

DISKRETNİ KRMILNI SISTEMI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Diskretni krmilni sistemi
Course title:	DISCRETE CONTROL SYSTEMS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Mehatronika in laserska tehnika (smer)	1. letnik	2. semester	obvezni

Univerzitetna koda predmeta/University course code:	0566814
Koda učne enote na članici/UL Member course code:	6057-M

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			65	5

Nosilec predmeta/Lecturer:	Primož Podržaj
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Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course	Obvezni strokovni predmet na smeri Mehatronika in
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type:

laserska tehnika, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Mechatronics and laser technology, which is an elective specialised course in other fields of study.

Jeziki/Languages:

Predavanja/Lectures:	Slovenščina
Vaje/Tutorial:	Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:**Prerequisites:**

Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.

Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.

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

1. Predavanje: Uvod
 - Splošna shema krmilnega sistema
 - Zvezni, diskretni in hibridni sistem
 - AD, DA pretvorba
 - Diferencialna/diferenčna enačba
2. Predavanje: Reševanje diferenčnih enačb
 - Primeri sistemov popisljivih z dif. enačbami
 - Postopek reševanja
3. Predavanje: Z transformacija
 - Definicija
 - Lastnosti
 - Primeri
 - Primerjava z Laplaceovo transformacijo
4. Predavanje: Reševanje dif. enačb s pomočjo Z transformacije
 - Razširitev na parc. ulomke
 - Postopek reševanja
5. Predavanje: Diskretne prenosne funkcije
 - Primerjava med zvezno in diskretno P.F.
 - Vpliv lege polov na odziv
 - Stabilnost

1. Lecture: Introduction
 - General scheme of a control system
 - Continuous, discrete and hybrid system
 - AD, DA conversion
 - Differential/difference equation
2. Lecture: Solving difference equations
 - Examples of systems modelled by dif. equations
 - Solving procedure
3. Lecture: Z transform
 - Definition
 - Properties
 - Examples
 - Comparison with the Laplace transform
4. Lecture: Solving dif. equations using Z transform
 - Partial fraction expansion
 - Solving procedure
5. Lecture: Discrete transfer function
 - Comparison between continuous and discrete T.F.
 - Influence of pole location on the

<p>6. Predavanje: Korenska krivulja</p> <ul style="list-style-type: none"> - Zvezna - Diskretna <p>7. Predavanje: Sinteza digitalnih krmilnih sistemov</p> <ul style="list-style-type: none"> - Tipične zahteve v časovni domeni - Zahteve v smislu lege korenov <p>8. Predavanje: Diskretni PID krmilnik</p> <ul style="list-style-type: none"> - Eulerjeva aproksimacija - Tustinova aproksimacija <p>9. Predavanje: Zvezna Fourier-jeva transformacija</p> <ul style="list-style-type: none"> - Definicija - Lastnosti - Frekvenčna karakteristika - Frekvenčni diagrami <p>10. Predavanje: Diskretna Fourierjeva transformacija</p> <ul style="list-style-type: none"> - DFT - FFT <p>11. Predavanje: Diskretno filtriranje</p> <ul style="list-style-type: none"> - Vloga filtrov - FIR in IIR filtri - Tipi <p>12. Predavanje: Diskretni filtri v več dimenzijah</p> <ul style="list-style-type: none"> - Uporaba na slikah - Konvolucija <p>13. Predavanje: Metoda prostora stanj</p> <ul style="list-style-type: none"> - Matrike stanja - Stabilnost sistema na osnovi systemske matrike <p>14. Predavanje: Uporaba Matlab/Simulink-a</p> <ul style="list-style-type: none"> - Sinteza v Matlabu - Simulink <p>15. Predavanje: Prostor stanj v Matlabu</p> <ul style="list-style-type: none"> - Računanje z matrikami - Control System Toolbox 	<p>response</p> <ul style="list-style-type: none"> - Stability <p>6. Lecture: Root locus</p> <ul style="list-style-type: none"> - Continuous - Discrete <p>7. Lecture: Digital control system synthesis</p> <ul style="list-style-type: none"> - Typical time domain requirements - Root location requirements <p>8. Lecture: Discrete PID controller</p> <ul style="list-style-type: none"> - Euler's approximation - Tustin's approximation <p>9. Lecture: Continuous Fourier transform</p> <ul style="list-style-type: none"> - Definition - Properties - Frequency transfer function - Frequency plots <p>10. Lecture: Discrete Fourier transform</p> <ul style="list-style-type: none"> - DFT - FFT <p>11. Lecture: Discrete filtering</p> <ul style="list-style-type: none"> - Role of filters - FIR and IIR filters - Types <p>12. Lecture: Discrete filters in several dimensions</p> <ul style="list-style-type: none"> - Image related applications - Convolution <p>13. Lecture: State space method</p> <ul style="list-style-type: none"> - State matrices - System stability based on the system matrix <p>14. Lecture: Application of Matlab/Simulink</p> <ul style="list-style-type: none"> - Matlab based synthesis - Simulink <p>15. Lecture: State space in Matlab</p> <ul style="list-style-type: none"> - Matrix calculations - Control System Toolbox
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Temeljna literatura in viri/Readings:

1. M. Sami Fadali: Digital Control Engineering: Analysis and Design, Academic Press, 2009, [COBISS.SI-ID [1540002783](#)] e-knjiga
2. Alan V. Oppenheim: Signals and Systems, Prentice Hall, 1983, [COBISS.SI-ID [747291](#)]
3. Katsuhiko Ogata: Discrete-Time Control Systems (2nd Ed.), Pearson, 1995, [COBISS.SI-ID [18158853](#)]

Cilji in kompetence:**Cilji:**

1. Razviti sposobnost kritičnega analitičnega ovrednotenja diskretnih krmilnih sistemov in njihovo sintezo.
2. Razviti sposobnost prenosa teoretično pridobljenega znanja na realne diskretne krmilne sisteme.
3. Razviti sposobnost modeliranja različnih v praksi pojavljajočih se diskretnih sistemov.

