UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Sodobne tehnologije vodenja sistemov
Course title:	Modern Control Technologies

Študijski program in stopnja Study programme and level	Modul Module	Letnik Academic year	Semester Semester
Informacijske in komunikacijske tehnologije, 2. stopnja	Digitalna transformacija	1	2
Information and Communication Technologies, 2nd cycle	Digital Transformation	1	2

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: IKT2-616

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike	Samost. delo Individ. work	ECTS
30	**30**			**30**	**210**	**10**

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Đani Juričić
Doc. dr. Damir Vrančić

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina, angleščina / Slovenian, English
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Zaključen študijski program prve stopnje s področja naravoslovja, tehnike ali računalništva.	Student must complete first-cycle study programmes in natural sciences, technical disciplines or computer science.

Vsebina:	**Content (Syllabus outline):**
1) Uvod Osnove življenjskega cikla sistemov vodenja: faze tehnične izvedbe; definiranje funkcionalnih zahtev (kaj naj sistem dela), specificiranje, načrtovanje, implementacija in vzdrževanje; ne-tehnični vidiki (vmesnik človek-stroj, tehnoekonomika, socialni vidiki).	**1) Introduction** Life-cycle basics: technical implementation phases, the analysis of functional requirements (what the system should do), specification, design, implementation and maintenance; non-technical aspects (man-machine interface, technoeconomics, social aspects).
2) Osnovni gradniki sodobnih tehnologij vodenja Osnove senzorjev in aktuatorjev, priprava in prenos signalov; vzorčenje.	**2) Basic building blocks of state-of-the-art control technologies** Review of sensors, actuators, signal conditioning and transmission; sampling.
3) Sodobni koncepti načrtovanja vodenja v	

časovnem prostoru
Temeljni koncepti: stabilnost, vodljivost, spoznavnost; optimalni regulator stanj; samonastavljivi in adaptivni regulatorji; primeri iz industrije.

4) Inteligentni nadzorni sistemi
Pomen zanesljivosti, učinkovitosti in kvalitete v industriji; postopki zgodnjega zaznavanja napak na podlagi modela; uporaba metod procesiranja signalov; lokalizacija napak s pomočjo aproksimativnega sklepanja; primeri industrijskih aplikacij.

5) Ocenjevanje stanj dinamičnih sistemov
Praktični pomen ocenjevanja stanj dinamičnih sistemov; Kalmanov filter; razširjeni Kalmanov filter; “bootstrap” postopki za ocenjevanje stanj nelinearnih dinamičnih sistemov; primeri uporabe pri napovedovanju in navigaciji.

6) Prediktivno vodenje
Osnovni koncepti; rešitev kvadratične kriterijske funkcije; nastavljanje; robustnost; primer industrijske uporabe.

3) Modern concepts of control design in time space
Basic concepts: controllability; identifiability; optimal state regulator; self-adjusting and adaptive regulators; examples from industry.

4) Intelligent supervisory systems
Reliability, efficiency and quality requirements; early error detection procedures based on models; application of signal processing methods; fault isolation by using approximate reasoning; examples of industrial applications.

5) Model based control
Practical relevance of state estimation of dynamic systems; Kalman filter; extended Kalman filter; "bootstrap" procedures for state estimation of nonlinear dynamic systems; examples of application in forecasting and navigation; predictive control

6) Predictive control
Basic concepts; solution of the quadratic cost function; tuning; robustness; application.

Temeljna literatura in viri / Readings:

- S. Strmčnik, Đ. Juričić (Ed’s) (2013), Case Studies in Control: Putting Theory to Work. Springer, London.
- J. Clempner, Y. Wen (Eds.) (2018).New Perspectives and Applications of Modern Control Theory. Springer. London.
- K. Ogata (2010). Modern Control Engineering, Prentice Hall, Boston.
- T. Samad, A. Annaswamy (2014). The Impact of Control Technology. IEEE Control Systems Society (available at http://ieeecss.org/general/IoCT2-report)
- J. Lu, X. Yu, G. Chen, W. Yu (Eds.) (2016). Complex Systems and Networks Dynamics, Controls and Applications. Springer, London.
- S. Yin, X. Li, H. Gao, O. Kaynak (2015). Data-based techniques focused on modern industry: an overview. IEEE Transactions on Industrial Electronics, Vol. 62, No. 1, 657-667
- D. Šiljak (2012). Decentralized Control of Complex Systems. Dover Publications, New York.
- S. Sarka (2013). Bayesian Filtering and Smoothing. Cambridge University Press, Cambridge.
- N.-H. Kim, D. An, J.-H. Choi (2016). Prognostics and Health Management of Engineering Systems: An Introduction. Springer, London.

