UČNI NAČRT PREDMETA / COURSE SYLLABUS	
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 in 2	prvi
Interdisciplinary Masters study programme Computer Science and Mathematics	none	1 in 2	first

Vrsta predmeta / Course type	izbirni
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:	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:**
Vsebina:	**Content (Syllabus outline):**

1. Zvezni in diskretni signali, zaporedja, enotin impulz. 2. Diskretni linearni časovno-invariantni sistemi, lastna funkcija, kavzalnost, stabilnost. 3. Diferenčne enačbe in z-transformacija. 4. Vzorčenje zveznih signalov, posplošeno vzorčenje, decimacija in interpolacija. 5. Analiza diskretnih sistemov v frekvenčnem prostoru, idealni filtri, sistemi z minimalno in linearno fazo. 6. Strukture za realizacijo diskretnih sistemov: direktna, kaskadna in paralelna. 7. Metode za načrtovanje digitalnih filtrov z neskončnim enotinim odzivom: bilinearna transformacija analognih filtrov, načrtovanje z uporabo linearnega programiranja. 8. Metode za načrtovanje digitalnih filtrov s končnim enotinim odzivom: okenske funkcije, frekvenčno vzorčenje, Remezov algoritem. 9. Diskretna Fourierova transformacija in FFT algoritem. 10. Hitro računanje diskretne konvolucije in korelacije. 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.	1. Continuous and discrete signals, sequences, unit impulse. 2. Discrete linear time-invariant systems, eigenfunction, causality, stability. 3. Difference equations and z-transform. 4. Sampling of continuous signals, sampling generalization, decimation and interpolation. 5. Analysis of discrete systems in the frequency domain, ideal filters, systems with minimal and linear phase. 6. Structures for discrete system: direct, cascade and parallel forms. 7. Methods for infinite impulse response digital filter design: bilinear transformation of analog filters, design with linear programming. 8. Methods for finite impulse response digital filter design: window functions, frequency sampling, Remez algorithm. 9. Discrete Fourier transform and FFT algorithm. 10. Fast discrete convolution and correlation. 11. Spectral analysis: nonparametric and parametric methods. LPC analysis. 12. Signal processors: properties, special functions and application. 13. Application of digital signal processing speech and video signals.

Temeljni literatura in viri / Readings:

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

Dodatna literatura:

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

Cilji in kompetence:

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.

Objectives and competences:

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:

Po uspešnem zaključku predmeta bo študent:
-razumeval principe digitalnega procesiranja signalov vključno s primerjavo in oceno različnih metod, ki se v njem uporabljajo,

-digitalno procesiranje signalov je danes prisotno v mnogih izdelkih, od mobilnih telefonov do računalnikov, študent bo razumeval delovanje in sposoben presoje kvalitete različnih rešitev v mnogih primerih,

-povezoval matematično-teoretične metode s praktičnimi izkušnjami in s tem povečal možnosti za poklicni uspeh,

-uspešno dopolnjeval znanja s predmeti s področja algoritmov, programiranja in arhitekture.

Intended learning outcomes:

After the completion of the course a student will be able to:
-understand the principles of digital signal processing including the comparison and evaluation of different methods,

-as digital signal processing is the basis of many products manufactured today, from mobile phones to computers, a student will understanding it and be able to evaluate the quality of different solutions in many cases.

-combine mathematical-theoretical methods with practical experience which will increase the chances for his successful career,

-complement the knowledge from this course with courses from the area of algorithms, programming and architecture.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje in domače naloge. Poseben poudarek je na praktičnem laboratorijskem delu. Študenti s pomočjo programskih orodij in signalnih procesorjev spoznavajo digitalno procesiranje signalov in njegovo uporabnost.	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 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, 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, 5 fail (according to the rules of University of Ljubljana).

Reference nosilca / Lecturer's references:

Patricio Bulić:

– 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 [COBISS.SI-ID 7696212]

– 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]

– 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]

– 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 [COBISS.SI-ID

9619028]

– 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 [COBISS.SI-ID 10373972]