CPE381
Fundamentals of Signals and Systems for Computer Engineers

Dr. Emil Jovanov
http://www.ece.uah.edu/~jovanov
emil.jovanov@uah.edu

CPE381

- **Instructor**
  - Dr. Emil Jovanov
  - Phone: (256) 824 5094
  - e-mail: emil.jovanov@uah.edu
  - http://www.ece.uah.edu/~jovanov
- **Office hours**
  - Tuesday 3 – 5 PM, and by appointment.
- **Description** Introduction to the fundamental concepts in continuous and discrete signals and systems, and methods of signal and system analysis. Topics covered: Fourier series, Fourier and Laplace transforms, system representation by transfer functions and impulse response functions, convolution integrals, discrete time signals and system, sampling techniques, Z and discrete Fourier transforms. No credit for EE or OPE students.

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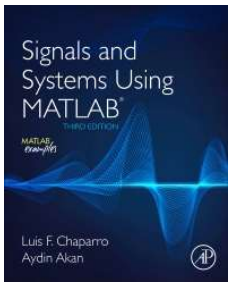
Textbook

- Luis Chaparro, Aydin Akan, *Signals and Systems using MATLAB*, 3rd Edition, Elsevier, 2019.
- Paperback ISBN: 9780128142042,
- eBook ISBN: 9780128142059



- https://www.elsevier.com/books/signals-and-systems-using-matlab/chaparro/978-0-12-814204-2
- Companion material
  - https://www.elsevier.com/books-and-journals/book-companion/9780128142042

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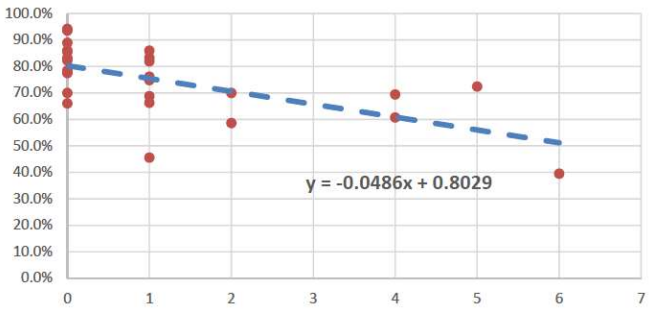
Attendance Policy

- Class attendance is mandatory.
  - Up to three unexcused absences are allowed
  - If your absence is excused, please bring your documentation within one week after the absence.
- Full credit for up to 3 absences



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Grading

- GTA: Amirahmad Ramezani ar0070@uah.edu
- Academic misconduct of any type will not be tolerated.
  - Students are expected to conform to the UAH policies concerning academic misconduct as outlined in Section 8.32 of the current UAH Student Handbook.
- Grades:
  - A (91-100), B (81-90), C (71-80), D (61-70), F (<60).
- Grading
  - Homework 20%, Quizzes 3%, Attendance 3%
  - Programming Project 20%
  - Midterm Exam 24%, Final Exam 30%
- Softcopies of all assignments must be submitted through Canvas with hard copy due at the beginning of classes.
  - No late assignments accepted.

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Important Dates

- Midterm Exam
  - Monday, March 2, 2020, 9:40 AM–11 AM
- Programming Project due
  - Phase I: Wednesday, March 4, 2020, 9:40 AM
  - Final: Wednesday, April 15, 2020, 9:40 AM
- Last day of Class
  - Monday, April 20, 2020
- Final Exam
  - Friday, April 24, 2020, 8 – 10:30 AM

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What do you have to know?

- Understand principles and system organization
- Design and implement real-time signal processing systems/algorithms
- Textbook coverage (2 semesters)
- Examples
  - Cruise control
  - Wearable health sensor
    - Cardiac monitoring example
    - Brain monitoring example

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Resources

- Canvas course page/Resources
- Textbook website
- Examples (textbook/website/Canvas)
- Matlab/Help
  - Mathworks web site

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Topics Covered

- Introduction. Continuous-time and discrete-time signals. Examples of signal processing applications.
- Continuous time Signals. Classification of time-dependent signals. Representation using basic signals.
- Continuous time Systems. System concept. LTI continuous-time systems. Linearity. Time invariance. Convolution integral. Causality. BIBO stability
- The Laplace Transform. Two-sided Laplace. One-sided Laplace. Analysis of LTI systems.
- Frequency Analysis: The Fourier Series. Eigenfunctions. Complex exponential Fourier series. Fourier series from Laplace. Time and frequency shifting. Response of LTI Systems to periodic signals.

