University of Ljubljana
Faculty of Computer and Information Science

# DIGITAL SIGNAL PROCESSING

Course: 63744
Professional study programme: elective, 2nd / 3rd year
University study programme: general elective

Lecturer: Prof. Franc Jager, PhD

Course: 63744

# Opis predmeta

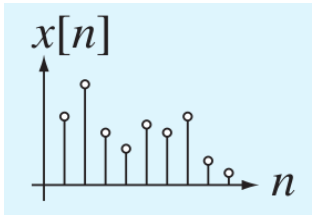
- Cilj: Osvojiti temelje teorije digitalnega procesiranja signalov.
- Predmet pokriva osnovne koncepte digitalnega procesiranja signalov.
- Študirali bomo: vzorčenje časovno zveznih signalov, časovno diskretne signale, predstavitve signalov v frekvenčnem prostoru, časovno diskretne sisteme, frekvenčne odzive časovno diskretnih sistemov, digitalne filtre, načrtovanje digitalnih filtor in filtriranje slik.
- Pokrite teme pri tem predmetu vključujejo: vzorčenje časovno zveznih signalov, linearne časovno nespremenljive (LČN) sisteme, časovno diskretno Fourierjevo transformacijo (ČDFT), diskretno Fourierjevo transformacijo (DFT), analizo signalov in linearnih časovno nespremenljivih (LČN) sistemov v frekvenčnem prostoru, ciklično in linearno konvolucijo, spektralno analizo preko DFT, tehnike načrtovanja in realizacije digitalnih filtrov z neskončnim (NEO) in končnim (KEO) enotinim odzivom, dvo-dimenzionalne signale in uvod v postopke digitalnega procesiranja slik.
- MATLAB in C bosta uporabljena pri predmetu.

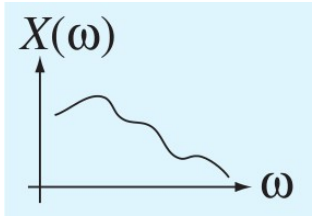
# Course description

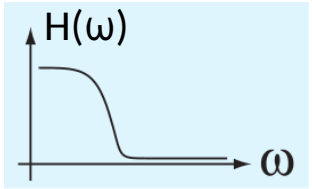
- Objective: To adopt fundamentals of Digital Signal Processing Theory.
- The course covers basic concepts in Digital Signal Processing.
- We are going to study: sampling of continuous-time signals, discrete-time signals, frequency domain representation of signals, discrete-time systems, frequency response of discrete-time systems, digital filters, digital filter design and image filtering.
- The topics covered in this course include: sampling of continuous time signals, linear time-invariant (LTI) systems, the Discrete-Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), Z-transform, transform analysis of signals and of linear time-invariant (LTI) systems, circular and linear convolution, spectral analysis via the DFT, techniques for designing and applying Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) digital filters, two-dimensional signals, and introduction to digital image processing procedures.
- MATLAB and C will be used during the course.

# Course syllabus

- Introduction to Digital Signal Processing
- Discrete-time signals and systems
- Spatial filtering
- Fourier transform
- Discrete Fourier transform
- The Z transform
- Transform-domain analysis of discrete-time signals and systems
- Digital filters
- Digital filter design
- Selected topics

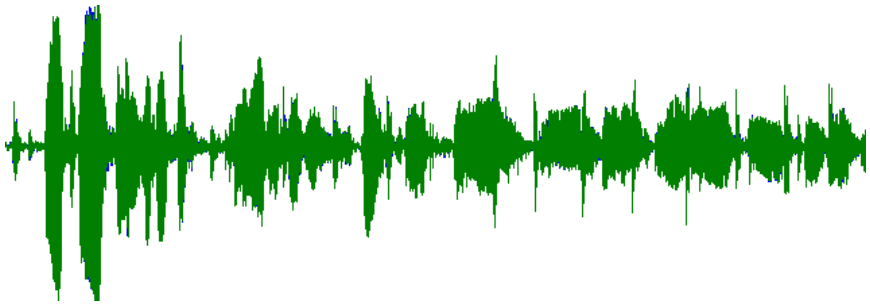


# Seminars during laboratory sessions

- Seminars at the course relate to processing of:
  - sound, voice, speech, music
  - medical signals (electrocardiogram)
  - brain waves (motor movement imagery)
  - grey scale and color images



