-initiated course drop deadline, instructors will determine a grade of "W" or "F" for each course. A grade of W will be considered only under exceptional circumstances and must be approved by the instructor and department chair for the course. A student may need to petition the instructor for a grade of "W" in writing with the necessary supporting documentation."

10 Office Hours

In addition to attending the lectures, plan to use office hours to get most out of EE 4364 - EE 5390. Feel encouraged to attend office hours and work with me on the textbook concepts and problems, `Matlab`® simulations, and preparing for the exams, homework, and projects. I can help you to learn *Systems and Controls*. You can use office hours to get more information on anything you are struggling with in class. During office hours, I can provide you with an opportunity (1) to carefully walk through an idea and (2) to get answered lots of questions that are specific to your needs, helping you to effectively learn the material. You can also use office hours to get more information on anything covered in class that triggered your interest, that you enjoyed. In addition to the regular office hours, you can contact me by email 24/7 with questions on the EE 4364 - EE 5390 material and I will reply and try to help you as soon as possible.

11 Academic Integrity

Review and comply with the policy on academic integrity available at https://www.utep.edu/student-affairs/osccr/student-conduct/academic-integrity.html.

12 Attendance

Class attendance is mandatory and will be monitored. Any student with more than two unexcused absences will be dropped out of the EE 3384. It is student's responsibility to sign the attendance sheet provided by the instructor for each class.

13 UTEP E-mail Account

To communicate with me, make sure your UTEP e-mail account is working fine. It is your responsibility to have a UTEP e-mail account working properly. By the end of the first week of classes, every student should have received at least one e-mail message from EE 3384. If you detect an e-mail problem (no EE 3384 e-mail message received by the end of the first week of classes), you should request UTEP's Help Desk assistance to fix the problem with your UTEP's e-mail account.

14 Accommodations and Support Services

If you have a disability and need classroom accommodations, please contact *The Center for Accommodations and Support Services (CASS)* at 747-5148, or by email at `cassutep.edu`, or visit their office located in UTEP Union East, Room 106. For additional information, visit the CASS website at `www.sa.utep.edu/cass`.

15 Use of Electronic Devices

The use of cell phones or electronic devices may pose a negative distraction (social media, internet, email) and disrupt classroom discussions. Phones must be silenced during classes, exams, or quizzes, and if you need to answer a call during a class, please step out of the classroom. You can use an electronic notepad for note taking only [5].

16 Copyright Statement for Course Materials

Materials in this course, unless otherwise indicated, are protected by the United States copyright law. Materials are presented in an educational context for personal use and study and should not be shared, distributed, or sold in print or digitally, outside the course without permission.

17 Related References and Reading

References Sorted by Order of Appearance

[1] J. Semmlow and B. Griffel. *Biosignal and Medical Image Processing*. CRC Press, Taylor & Francis Group, Boca Raton, FL, third edition, 2014.

[2] `Matlab`® *and its Toolboxes: Signal Processing, Image Processing, Wavelet, Statistics and Machine Learning.*

[3] https://www.mathworks.com/help/matlab/getting-started-with-matlab.html. `Matlab`® documentation.

[4] https://www.youtube.com/user/MATLAB?feature=watch. `Matlab`® tutorials.

[5] P. A. Mueller and D. M. Oppenheimer. The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science*, 25(6):1159–1168, April 2014.

[6] S. Theodoridis, A. Pikrakis, K. Koutroumbas, and D. Cavouras. *Introduction to Pattern Recognition: A Matlab Approach*. Academic Press, Burlington, MA, 2010.

[7] A. J. Izenman. *Modern Multivariate Statistical Techniques: Regression, Classification, and Manifold Learning*. Springer, New York, NY, 2008.

[8] K. Koutroumbas and S. Theodoridis. *Pattern Recognition*. Academic Press, New York, NY, fourth edition, 2008.

[9] J. V. Stone. *Independent Component Analysis: A Tutorial Introduction*. A Bradford Book. The MIT Press, Cambridge, MA, 2004.

[10] J. L. Prince and J. M. Links. *Medical Imaging Signals and Systems*. Pearson Education, Inc., Upper Saddle River, NJ, 2015.

[11] C. S. Burrus, R. Gopinath, and H. Guo. *Wavelets and Wavelet Transforms*. OpenStax-CNX, 2015. http://cnx.org/content/col11454/1.6/.

A Calendar

EE 5353 and EE 4359, TR 9:00 am – 10:20 am

January

M	T	W	R	F	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

2022

February

M	T	W	R	F	S	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

2022

March

M	T	W	R	F	S	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
					19	20
21	22	23	24	25	26	27
28	29	30	31			

2022

April

M	T	W	R	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

2022

May

M	T	W	R	F	S	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

2022

- ☐ **Midterm Exam**: March 10, Thursday
- ☐ **Course Drop/Withdrawal Deadline** April 1
- ☐ **Spring Break** March 14 to 18
- ☐ **Final Exam**: May 10, Tuesday 10:00 am to 12:45 pm