Lab 5

School of Architecture, Civil and Environmental Engineering

EPFL, SS 2018-2019

http://disal.epfl.ch/teaching/signals_instruments_systems/

Lab 5 Outline

- Concepts:
  - Convolution
  - Sampling
  - Aliasing
  - Reconstruction
- Tools:
  - Matlab

Part 1: Continuous Convolution

$$(f * g)(t) = \int_{-\infty}^{\infty} f(\tau) \cdot g(t-\tau) d\tau$$

- For each value of *t*:
  1. Flip (reflect) ***g***
  2. Shift ***g*** by ***t***
  3. Multiply ***f*** and ***g***
  4. Integrate over ***τ***

1) $g(\tau) \rightarrow g(-\tau)$

2) $g(-\tau) \rightarrow g(t-\tau)$

3) $f(\tau) \cdot g(t-\tau)$

4) $\int_{-\infty}^{\infty} f(\tau) \cdot g(t-\tau) d\tau$

- Note that the result does **not** depend on τ!

Part 2: Discrete Convolution

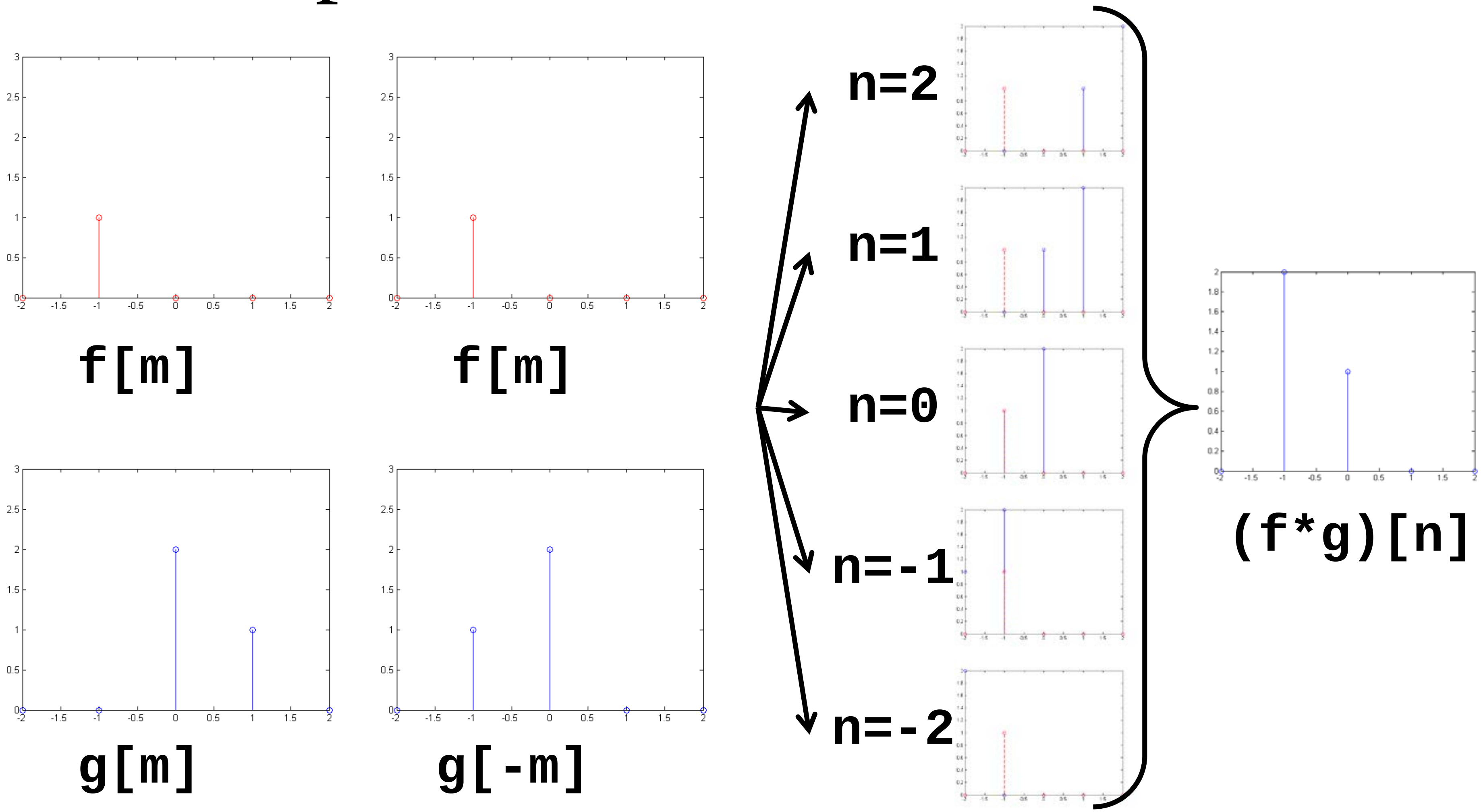
$$(f * g)(t) = \int_{-\infty}^{\infty} f(\tau) \cdot g(t-\tau) d\tau$$

$$\downarrow$$

$$(f * g)(n) = \sum_{m=-\infty}^{\infty} f(m) \cdot g(n-m)$$

- Similar to the continuous version
- The integral becomes an infinite sum
- Matlab, operating on a computer, can only emulate continuity and therefore use the discrete version with an adjustable discretization level in time and amplitude

