Digital Signal Processing Introduction

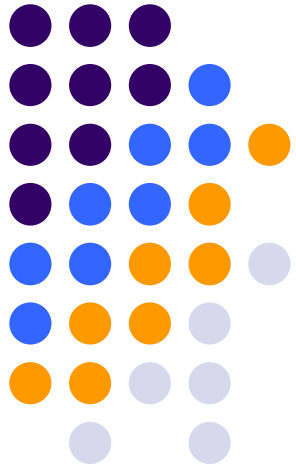
Gergely Tuboly, PhD

Assistant Professor

University of Pannonia

Department of Electrical Engineering and Information Systems

tuboly.gergely@virt.uni-pannon.hu



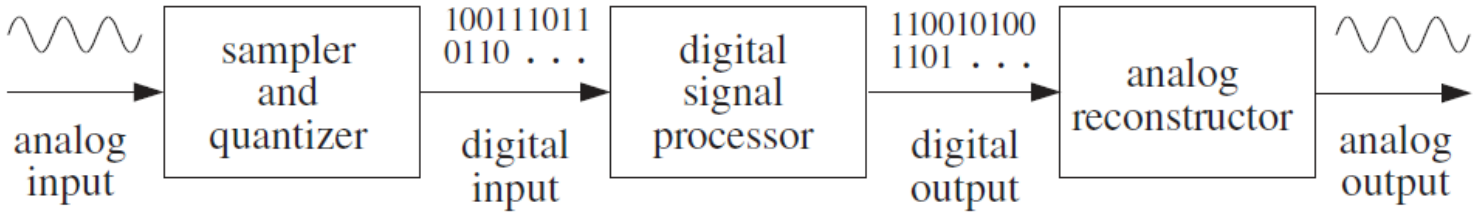
About the Course

- Structure: 2 theoretical and 2 practical (seminar) classes
- Attendance: optional for the theoretical part and mandatory for the seminars
- Requirements:
  - Signature: attendance on the seminars
  - Final mark: at least 50% result of the written exam
- Website
  - http://virt.uni-pannon.hu/index.php/hu/oktatas/tantargyak/284-digitalis-jelfeldolgozas

What is Digital Signal Processing?

- Necessary „toolkit” of today’s technology
- Involved in all cases when processes of the outside world are to be analyzed by computers
- Some of the many fields it is used in:
  - Telecommunication (phone, radio, TV, computer networks – Internet)
  - Recording, playing and manimpulating audio signals (sound, music)
  - Motion detection
  - Seismology
  - Biomedical engineering
    - ECG, EEG, Ultrasound, CT, MRI, etc.

A Typical DSP System



- Input: analog signal
- A/D conversion (analog → digital signal)
- Signal processing (digital signal)
- D/A conversion (digital → analog signal)
- Output: analog signal

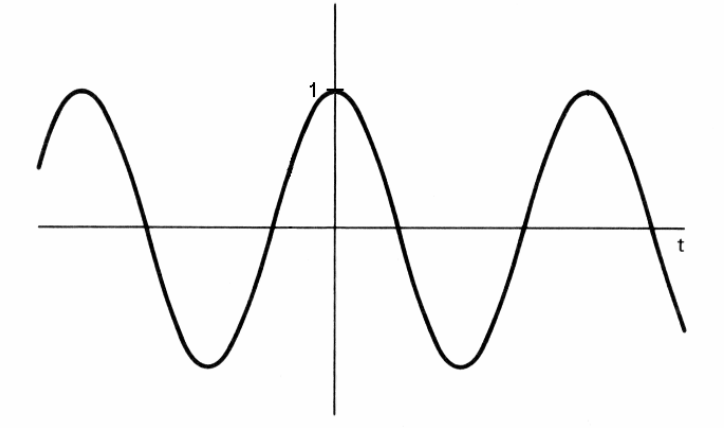
Definition(s) of Signal

- Information about the behavior or attributes of a phenomenon
- A function of time: e.g. $f(t)$
- Input and output of a system

