UČNI NAČRT PREDMETA / COURSE SYLLABUS (leto / year 2016/17)
Predmet: Digitalno procesiranje signalov
Course title: Digital signal processing

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Interdisciplinarni magistrski študijski program Računalništvo in matematika	ni smeri	1 ali 2	prvi
Interdisciplinary Master's study programme Computer Science and Mathematics	none	1 or 2	first

Vrsta predmeta / Course type | izbirni / elective

Univerzitetna koda predmeta / University course code: | 63516

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work		ECTS
45	10	20			105		6

Nosilec predmeta / Lecturer: | prof. dr. Patricio Bulić

Jeziki / **Languages:**	**Predavanja /** **Lectures:**	slovenski / Slovene, angleški / English
	Vaje / Tutorial:	slovenski / Slovene, angleški / English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Vpis v letnik študija.	Enrolment in the programme.

Vsebina:	**Content (Syllabus outline):**

1. Zvezni in diskretni signali, zaporedja, enotin impulz.	1. Continuous and discrete signals, sequences, unit impulse.
2. Diskretni linearni časovno-invariantni sistemi, lastna funkcija, kavzalnost, stabilnost.	2. Discrete linear time-invariant systems, eigenfunction, causality, stability.
3. Diferenčne enačbe in z-transformacija.	3. Difference equations and z-transform.
4. Vzorčenje zveznih signalov, posplošeno vzorčenje, decimacija in interpolacija.	4. Sampling of continuous signals, sampling generalization, decimation and interpolation.
5. Analiza diskretnih sistemov v frekvenčnem prostoru, idealni filtri, sistemi z minimalno in linearno fazo.	5. Analysis of discrete systems in the frequency domain, ideal filters, systems with minimal and linear phase.
6. Strukture za realizacijo diskretnih sistemov: direktna, kaskadna in paralelna.	6. Structures for discrete system: direct, cascade and parallel forms.
7. Metode za načrtovanje digitalnih filtrov z neskončnim enotinim odzivom: bilinearna transformacija analognih filtrov, načrtovanje z uporabo linearnega programiranja.	7. Methods for infinite impulse response digital filter design: bilinear transformation of analog filters, design with linear programming.
8. Metode za načrtovanje digitalnih filtrov s končnim enotinim odzivom: okenske funkcije, frekvenčno vzorčenje, Remezov algoritem.	8. Methods for finite impulse response digital filter design: window functions, frequency sampling, Remez algorithm.
9. Diskretna Fourierova transformacija in FFT algoritem.	9. Discrete Fourier transform and FFT algorithm.
10. Hitro računanje diskretne konvolucije in korelacije.	10. Fast discrete convolution and correlation.
	11. Spectral analysis: nonparametric and parametric methods. LPC analysis.
	12. Signal processors: properties, special

11. Spektralna analiza: neparametrične in parametrične metode. LPC analiza. 12. Signalni procesorji: lastnosti, posebnosti, programiranje in uporaba. 13. Uporaba digitalnega procesiranja signalov pri govornih in video signalih.	functions and application. 13. Application of digital signal processing speech and video signals.

Temeljni literatura in viri / Readings:

1. A.V. Oppenheim, R.W. Shafer: Discrete-Time Signal Processing, 2nd Edition, Prentice Hall, 1999, poglavja 1 do 10.

2. J. G. Proakis, D.G. Manolakis: Digital Signal Processing, 4th Edition, Prentice Hall, 2006.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je predstaviti področje obdelave signalov z digitalnimi metodami in še posebej uporabo računalnikov na tem področju. Poleg teoretičnih znanj, ki so osnova za razumevanje uporabljenih metod, je predmet namenjen tudi pridobivanju praktičnih izkušenj na resničnih problemih. Poseben poudarek je dan pregledu naprav in dejavnosti, pri katerih se uporabljajo metode iz digitalnega procesiranja signalov.	The objective is to present the processing of signals by digital techniques, including the application of computers in this area. The theory which is the basis for understanding the processing methods is combined with practical projects that are derived from the real world problems. Special attention is given to devices and activities that use the digital signal processing methods.