Cilji in kompetence:

Vodenje je "skrita" tehnologija, ki zagotavlja učinkovito in varno delovanje sistemov v skladu z zahtevami.
Cilj predmeta je seznaniti slušatelje z osnovnimi koncepti ter predstaviti nekaj sodobnih postopkov za reševanje zahtevnejših problemov vodenja.

Objectives and competences:

Control is a "hidden" technology which ensures efficient and safe operation of systems in accordance with the requirements.
The aim of the course is to acquiaint students with basic concepts and to present a number of state-of-the-art procedures for solving complex control problems.

Okvir za razumevanje tehnologije vodenja predstavlja model življenjskega cikla, ki na strnjen način povezuje praktične zahteve, načrtovanje in implementacijo. Nekoliko več poudarka je na postopkih za načrtovanje samonastavljivih in adaptivnih sistemov, sistemov nelinearnega vodenja in sistemov nadzora. Pri tem bodo uporabljeni konkretni praktični zgledi za ponazoritev osnovnih idej. Študent bo sposoben analizirati dinamiko sistema, načrtati sistem optimalnega vodenja in načrtovanja virtualnih senzorjev.	The course will provide a framework for understanding control technology in the form of a life cycle model which interconnects practical requirements, design and implementation in a concise manner. Procedures for planning self- adjusting and adaptive systems, non-linear control systems and supervision systems will be presented in greater detail. Practical examples highlighting the basic concepts will be provided as well. The student will be able to analyze the dynamics of the system, plan a system of optimal management, and plan virtual sensors.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili: • razumevanje procesa načrtovanja sistemov vodenja • razumevanje temeljnih konceptov vodenja • sposobnost povezovanja sistemskih znanj in matematičnih orodij pri formulacji problema vodenja realnih sistemov, • sposobnost uporabe teoretičnih znanj v praksi, • delo v multidisciplinarnih skupinah • dokumentiranje in diseminacija rezultatov dela na mednarodnem nivoju • spoisobnost reševanja zahtevnejših problemov vodenja • razumevanje (nelinearne) dinamike sistemov • poznavanje tehnološke podlage za implementacijo sodobnih sistemov vodenja	Students successfully completing this course will acquire: • understanding of the process of control system design • understanding of the fundamental control concepts • the ability to combine knowledge of systems and mathematical tools in formulating the problem of control of real systems • the ability to apply theoretical knowledge in practice • co-operation in multi-disciplinary teams • documentation and dissemination of results on the international level • ability to solve non-trivial control problems • understanding the (nonlinear) systems dynamics • familiarity with technologies for implementation of modern control systems

Metode poučevanja in učenja:	**Learning and teaching methods:**
• predavanja • seminarji • laboratorijsko delo	• lectures • seminar work • laboratory work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminar	50 %	Seminar
Ustni izpit	50 %	Oral exam

Reference nosilca / Lecturer's references:

- Mileva-Boshkoska, B., Boškoski, P., Debenjak, A., Juričić, Đ. Dependence among complex random variables as a fuel cell condition indicator. Journal of Power Sources, [in press], 26 str., 2015.
- Debenjak, A., Boškoski, P., Musizza, B., Petrovčič, J., Juričić, Đ. Fast measurement of proton exchange membrane fuel cell impedance based on pseudo-random binary sequence perturbation signals and continuous wavelet transform. Journal of Power Sources, 254, 112-118, 2014.

- Boškoski, P., Gašperin, M., Petelin, D., Juričić, Đ. Bearing fault prognostics using Rényi entropy based features and Gaussian process models. Mechanical Ssystems and Signal Processing, 11 str.,2014
- Moura O. P. B., Vrančić, D., Boaventura C.J., Solteiro P. E.J. Teaching particle swarm optimization through an open-loop system identification project. Computer Applications in Engineering Education, 22(2), 227-237, 2014

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