Wavelets and Signal Processing with Applications
EE 6391-002, CRN-20326
Fall 2022

Syllabus
Department of Electrical & Computer Engineering
The University of Texas at El Paso, El Paso, Texas 79968, USA
R. von Borries
rvonborries@utep.edu

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Monday, August 22, 2022

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1 General Information

- **Course ID:** Individual Studies, EE 6391-002, CRN-20326
- **Time:** Friday, 5:30 pm to 8:10 pm
- **Lecture Room:** Engineering Building E324
- **Prerequisites:** Discrete-Time Signals and Systems EE 4383
- **Computational Software:** Matlab® [uMa] [uMb] and Mathematica [Mat]
- **Instructor:** von Borries – rvonborries@utep.edu
- **Office:** Engineering Building 313
- **Office Hours:** MW 6:00 pm to 7:00 pm (room 313 or Blackboard)
  - F 4:00 pm to 5:00 pm (room 313 or Blackboard)
- **Version:** Monday, August 22, 2022
2 Description

Wavelets and Signal Processing with Applications is a doctoral level Individual Studies course implemented to enhance both (1) research expertise on wavelets and signal processing; and (2) research collaboration between UTEP and Sandia National Laboratories with application in the power systems area (e.g. detection and localization of faults in electric power lines).

3 Textbook and Numerical Computation Software

Wavelets and Signal Processing with Applications has two required resources: (1) the textbook by C. S. Burrus, R. Gopinath, and H. Guo. Wavelets and Wavelet Transforms. OpenStax-CNX, 2015. http://cnx.org/content/col11454/1.6/; (2) the textbook by S. Mallat. A Wavelet Tour of Signal Processing: The Sparse Way. Elsevier Science, 3rd edition, 2008 (available at UTEP’s library); and (3) the software Matlab® for numerical computation and visualization developed by The MathWorks, Inc. [uMa, Matlab® on MathWorks].

4 Course Topics

1. Fourier Domain [Mal08, Chapter 2]
   (a) Linear time-invariant filtering: impulse response, transfer function
   (b) Fourier integrals: in $L^1(\mathbb{R})$, in $L^2(\mathbb{R})$
   (c) Properties: regularity and decay, uncertainty principle, total variation
   (d) Two-dimensional Fourier transform

2. Discrete-time Signals and Systems [Mal08, Chapter 3]
   (a) Sampling analog signals: sampling theorem, aliasing
   (b) Finite signals: circular convolution, discrete Fourier transform

3. Introduction to Wavelets [BGG15, Chapters 1, 2]
   (a) Wavelet transform: scaling, translation, Haar scaling functions and wavelets
   (b) Continuous wavelet transforms: continuous-time and continuous-scale
   (c) Discrete wavelet transforms: discrete-time and discrete-scale

4. Multiresolution Analysis [BGG15, Chapter 3]
   (a) Signal spaces: multiresolution analysis, scaling functions, wavelet functions, discrete-wavelet transform
   (b) Parseval’s theorem
   (c) Examples of discrete wavelet expansions
5. Filter Banks and Discrete Wavelet Transform [Vai93, Chapter 4], [BGG15, Chapter 4]
   (a) Basic multirate operations: upsampling, downsampling, filtering, interpolation,
   decimation, building blocks, polyphase representation, multistage implementations
   (b) Wavelet analysis: from fine scale to coarse scale
   (c) Wavelet synthesis: from coarse scale to fine scale
   (d) Input coefficients
   (e) Multiresolution versus time-frequency analysis
   (f) Periodic versus nonperiodic discrete wavelet transforms

6. Frames [BGG15, Chapter 5]
   (a) Bases: orthogonal, biorthogonal
   (b) Frames and tight frames

7. Properties of Scaling and Wavelet Functions [BGG15, Chapter 6]
   (a) Scaling functions: time-domain and frequency-domain necessary conditions, suffi-
   cient conditions
   (b) Wavelet functions: properties
   (c) Examples
   (d) Iterating the filter bank

8. Regularity and Moments [BGG15, Chapter 7]
   (a) Regular scaling filters
   (b) Vanishing wavelet moments
   (c) Daubechies’ wavelets

9. Applications [Mal08, Chapter 11]
   (a) Matlab® toolbox
   (b) Wavelet denoising: signal denoising, image denoising
   (c) Detection and localization of faults in electric power lines
   (d) Compressive sensing

5 Evaluation

Based on activities developed by the student, under instructor guidance, including: active
participation in classroom discussions, lecture assignments with classroom summary presenta-
tions, mathematical detailed description of main concepts, and scientific programming of
several small projects.
6 Grading

\[ A = 100 - 90\%, \quad B = 90 - 80\%, \quad C = 80 - 70\%, \quad D = 70 - 60\% \text{ and } F = 60 - 0\%. \]

7 Attendance

Class attendance is mandatory and will be monitored. Any student with more than two unexcused absences will be dropped out of the EE 6391.

8 Textbooks and Related References


A Calendar

EE 6391, F 5:30 pm to 8:10 pm

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- **Labor Day, UTEP Closed** September 5, Monday
- **Course Drop/Withdrawal Deadline** October 28
- **Thanksgiving, UTEP closed** November 24 to 25