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Topics Covered

- The Fourier TransformFourier Transform from Laplace Transform. Inverse proportionality of time and frequency. Spectral representation. Convolution and Filtering. Examples.
- Sampling Theory. Uniform sampling. Nyquist-Shannon sampling theorem.
- Discrete-time signals and systems. Basic discrete-time signals. Recursive and non-recursive discrete-time systems. Convolution sum.
- Real-time System Implementation. Programming and implementation of signal processing algorithms. Real-time performance analysis and optimization.
- The Z-transform. Two-sided Z-transform. One-side Z-transform. Inverse Z-transform with MATLAB.
- Fourier analysis of discrete-time signals and systems. Discrete-time Fourier transform. Discrete Fourier transform.
- Applications.

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ECG example

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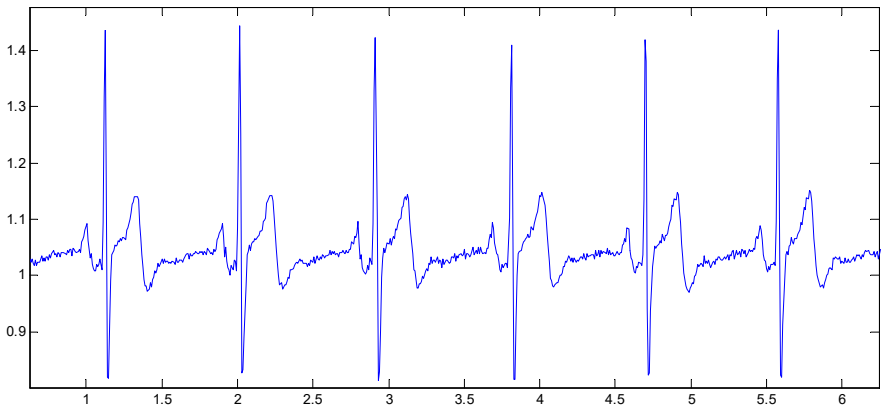
ECG



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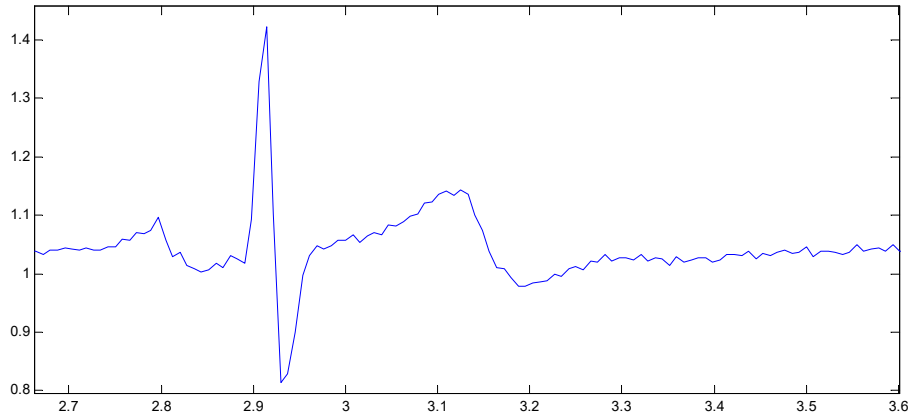
ECG – one heart beat



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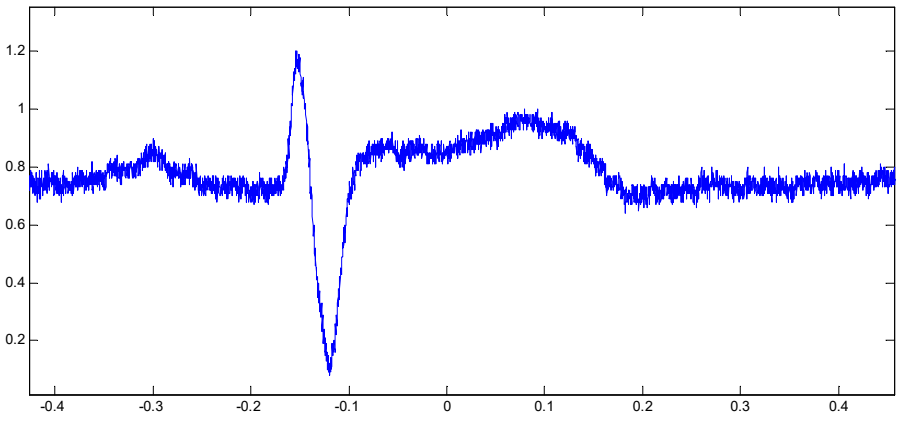
ECG with noise



