GENERAL OVERVIEW OF SIGNAL PROCESSING

• Digital vs analog vs discrete time.
• Theoretical vs applied.
• Algorithm development vs implementations.
• Applications:
  1. Telecommunications.
  2. Audio
  3. Speech
  4. Analog to digital conversion
  5. Video
  6. Images
  7. Radar
  8. Sonar
  9. Biomedical
  10. Geophysical
IMAGE PROCESSING

- Image enhancement $\rightarrow$ dynamic range/histogram modifications.

- Image restoration $\rightarrow$ deblurring due to motion or being out of focus.

- Image reconstruction from partial information:
  1. Fourier transform phase.
  2. Fourier transform magnitude.
  3. Projection $\rightarrow$ projection slice theorem.

- Image compression for communications, storage, entertainment, etc. ..
VIDEO SIGNAL PROCESSING

• Implementation: VLSI architectures need to be resolved for real time operation.

• Algorithmic issues → Compression strategies:
  1. What to quantize:
     - Space domain information: pixels.
     - Frequency domain information: DCT or DFT.
     - Predictive coding: DPCM.
  2. How to quantize:
     - Uniform
     - Max - Loyd.
  3. How to allocate bits:
     - Entropy coding.
     - Arithmetic coding.
     - Hoffman coding.

• Motion Estimation:
  - Reduce redundancy → compression.
  - Frame interpolation → rate conversion.
  - Enhancement.
• Present research topics:
  – HDTV.
  – Video conferencing.
  – Compact disc $\rightarrow$ 1.5 Mb/sec.
  – Video communications over digital networks.
SPEECH

• Problems in speech:

1. Analysis and Synthesis.
2. Voiced/unvoiced discrimination, pitch detection.
3. Coding → LPC coding, pole zero modeling.
4. Speech recognition
   – Speaker dependent vs independent.
   – Connected words vs isolated words.
   – Vocabulary size.
   – Extensive training.
   – Error rate
   – Applications of AI for context dependent recognition.
AUDIO

• Problems in audio:
  1. Generation of signals → music synthesis.
  2. Storage and Transmission of signals → tapes, compact disc players.
  3. Restoration of old signals → Caruso’s operas.
  4. Faithful reproduction of signals in the form of acoustic wave → Speaker design.
  5. Adding reverb.
  8. Precise analog to digital converter design → Sigma delta converters.
TELECOMMUNICATION

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- Digital versus analog message source.
- Modulation techniques → AM vs FM vs PM.
- Error Correction Codes:
  - Block Codes.
  - Convolutional Codes.
- Compensation for channel nonidealities:
  - Atmospheric Fading.
  - Distortion → Adaptive equalization.
- Viterbi Decoding:
  - ISI.
  - CPM.
  - Convolutional decoding.
BIOMEDICAL APPLICATION

• Ultra sound.

• Magnetic Resonance Imaging.

• PET.

• X ray Tomography:
  – Projection slice theorem.
  – Application to other tomography problems such as NDE, radar, geophysics.
  – Limited angle tomography.
RADAR

• Principle of operation:
  – Estimate range by measuring time delay → short pulses.
  – Estimate doppler by measuring frequency of the received signal → Continuous wave such as sinuosid.
  – Tradeoff between range and doppler resolution.
  – Time compression waveforms. → matched filtering.

• High resolution Radar Imaging:
  – SAR → Optical Fourier Transform.
  – ISAR.
SONAR

- Similar to radar except for operating frequency and passive mode of operation.
- delay and direction of arrival estimation.
- Adaptive beamforming.
- Adaptive nulling to combat unwanted interference.
GEOPHYSICS

- Applications: Geology, Oil/mineral exploration.
- Signal processing techniques used: DECONVOLUTION: predictive, dynamic homomorphic.
IMPLEMENTATION ISSUES

- Fixed point versus floating point arithmetic.
- Accumulation of round off errors.
- Filter design and implementation: FIR versus IIR.
- Stability and robustness of algorithms.
ANALOG VERSUS DIGITAL

• Analog signal processing can handle up to 8 bits of accuracy.

• Advantages of digital:
  – Robustness with respect to aging and temperature.
  – Added flexibility.

• Which one is more appropriate for what?