5月 - 北京、上海、深圳
2014 MATLAB 巡回研讨会
迎接复杂性设计的挑战
Practical Signal Processing Techniques
with MATLAB
实用信号处理技术

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Agenda

- Signal Processing and Its Applications

- Practical Signal Processing Examples
  - Signal Generation
  - Signal Measurement
  - Signal Smoothing
  - Signal Similarity

- Signal Processing Workflow

- Summary
Signals are Everywhere
Why Do Signals Need Processing?

- Convert the physical “real world” to information
- Eliminate noise, distortion, fading, echoes, interference, etc.
- Optimize resource utilization
- Improve system performance
  - Capacity and speed of mobile networks
  - Range and accuracy of RADAR
What is Signal Processing?

Mathematical algorithms that

- Extract information from data and the physical world
- Enable communications and many other electronic systems

Fundamental concepts

- Analog-to-digital (A/D) and Digital-to-analog (D/A) conversion
- Spectral analysis
  - Estimate frequency components in a signal
  - Key buzzword: FFT (Fast Fourier Transform)
- Filtering
  - Enhance or remove specific elements of a signal
Example: Internet of Things (IoT)

Pump vibration monitor

Send/store vibration data

Live information on mobile app

95% of pumps fail soon after the vibration reading climbs above 1.35

Analysis of pump failure data

Source: iAquaLink by Zodiac

Please contact technical support – your pump is likely to fail soon
What’s in Signal Processing Toolbox?

- Signal generation, visualization and measurement
- Signal transforms
- Digital filter design, analysis, and implementation
- Statistical signal measurements and data windowing functions
- Power Spectral Density estimation algorithms
Example: Generate commonly used waveforms

- Periodic (Square, Sawtooth)
- Aperiodic (Chirp)
- Specialty Functions
  - Pulstran function
  - Sinc function
Signal Identification

- What is the signal telling you?
- How do I tell signal apart from noise?
- Are there similarities between these signals?
- Is this signal periodical?
Example: Measure Sunspot Activity

- Sunspots are temporary phenomenon that appear as dark spots
- Two methods to determine the cycle of the sunspot activity
  - Time Series Analysis
  - Frequency Analysis
Example: Align Signals With Different Start Time
Measurement Functions

- **Signal Statistics**
  - Min/Max, Mean, Median, RMS
  - PeakToPeak, PeakToRMS

- **Pulse Measurements**
  - State Levels
  - Rise/Fall Time, Overshoot/Undershoot, Settling Time
  - Pulse Width/Period/Frequency, Duty Cycle

- **Channel power**
  - Bandpower, ENBW

- **Distortion Measurements**
  - SFDR, SINAD, SNR*, THD, TOI
Examples: Clock Signal Measurement

- State levels
- Pulse period
- Pulse duty ratio
- Overshoot and undershoot
- RMS
Signal Smoothing

- Why smoothing?
  - Better visual and graphics
  - Removing interference information

- Types of smoothing
  - Removing trend from a signal
  - Remove spikes
  - Removing noises
  - Recovering missing samples
Filter Design in Signal Processing Toolbox

- **Filter Types**
  - lowpass, highpass, bandpass, bandstop, Hilbert, differentiator, pulse-shaping, and arbitrary magnitude

- **Design Methods**
  - FIR: Parks-McClellan and Kaiser window
  - IIR: Butterworth, Chebyshev Type I and Type II, and elliptic

- **Analyses**
  - Magnitude response, phase response, and group delay
  - Impulse response and step response
  - Pole-zero plot
Example: Analyze and Filter an EKG signal

Signal Processing Algorithms

1. Load EKG Signal
2. De-trend the EKG signal
3. Low Pass Filtering
4. Delay Compensation
5. Visualize
Example: Removing Spikes
Example: Recovering Missing Sample
What We have Seen …

- De-trending an EKG signal
- Visualize in power content of signal
- Design and apply a lowpass IIR filter
- Compensate the delay introduced by the filter
- Removing spikes from a signal
- Recover missing data in a signal
Signal Processing Workflow

Access
- Files
- Software
  - Code & Applications
- Instruments/Devices

Explore & Discover
- Signal Analysis & Visualization
- Algorithm Development
- Application Development

Share
- Reporting and Documentation
- Outputs for Design

Automate
Summary

With MATLAB and Signal Processing Toolbox, you can perform

- Signal Generation, Visualization and Measurement
- Signal transforms
- Analog and Digital filter design, analysis, and implementation
- Statistical signal measurements and data windowing functions
- Power Spectral Density estimation algorithms