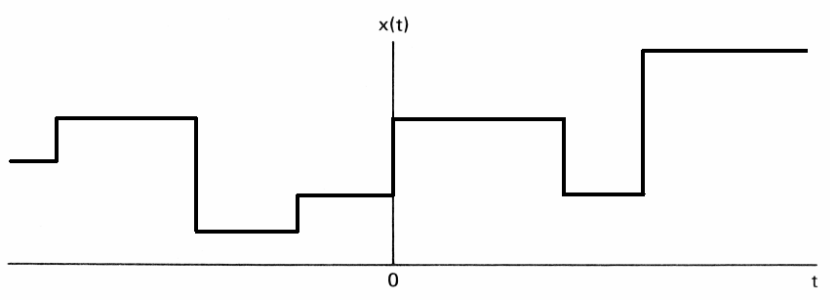
Categories of Signal

- There are many categorizations, e.g.:
  - Analog: continous both in time and amplitude
  - Continous-time (CT): continous in time
  - Discrete-time (DT): discrete in time
  - Digital: discrete both in time and amplitude

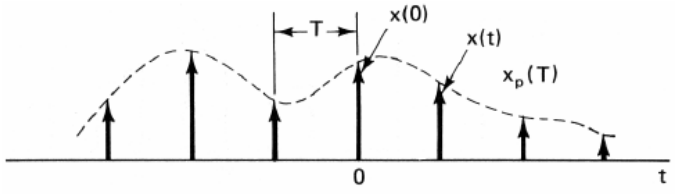
Signals – Examples



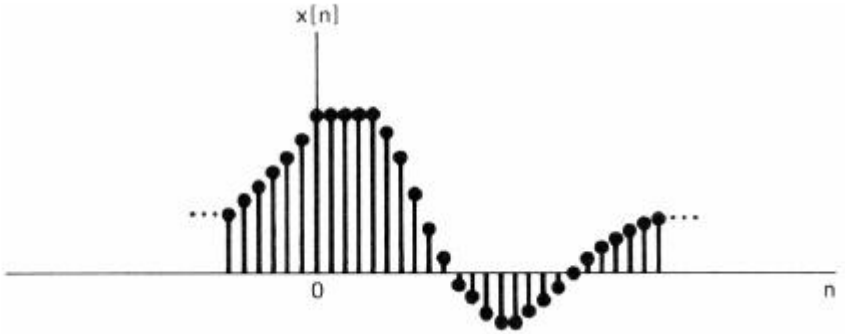
Analog



Continous-time

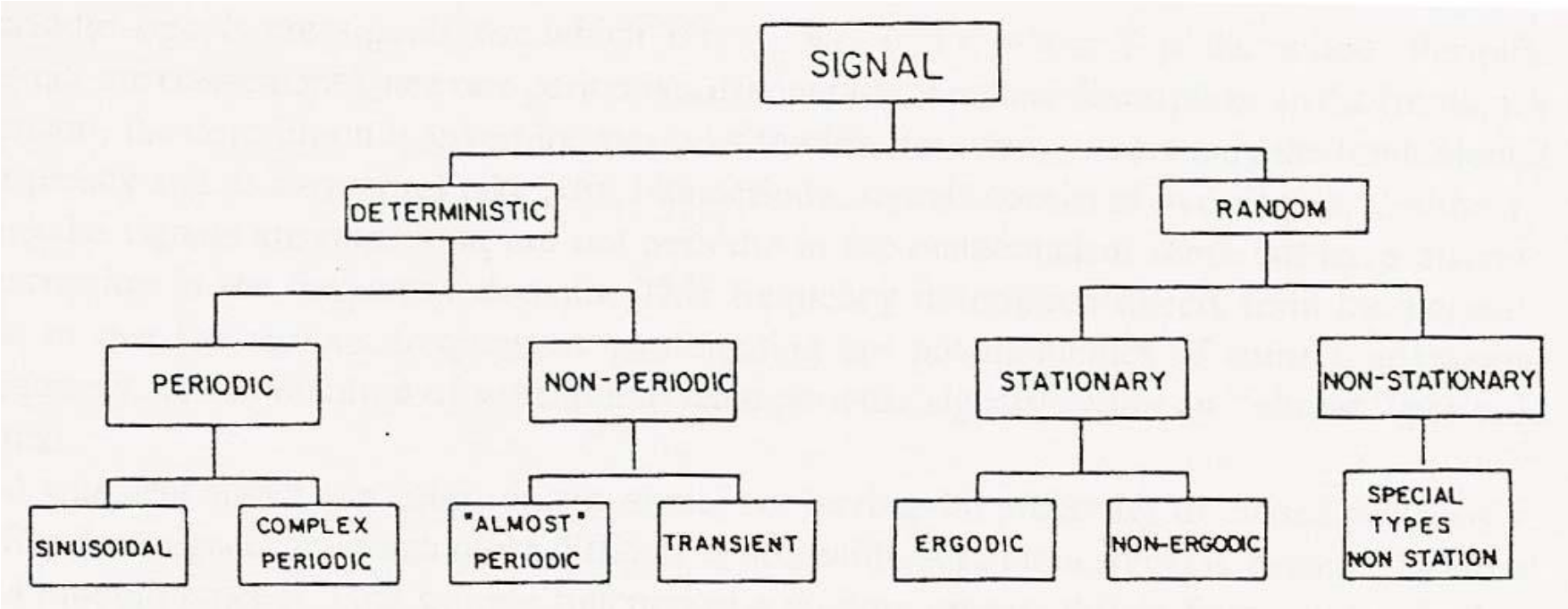


Discrete-time



Digital

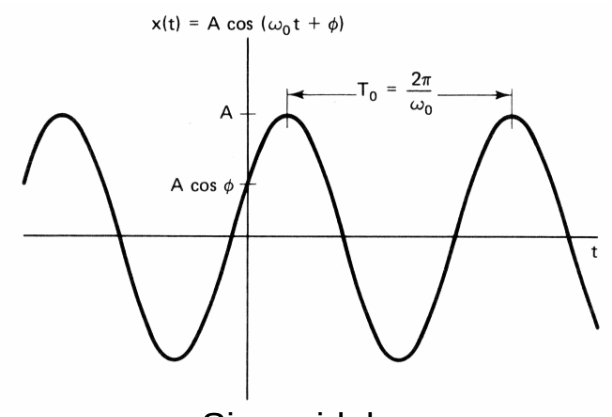
Categories of Signal



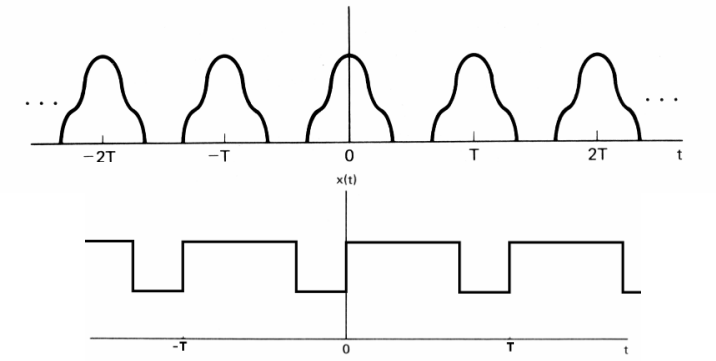
Deterministic Signals

- Deterministic: there is no uncertainty in it
  - Periodic: there is a constant *C* such that $f(t) = f(t + C)$
    - Sinusoidal: can be described as $f(t) = A\sin(2\pi ft + \theta)$, where *A* is the amplitude, *f* is the frequency (in Hz) and θ is the phase (in radian)
    - Complex (general) periodic: other periodic (non-sinusoidal) signals
  - Non-periodic
    - „Almost" periodic (quasiperiodic): not exactly periodic, but „similar" $f(t) \approx f(t + C(t)), \qquad |f(t) - f(t + C(t))| < \varepsilon$
    - Transient: finite, „short-lived" signals: $\int_{-\infty}^{+\infty} f^2(t)\mathrm{d}t < \infty$