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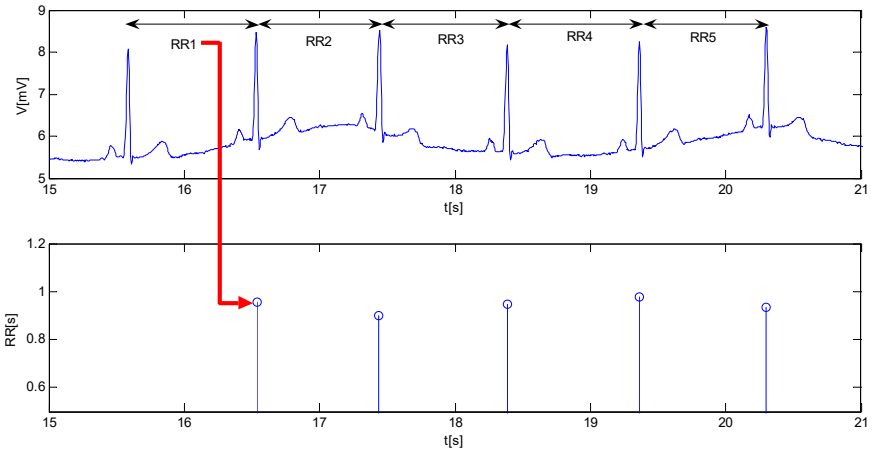
Heart Rate Variability



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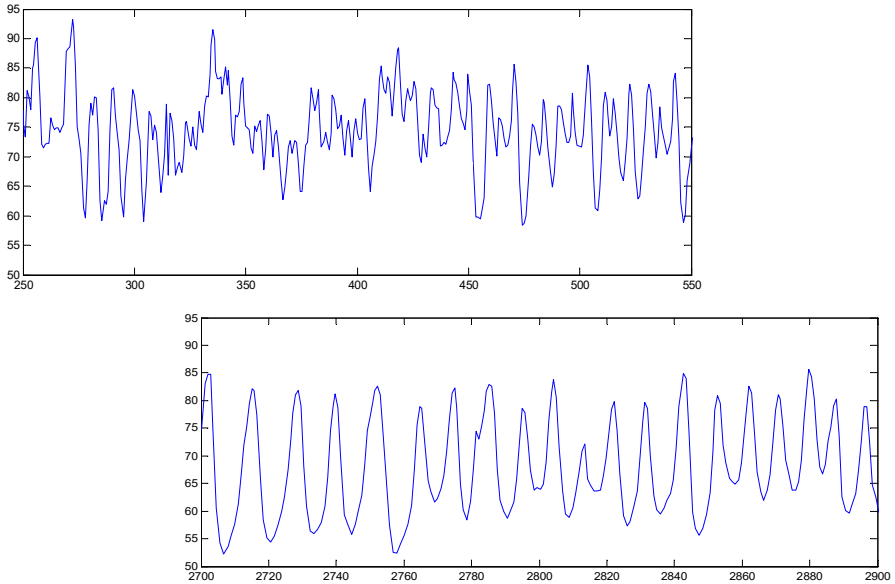
Heart Rate Variability



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Photoplethysmogram (PPG)

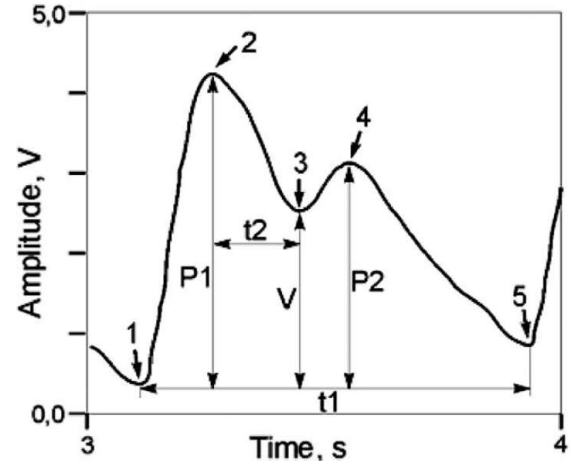

Figure 6. Example of blood volume pulse signal with amplitude and timing markers. Time t1 (between markers 1 and 5) indicates the interbeat interval and is used to calculate the heart rate. Pulse measure P1 (marker 1) is a measure of pulse amplitude. Volume at V (marker 3) is the indicator of the blood volume influenced by the dicrotic notch. Reprinted with permission from Hlimonenko, Meigas, and Vahisalu (2003).

