ECE/BIOM 431: Biomedical Signal and Image Processing

IN

Foundations in Physics

- Apply fundamental physical principles (specifically: electromagnetism, including electrical circuit principles, and both geometric and physical optics) to analyze physical systems and solve problems
- Represent information; specifically, convert information into and between various mathematical forms (e.g., equations, graphs, diagrams, tables, words)
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Statistics and Probability

- Specify probability space and probability measure for an experiment
- Understands independence and conditional probability
- Apply Bayes Rule
- Simulate samples and construct histograms
- Generate arbitrarily distributed random variables

Linear Systems

- Understand interplay between time and frequency domain analysis of LTI systems:
  - Impulse response and convolution
  - Complex frequency response and sinusoidal response
  - Bandwidth and time constant
- Compute Fourier transforms and series for standard signals
- Analyze systems in time and frequency domain using MATLAB and/or Simulink tools

Pre-requisites

- PH142 with a minimum grade of C; ECE311 with a minimum grade of C; ECE303 with a minimum grade of C

Concepts:

- Sources of biomedical signals, transducers, and noise sources
- Data visualization
- Analog-to-digital conversion, aliasing and quantization artifacts
- Improving signal-to-noise ratio through averaging or filtering
- Statistics of time-series data and multivariate statistics
- Discrete-time Fourier series as a harmonic series decomposition.
- Filter design tradeoffs between performance/sharpness and complexity
- Electrophysiology: how cells maintain membrane voltage potential, how electrical impulses are transmitted. Connection between cell membranes and semiconductor physics, and transmission line equations
- Electrocardiography, electromyography, electroencephalography
- Linear and nonlinear (neural network) classifier training and performance evaluation: true/false positive/negative rates, sensitivity/specificity, receiver-operator characteristic
- Images, data representation, visualization, and statistics
- 2D Fourier Transform and image filtering
- Image coordinate transformations and interpolation
- Selected topic in biomedical imaging (e.g. MRI, CT, microscopy, ultrasound)

Applications:

- Visualizing biomedical signals in time and frequency domain
- Applying filters to reduce noise and extract features
- Automated feature extraction and diagnosis from biomedical signals
- Biomedical imaging technologies

Tools:

- MATLAB, including Statistics, DSP, and Image Processing toolboxes
- PhysioNet database of biomedical signals

OUT

Sources of Signals and Noise

- Understand the physics, physiology, transducers, and core electronics behind modern biomedical instrumentation
- Recognize common abnormalities in an electrocardiogram, and has familiarity with how to detect problems

Filtering and Time-Series Analysis

- Design and implement digital filters to remove noise and extract features from biomedical signals
- Implement heuristic approaches (e.g. Pan-Tompkins algorithm) to extract features from biomedical signals

Data Visualization

- Visualize a collection of biomedical signals, identify features in frequency or time domain that can be used for diagnosis/classification

Statistics of Time-Series Data and Multivariate Statistics

- Construct a linear classifier or neural network and apply to features extracted from biomedical signals
- Understand tradeoffs between sensitivity and specificity

Biomedical Imaging

- Reconstruct an image from raw data in at least one of modern imaging technologies (MRI, PET, Ultrasound, etc.)

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