Kompetence:

1. S2-MAG: Širitev sposobnosti kritičnega, analitičnega in sintetičnega mišljenja na področju diskretnih krmilnih sistemov.
2. S7-MAG: Usposobljenost za uporabo pridobljenih znanj pri samostojnem reševanju tehničnih problemov na področju diskretnih krmilnih sistemov.
3. P4-MAG: Sposobnost modeliranja diskretnih sistemov z razvito sposobnostjo kritične analize rezultatov.
4. P6-MAG: Sposobnost samostojnega razvoja diskretnih krmilnih sistemov.
5. P7-MAG: Na osnovi analize in sinteze razvita sposobnost iskanja optimalnih diskretnih krmilnikov.

Objectives and competences:**Objectives:**

1. Develop the capability of critical analytical assessment of discrete control systems and their synthesis.
2. Develop the capability to transfer the theoretical knowledge to real discrete control systems.
3. Develop the capability to model various discrete system common in the real environment.

Competences:

1. S2-MAG: Improved capability of critical, analytical and synthetical thinking in the field of discrete control systems.
2. S7-MAG: The qualification to use the attained knowledge to autonomously solve technical problems in the field of discrete control systems.
3. P4-MAG: The ability for modelling of discrete system with the developed capability of critical assessment of the results.
4. P6-MAG: The ability to autonomously develop discrete control systems.
5. P7-MAG: The ability to find optimal discrete controllers based on analysis and synthesis.

Predvideni študijski rezultati:**Znanja:**

Z1: Poglobljeno teoretično, metodološko in analitično poznavanje analize in sinteze diskretnih krmilnih sistemov

Spretnosti:

S2.1: Obvladovanje zelo zahtevnih, kompleksnih matematičnih postopkov za analizo in sintezo diskretnih

Intended learning outcomes:**Knowledge:**

Z1: Deeper theoretical, methodological and analytical knowledge of discrete control system analysis and synthesis

Skills:

S2.1: Mastering very demanding and complex mathematical procedures for discrete control system analysis and synthesis.

krmilnih sistemov. S2.3: Sposobnost izvirnih dognanj na področju diskretnih krmilnih sistemov.	S2.3: Ability of unique innovations in the field of discrete control systems.
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Metode poučevanja in učenja:

Learning and teaching methods:

<p>P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.</p> <p>P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P4 Laboratorijske vaje z namenskim didaktičnim pripomočki kot so mikrokrmilniki (Arduino) ali računalnik Raspberry Pi.</p>	<p>P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases.</p> <p>P2 Presenting the content according to the explained system.</p> <p>P4 Laboratory exercises with special-purpose didactic devices (microcontrollers (Arduino) or Raspberry Pi computer.</p>
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Načini ocenjevanja:

Delež/ Weight

Assessment:

Pisni izpit.	50,00 %	Written examination.
Ustno izpraševanje.	30,00 %	Oral examination.
Projekt.	20,00 %	Project.

Ocenjevalna lestvica:

Grading system:

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Reference nosilca/Lecturer's references:

Primož Podržaj:

- PLETERSKI, Jan, ŠKULJ, Gašper, ESNAULT, Corentin, PUC, Jernej, VRABIČ, Rok, **PODRŽAJ, Primož**. Miniature mobile robot detection using an ultra-low resolution time-of-flight sensor. IEEE transactions on instrumentation and measurement. [Print ed.]. Sep. 2023, vol. 72, str. 1-9, ilustr. ISSN 0018-9456. <https://ieeexplore.ieee.org/document/10262176>, <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=151584>, DOI: 10.1109/TIM.2023.3318710. [COBISS.SI-ID [166014211](#)]
- FINŽGAR, Miha, **PODRŽAJ, Primož**. Feasibility of assessing ultra-short-term pulse rate variability from video recordings. PeerJ. Jan. 2020, vol. 8, f. 1-26, ilustr. ISSN 2167-8359. <https://peerj.com/articles/8342/>, DOI: 10.7717/peerj.834 [COBISS.SI-ID [17000731](#)]
- PODRŽAJ, Primož**, JERMAN, Boris, SIMONČIČ, Samo. Poor fit-up condition in resistance spot welding. Journal of materials processing technology. Apr.

2016, vol. 230, str. 21-25, ilustr. ISSN 0924-0136. DOI:

10.1016/j.jmatprotec.2015.11.009. [COBISS.SI-ID [14378779](#)]

4. SIMONČIČ, Samo, KLOBČAR, Damjan, **PODRŽAJ, Primož**. Kalman filter based initial guess estimation for digital image correlation. Optics and lasers in engineering. [Print ed.]. Oct. 2015, vol. 73, str. 80-88, ilustr. ISSN 0143-8166. DOI: 10.1016/j.optlaseng.2015.03.001. [COBISS.SI-ID [14176283](#)]
5. **PODRŽAJ, Primož**, MULH, Tadej. An Arduino based temperature monitoring system for beehives. V: ICESS2022 & ICIA2022 : the 10th International Conference on Informatics and Applications ICIA2022 : the Seventh International Conference on Electronics and Software Science ICESS2022 : virtual Conference - Japan, Dec. 31, 2020. [S. l.]: SDIWC, 2020. Str. 1-5, ilustr. ISBN 978-1-941968-64-2. <https://sdiwc.net/conferences/tenth-icia-2022/wp-content/uploads/2022/03/ICISS-ICIA-2022-Proceedings.rar>. [COBISS.SI-ID [99957507](#)]