Predvideni študijski rezultati: **Intended learning outcomes:**

Znanje in razumevanje:
Osnovni cilj je razumevanje principov digitalnega procesiranja signalov vključno s primerjavo in oceno različnih metod, ki se v njem uporabljajo.

Uporaba:

Digitalno procesiranje signalov je danes prisotno v mnogih izdelkih, od mobilnih telefonov do računalnikov. Razumevanje delovanja in sposobnost za presojo kvalitete različnih rešitev je koristno v mnogih primerih.

Refleksija:

Povezava matematično-teoretičnih metod s praktičnimi izkušnjami in s tem povečanje možnosti za poklicni uspeh diplomanta.

Prenosljive spretnosti - niso vezane le na en predmet:

Predmet se dopolnjuje s predmeti s področja algoritmov, programiranja in arhitekture.

Knowledge and understanding:
Understanding the principles of digital signal processing including the comparison and evaluation of different methods.

Application:

Digital signal processing is the basis of many products manufactured today, from mobile phones to computers. Understanding it and being able to evaluate the quality of different solutions is essential in many cases.

Reflection:

Combination of mathematical-theoretical methods with practical experience increase the chances for graduate's successful career.

Transferable skills:

This course complements the courses from the area of algorithms, programming and architecture.

Metode poučevanja in učenja:

Predavanja, laboratorijske vaje in domače naloge. Poseben poudarek je na praktičnem laboratorijskem delu. Študenti s pomočjo programskih orodij in signalnih procesorjev

Learning and teaching methods:

Lectures, laboratory and homework. Special emphasis is given to practical laboratory work.

Students use programming tools and digital signal processors to get hands on knowledge of

| spoznavajo digitalno procesiranje signalov in njegovo uporabnost. | digital signal processing and its application. |

Načini ocenjevanja:	**Delež (v %) /** Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): Sprotno preverjanje (domače naloge, kolokviji in projektno delo) Končno preverjanje (pisni in ustni izpit) Ocene: 6-10 pozitivno, 1-5 negativno (v skladu s Statutom UL)	50% 50%	Type (examination, oral, coursework, project): Continuing (homework, midterm exams, project work) Final (written and oral exam) Grading: 6-10 pass, 1-5 fail (according to the rules of University of Ljubljana)

Reference nosilca / Lecturer's references:

AVRAMOVIĆ, Aleksej, BABIĆ, Zdenka, RAIČ, Dušan, STRLE, Drago, BULIĆ, Patricio. An approximate logarithmic squaring circuit with error compensation for DSP applications. Microelectronics journal, ISSN 0959-8324. [Print ed.], 2014, vol. 45, iss. 3, str. 263-271. , doi: . [COBISS.SI-ID 10373972]

ČEŠNOVAR, Rok, RISOJEVIĆ, Vladimir, BABIĆ, Zdenka, DOBRAVEC, Tomaž, BULIĆ, Patricio. A GPU implementation of a structural-similarity-based aerial-image classification. The journal of supercomputing, ISSN 0920-8542, Aug. 2013, vol. 65, no. 2, str. 978-996, ilustr. , doi: . [COBISS.SI-ID 9619028]

BULIĆ, Patricio, GUŠTIN, Veselko, ŠONC, Damjan, ŠTRANCAR, Andrej. An FPGA-based integrated environment for computer architecture. Computer applications in engineering education, ISSN 1061-3773. [Print ed.], Mar. 2013, vol. 21, no. 1, str. 26-35, ilustr. , doi: . [COBISS.SI-ID 7696212]

LOTRIČ, Uroš, BULIĆ, Patricio. Applicability of approximate multipliers in hardware neural networks. Neurocomputing, ISSN 0925-2312. [Print ed.], Nov. 2012, vol. 96, str. 57-65, ilustr. [COBISS.SI-ID 9160276]

BABIĆ, Zdenka, AVRAMOVIĆ, Aleksej, BULIĆ, Patricio. An iterative logarithmic multiplier. Microprocessors and microsystems, ISSN 0141-9331. [Print ed.], 2011, vol. 35, no. 1, str. 23-33, ilustr. [COBISS.SI-ID 7837780]