Example of Discrete Convolution



Part 3: Sampling and reconstruction

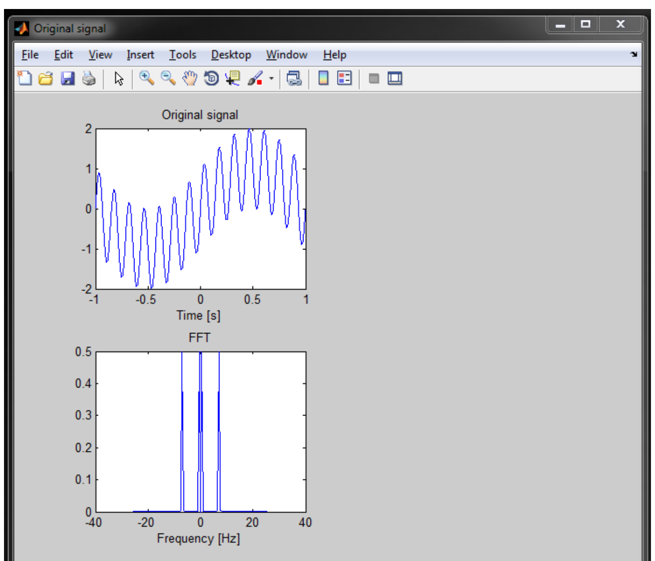
Signal generation → Filtering → Sampling → Reconstruction

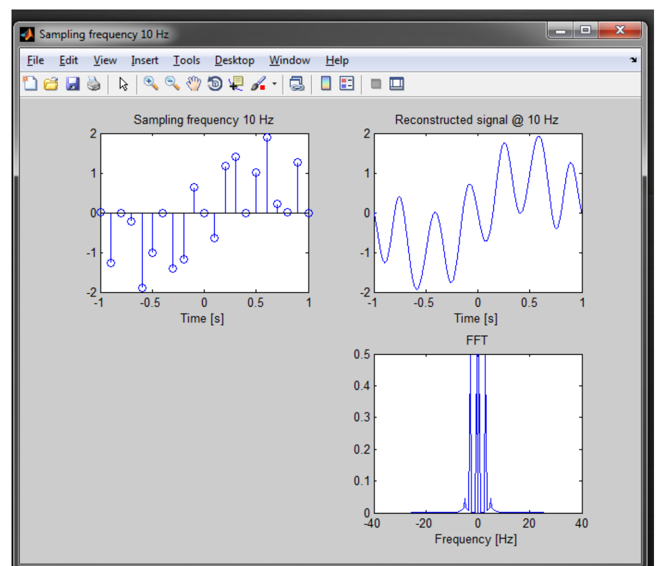
Signal generation
- $f(t) = \sum_i A_i \sin(2\pi f_i t)$
- frequencies
- amplitudes

Filtering
- Not in this lab

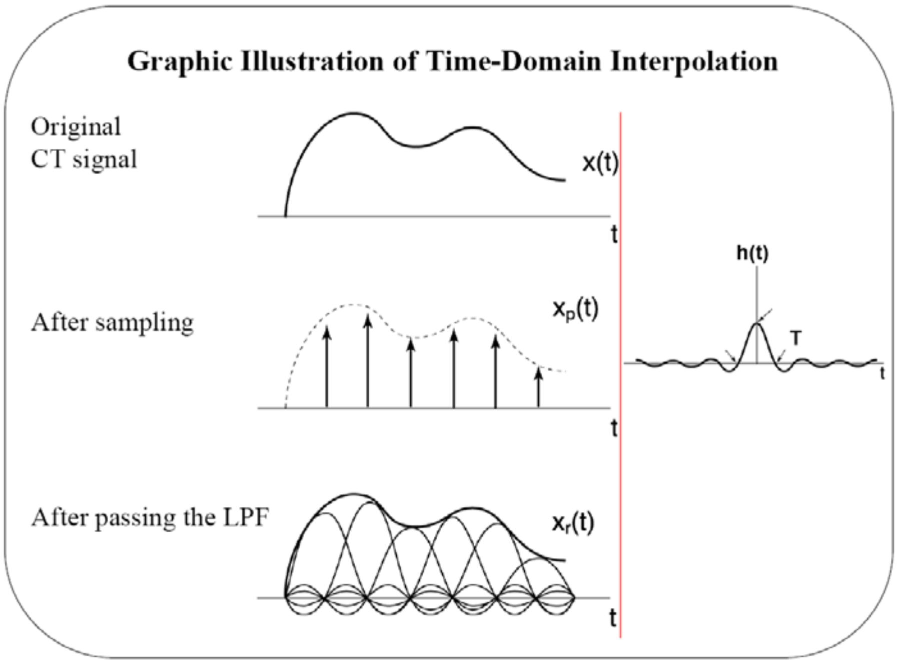
Sampling
- Sampling frequency

Reconstruction
- Linear interpolation
- Whittaker-Shannon





Reconstruction:
Linear vs. Wittaker-Shannon



Interpolation Methods

- Bandlimited Interpolation
- Zero-Order Hold
- First-Order Hold — Linear interpolation