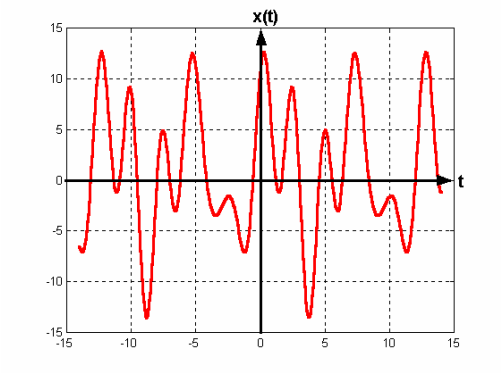
Deterministic Signals – Examples



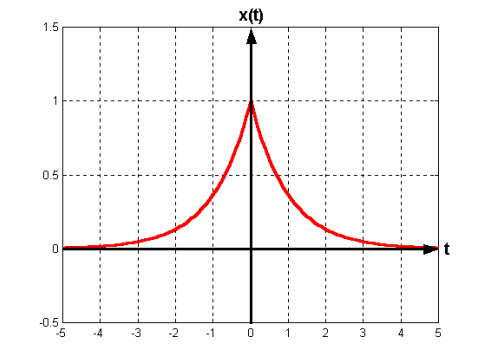
Sinusoidal



Non-sinusoidal



Quasiperiodic

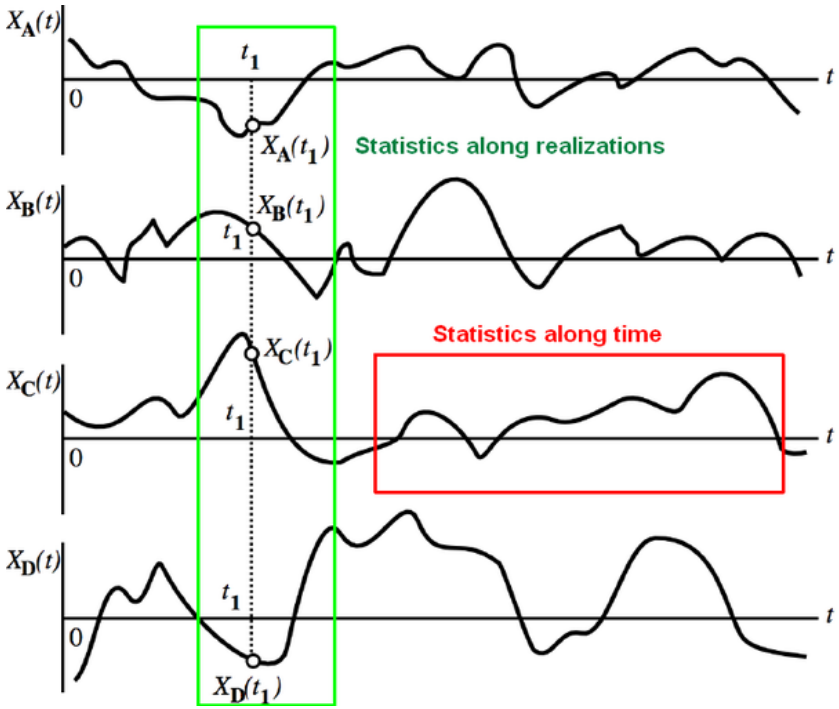


Transient

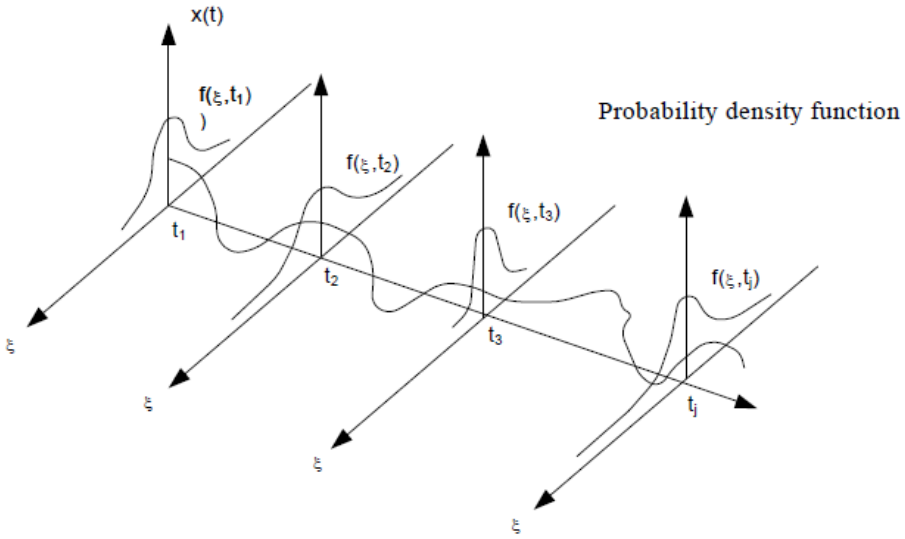
Random Signals

- Random: it varies in a stochastic way
  - Stationary: the statistical properties (expected value and standard deviation) are time invariant
    - Ergodic: the statistical properties along time and observations are the same
    - Non-ergodic
  - Non-stationary

Random Signals – Examples



Stationary, ergodic



Non-stationary

Stochastic Processes – Examples

- *X*1: stochastic process – choosing always D6 and rolling 100 times
- *X*2: choosing D4 or D6 with 50% probability and rolling 100 times