DIGITAL SIGNAL PROCESSING

Introduction
What is Signal?

• A SIGNAL is a measurement of a physical quantity of certain medium.

• Examples of signals:
  – Audio patterns (voice, speech, music)
  – Visual patterns (written documents, picture, video, gesture, facial expression)
  – Change patterns of other physical quantities: temperature, EM wave, share market prices, spring displacement, etc.

• Signal contains INFORMATION!
What is Signal?

• **Medium:**
  – Physical materials that carry the signal.
  – Examples: paper (visual patterns, handwriting, etc.), Air (sound pressure, music, voice), various video displays (CRT, LCD)

• **Modality:**
  – Different modes of signals over the same or different media.
  – Examples: voice, facial expression and gesture.
What is Signal Processing?

- Ways to manipulate signal in its original medium or an abstract representation.
- Signal can be abstracted as functions of time or spatial coordinates.
What is Signal Processing?

• **Types of processing:**
  – Transformation
  – Filtering
  – Detection
  – Estimation
  – Recognition and classification
  – Coding (compression)
  – Synthesis and reproduction
  – Recording, archiving
  – Analyzing, modeling
The task of DSP is to process sampled signals (from A/D analog to digital converter), and provide its output to the D/A (digital to analog converter) to be transformed back to physical signals.
Digital Signal Processing (DSP)
Example: Electro Cardio Graph (ECG)
Early Signal Processing Systems

- Implemented with either main frame computer or special purpose computers.
- Batch processing rather than real time, streamed data processing.
- Accelerate processing speed is of main concern.
- Key approach:
  - Faster hardware
  - Faster algorithms
- Faster algorithms
  - Reduce the number of arithmetic operations
  - Reduce the number of bits to represent each data
  - Most important example: Fast Fourier Transform
DSP Development
1960's: Mainframe
DSP Development
The end of 1970s – 1980s : Intel 2920 DSP
DSP Development

1980's: DSP Board with an ADSP 2181 chip
DSP Development
Video DSP Chip
DSP Development
Video DSP Card
DSP Development
ASIC Chip
DSP Development
Audio DSP Card
The Applications of DSP
Applications of DSP in Engineering & Science

- TELECOMMUNICATION
- MEDICAL
- BIOTECHNOLOGY
- MILITERY
- INDUSTRIAL
- SCIENTIFIC
- SPACE
- COMMERCIAL
DSP Applications in Telecommunication

- Image/Video Compression
- Video Conferencing
- Speech/Audio Compression
- Data Compression
- Signal Multiplexing
- Echo Cancellation/Reduction
- Mobile Communication
DSP Applications in Telecommunication

Echo Canceller

PSTN  →  Echo Cancellers  ←  Wireless

PCS Network

Central Office  →  Hybrid  ←  Central Office

Long distance (digital)

Four wire

Two wire to home

Hybrid leakage transfer function

$X_k$
DSP Applications in Telecommunication

Signal Multiplexer
DSP Applications in Medical

- Diagnostic Imaging
  - Computer Tomography
  - Magnetic Resonance Imaging
  - Ultrasound

- Medical Image Storage and Retrieval

- Electrocardiogram Analysis
DSP Applications in Medical Diagnostic Imaging
DSP Applications in Medical Magnetic Resonance Imaging
DSP Applications in Medical Electrocardiogram Analysis
DSP Applications in Biotechnology

• Genomic Signal Processing
• Biometric Signal Processing
DSP Applications in Biotechnology
Genomic Signal Processing

DNA schematic
sugar-phosphate backbone

5' A T T C A T A G T 5'
3' T A A G T A T C A 3'

DNA
AACTGGCATCCGGGAATAAGGTC

x_A(n) 1 1 0 0 0 0 0 1 0 0 0 0 0 1 1 0 1 1 0 0 0 0
DSP Applications in Biotechnology
Biometrics Signal Processing

Psychological Characteristic

Behavioural Characteristic

Bill Clinton
DSP Applications in Biotechnology

Biometrics with Iris Recognition
DSP Applications in Military

- Secure Communication
- Radar and Sonar
- Ordnance Guidance
- Intelligent Sensory Analysis by Remote Space Probes
DSP Applications in Military
Secure Communication

Figure 2: Re-use of NSK 200 and Sectra Tiger platform in Tiger XS.
DSP Applications in Military
Ordnance Guidance
DSP Applications in Military
Submarine
DSP Applications in Military Radar
DSP Applications in Military
Sonar
DSP Applications in Industry

• Process Monitoring & Control
• CAD and Design Tools
• Nondestructive Testing
• Oil and Mineral Prospecting
Sequence of high speed video images of a water balloon falling on pavement
DSP Applications in Industry
CAD and Design Tools

Software

Block Diagram

Chip

Layout Design
DSP Applications in Science

- Earthquake Recording & Analysis
- Spectral Analysis and Data Acquisition
- Simulation Modeling
- Space Photograph Enhancement
DSP Applications in Science
Earthquake Analysis
DSP Applications in Science
Earthquake Lab Equipment
DSP Applications in Science
Spectral Analysis for DWDM
Models of Metal Recovery
DSP Applications in Science
Equipment Layout
DSP Applications in Space
Space Photo Enhancement

Original Image

Enhancement
DSP Applications in Space
Intelligent Sensory Space
DSP Applications in Commercial

• Movie Special Effects
• Multimedia Presentation
• Hifi Music Reproduction
DSP Applications in Commercial Movie Special Effect
DSP Applications in Commercial Hi-Fi Music Reproduction
DSP Applications in Commercial Hi-Fi Music Reproduction
Digital Signal Processing (DSP)

Key points of operation in DSP
- Correlation/Convolution
- Transformation
- Filtering
- Modulation
References


• Dadang Gunawan, “Lecture Note DSP”, EE Department University of Indonesia, 2005.