Convolution

Lab 6, DSP

Objective

Students should know the convolution equation and be able to implement it in Matlab

Theoretical aspects

For two signals $x[n]$ and $h[n]$, the **convolution** operation is defined as

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$

When one signal is the input to a LTI system, and the other signal is the impulse response of the system, the convolution defines the output of the system.

Properties of convolution:

- it is commutative
- it is associative
- convolution with $\delta[n]$ leaves the signal unchanged

LTI systems interconnection:

- connection in series <=> convolution of their impulse responses
- connection in parallel <=> *co* sum of their impulse responses

Exercises

1. Implement a Matlab function `y = myconv(x,h)` which implements convolution. The function is given two input vectors and outputs the resulting vector.

2. Load an audio signal and extract an 100000-long sequence of it. Convolve the sequence with the impulse response $\{1/6, 1/6, 1/6, 1/6, 1/6, 1/6\}$. Play the resulting sequence and compare with the original.

3. Download the "IM Reverbs Pack" archive from http://www.voxengo.com/impulses/. It contains impulse responses that create a reverberation effect.

   a. Unzip and play the file "Scala Milan Opera Hall.wav".
   b. Load file "Scala Milan Opera Hall.wav" in Matlab (use `audioread()`). Restrict the data to about 1 second length. Call the resulting vector `h`.
   c. Load the first 4 seconds of "Kalimba.mp3" (use `audioread()`), convolve with `h` and play the result (use `audioplayer()`). How does the signal sound? What audio effect did we implement here?

4. Check the length of the convolution result vector, and deduce the general rule: what is length of the convolution of two signals of lengths L_1 and L_2?

5. Redo exercise 2 using the `conv()` function from Matlab.

Final questions

1. TBD