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PPG processing

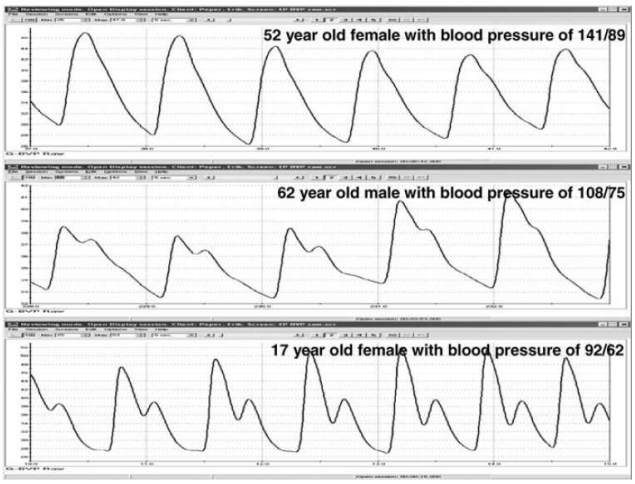

Figure 7. Comparison of finger blood volume pulse recording of parents (62-year-old father and 52-year-old mother) and child (17-year-old daughter). The mother has borderline hypertension. The absence of the dicrotic notch in the borderline hypertensive (top) tracing suggests a stiffening of the arteries, indicating increased blood pressure.

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PPG touch sensor

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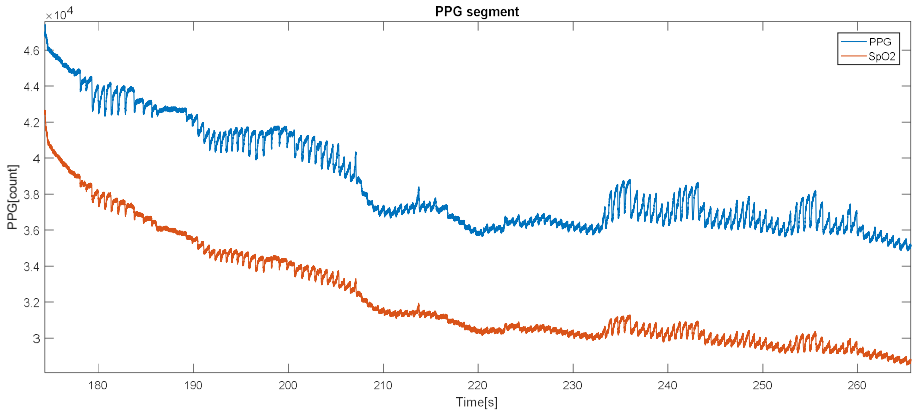
PPG example



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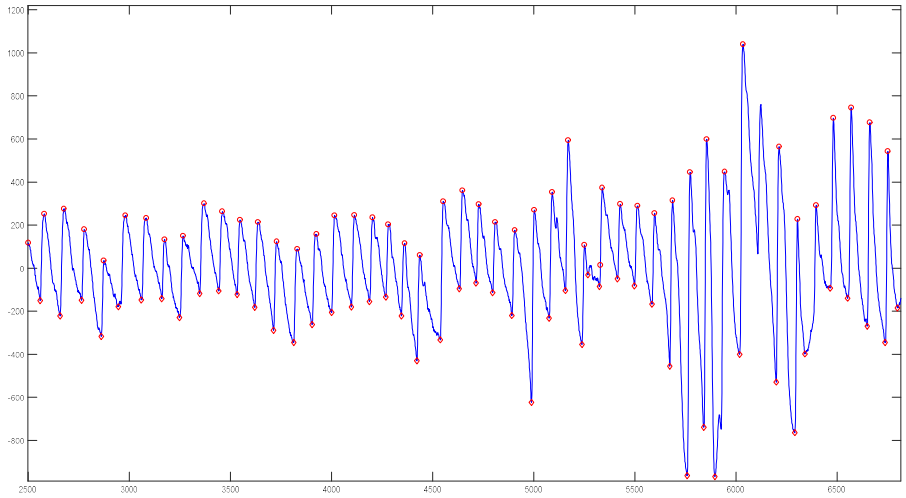
Processed PPG signal



