Digital Signal Processing

Lab 1: Signal generation & analysis in Matlab

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Digital Signal Processing: Lab Sessions

- **Session 1:** Signal generation & analysis in Matlab
- **Session 2:** Embedded DSP implementation of energy-based voice activity detector
- **Session 3:** Filter analysis & implementation in Matlab
- **Session 4:** Embedded DSP implementation of FIR filter
- **Session 5:** NLMS adaptive filtering in Matlab
- **Session 6:** Embedded DSP implementation of NLMS adaptive filter
- **Session 7:** Embedded DSP implementation of acoustic echo canceller

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Signal generation & analysis in Matlab

- In this session, we'll use these **built-in Matlab functions**:
  - basis arithmetic: `+, -, *, /, sin, cos, abs, ...`
  - random signal generation: `rand, randn, ...`
  - frequency analysis: `fft, ifft`

    (FFT implementation of discrete Fourier transform)
  - time-frequency analysis: `spectrogram`

    (FFT implementation of short-time Fourier transform)
  - audio I/O: `audioread, audiowrite, soundsc, ...`
  - visualization: `figure, plot, ...`
- Remember: **Matlab Help** is your best friend

```
>> help
>> doc
```

Signal generation & analysis in Matlab

- **Exercise 1.1: Generation & analysis of sinusoids**
  - Generate a signal of length 10 s sampled at 16 kHz, containing a sum of sines of 50, 100, 200, 500, 1000, 2000, 4000 and 6000 Hz. Plot the signal as a function of time.
  - Compute and plot the frequency magnitude spectrum. Think about what you observe.
  - Compute and plot the spectrogram. How to interpret this? Play around with the spectrogram parameters (window size, FFT size, …) and see how the figure changes.
  - Play back the signal through your PC loudspeaker. Make sure clipping is avoided!

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- **Exercise 1.2: Generation & analysis of sinusoids**
  - Multiply the signal from Exercise 1.1 with a gain factor that linearly decreases from value 1 at time = 0 s to value 0 at time = 10 s.
  - Plot again the time-domain signal, the frequency magnitude spectrum, and the spectrogram, and listen to the audio playback of the signal.
  - What do these results tell you about the frequency spectrum of a non-stationary signal?

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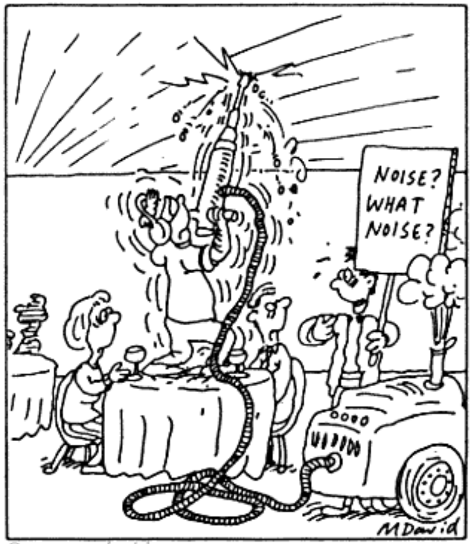
- **Exercise 1.3: Generation & analysis of random noise**
  - Generate a Gaussian white (pseudo-)random noise signal of length 10 s sampled at 16 kHz. Plot the signal as a function of time and listen to the audio playback of the signal.
  - Compute and plot the frequency magnitude spectrum as well as the spectrogram and interpret the results.
  - Square the frequency magnitude spectrum values and transform the result back to the time domain. Plot the resulting time-domain signal. What does this represent? Why does it look like this?



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- **Exercise 1.4: Recording & analysis of speech**
  - Record about 10 s of your own voice using your favorite audio recording/editing software.
  - Save the recording in a WAV file using a sampling frequency of 16 kHz and 16-bit quantization.
  - Open the recorded WAV file in Matlab. Plot the signal as a function of time and listen to the audio playback of the signal.
  - Compute and plot the frequency magnitude spectrum as well as the spectrogram and interpret the results.
  - Repeat the last 3 steps using an 8 kHz sampling frequency. What do you observe?