# Environments, sites, and tools for laboratory sessions

- Web classroom, *https://ucilnica.fri.uni-lj.si*

- Materials available on Web classroom
  - Lecture notes
  - Laboratory session materials
  - Archives containing relevant data files and records (sounds, voice, music, speech) that will be used

- PhysioNet site, *http://www.physionet.org*
  (the research resource for complex physiologic signals)
  - Databases: EEG Motor Movement/Imagery Dataset (EEGMMI DS),
    MIT-BIH Arrhythmia Database (MIT/BIH DB)
  - Software: WFDB library, lightWAVE, gnuplot, ATM tools

- Ubuntu 18.04 (LTS), (20.04), Linux

- Matlab
- C, (C++)

# Literature

- Lecture notes, web classroom, and notes from laboratory sessions
- Lyons Richard G, Understanding Digital Signal Processing, Third Edition, 2011, Pearson Education, Inc. (in our library) [Lyons]
- Oppenheim Alan V, Schafer Ronald W, Discrete-Time Signal Processing, Third Edition, 2014, Pearson Education Limited. (in our library) [Oppenheim, Schafer]
- Smith Steven W, The Scientist and Engineer's Guide to Digital Signal Processing, *http://www.dspguide.com/* [GDSP]
- Proakis John G, Manolakis Dimitris K, Digital Signal Processing, Fourth Edition, 2014, Pearson Education Limited. (in our library) [Proakis, Manolakis]
- Gonzales Rafael C, Woods Richard E, Digital Image Processing, 2008, Pearson Prentice Hall. (available in laboratory and during laboratory work) [Gonzales, Woods]

# Other literature, links, lectures, video lectures, and demos

- The Scientist and Engineer's Guide to Digital Signal Processing:
  http://www.dspguide.com/editions.htm

- MIT Open Courseware, Digital Signal Processing, materials, video lectures, demos:
  http://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

- Berkely University, Signals and systems, lectures:
  http://ptolemy.eecs.berkeley.edu/eecs20/lectures.html

- Purdue University, general, demos:
  https://engineering.purdue.edu/VISE/ee438/demos/
  (Sampling, Discrete-time Convolution, Fast Fourier Transform, Spectrograms, FIR and IIR Filters, Pole-Zero Plots and Frequency Response)

# Grading

- Laboratory sessions: seminars and home works
  - Set of seminars I (Max: 40 – 55 points)
  - Set of seminars II (Max: 45 – 60 points)
    - → Student selects one seminars from the set I and one seminar from the set II
    - → Obligatory: each seminar has to be *submitted* and *defended* ongoing.
      Minimum (seminar + seminar) 50 points; Maximum: 115 points.

- Exam at the end of semester (obligatory Min 50 points, Max 100 points) (Depends also on Corona situation)

- How preliminary grade (5 – 10) will be composed?

  *Total score* = (number of points from seminars plus number of points from exam) divided by two

  | | | | | | |
  |---|---|---|---|---|---|
  | | | *Total score* | ≤ | 49 | → 5 |
  | 50 | ≤ | *Total score* | ≤ | 59 | → 6 |
  | 60 | ≤ | *Total score* | ≤ | 69 | → 7 |
  | 70 | ≤ | *Total score* | ≤ | 79 | → 8 |
  | 80 | ≤ | *Total score* | ≤ | 89 | → 9 |
  | 90 | ≤ | *Total score* | | | → 10 |

- To decide the final grade, oral exam follows