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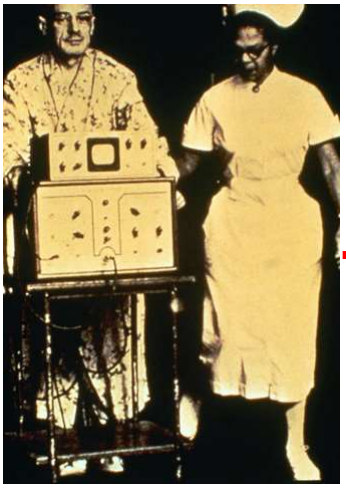
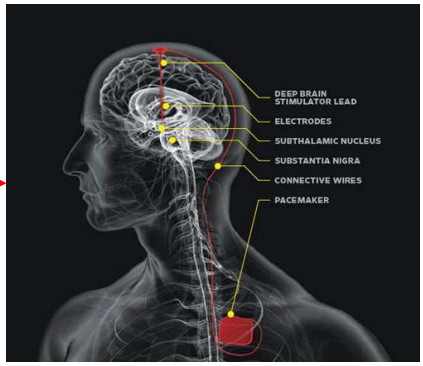
Sensor technology

- Disappearing technology





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System Architecture

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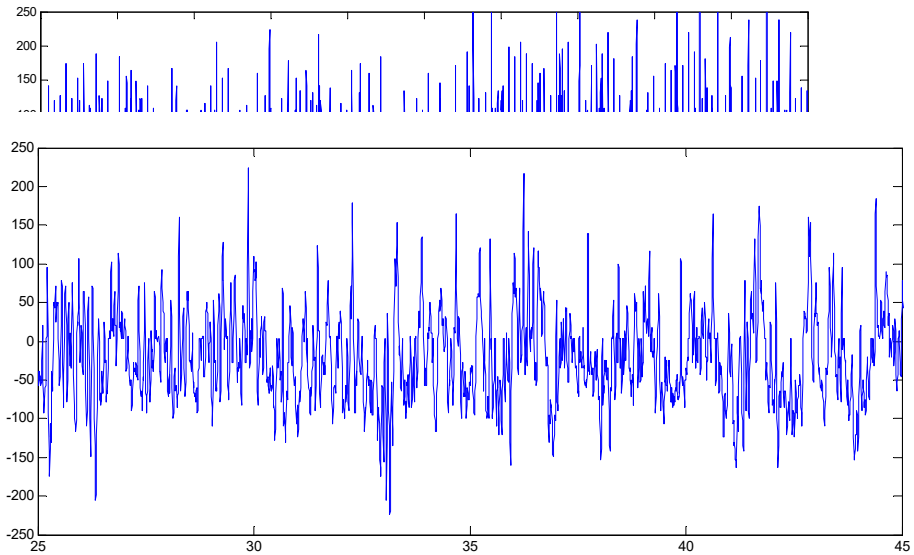
EEG Signal



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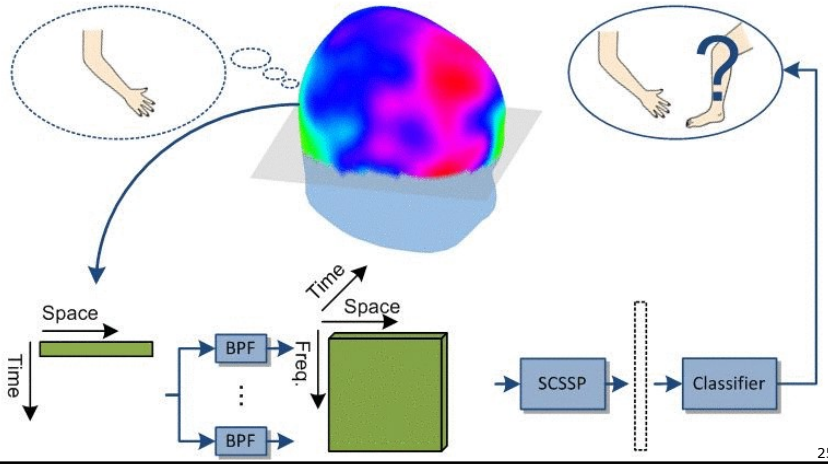
BCI example

- Brain-computer interface
- EEG/EMG/fMRI
- Direct control of artificial limbs or external devices



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Mind control

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