

**Description of Topics and
Applications of Signal Processing**

Review: Signals and Systems

- Digital vs analog signal processing
- Linear vs non-linear systems
- Deterministic vs stochastic systems
- Time/Space/Shift-invariance and convolution
- Fourier Transform and frequency analysis
- Other common signal transforms
- Sampling and Interpolation

Review: Probability Theory

- Probability basics
- Probability distribution functions (PDF), cumulative distribution functions (CDF)
- Bayesian rule, derived PDF's
- What is detection and estimation
- Different schools of estimation

Fast Fourier Transform

- Why so important?: imagine your PC decoding/encoding some song in 1 *hour* instead of 1 *sec*
- The general idea behind FFT
- Divide and Conquer
- Using FFT in filtering
- Other methods for FFT (other than divide and conquer)

Discrete Time Systems

- How to implement them?
- Digital vs discrete, effects of digitizing a signal
- Digital Filters
- Finite vs. infinite impulse response filters

Multirate Signal Processing

- Why we need them?
- Decimation and interpolation
- Rate conversion
- Filter banks

Random Signals and Linear Prediction

- Random signals review
- Stationarity and ergodicity
- Linear prediction algorithms: Levinson Durbin, Schur
- Wiener filtering

Adaptive Filters

- Challenges
- Algorithms
- Applications

Spectrum Estimation

- Parametric vs non-parametric estimation
- Eigenanalysis algorithms
- MUSIC and ESPRIT
- Applications: e.g. RADAR, EEG/MEG

Applications of Digital Signal Processing: a Few Examples

- Biomedical applications: medical imaging, EEG/MEG
- Audio/Video compression
- Biometrics: face, fingerprint, voice recognition
- Communications: wired and wireless

Biomedical Applications

- Medical imaging: MR, PET, CT, ultrasound etc
- Detection: cancer, heart stroke, organ failure
- Therapy: Radiotherapy
- Electroencephalography/magnetoencephalography
- Epilepsy, neuroscience
- EEG/MEG can allow to read thoughts (NO THIS IS NOT A MISPRINT)

Audio Video Compression

- Makes it possible to carry 20K songs in your pocket
- Video compression rates upto thousands
- Entertainment and also archiving

Biometrics

- Security applications
- Automated person identification
- Fingerprints (oldest one), face, voice recognition
- O Boy! so difficult to make computers perform tasks 5 year old human can perform very easily (e.g. recognizing a person)

Communications

- An application of signal processing
- Cell phones, TV, satellite, internet
- All around us and not possible without signal processing