UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Inteligentni sistemi vodenja robotov
Course title:	Intelligent Robot Control

Študijski program in stopnja Study programme and level	Modul Module	Letnik Academic year	Semester Semester
Informacijske in komunikacijske tehnologije, 3. stopnja	Inteligentni sistemi in robotika	1	1
Information and Communication Technologies, 3rd cycle	Intelligent Sytems and Robotics	1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: IKT3-628

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
15	**15**			**15**	**105**	**5**

**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: Doc. dr. Tadej Petrič

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Zaključena druga stopnja bolonjskega študija ali diploma univerzitetnega študijskega programa. Potrebna so osnovna znanja iz matematike, fizike in vodenja dinamičnih sistemov. Potrebno je poznavanje osnov robotike (kinematika, dinamika).	Completed Bologna second cycle study program or an equivalent pre-Bologna university study program. Basic knowledge of mathematics, physics and control of dynamic systems is also required. Knowledge of robot systems (kinematics and dynamics) is also necessary.

Vsebina:	**Content (Syllabus outline):**
Uvod: kinematika in dinamika robotskih mehanizmov, načrtovanje gibanja, vodenje robotov v sklepih in vodenje robotov v prostoru naloge Modeliranje in simulacija robotskih mehanizmov: simulacija robotskih sistemov v okolju MATLAB/Simulink, načrtovanje vodenja z uporabo simulacije, sprotna simulacija Vodenje robotskih mehanizmov:	Introduction: kinematics and dynamics of robot mechanisms, motion planning, joint space robot control and task space robot control Modeling and simulation of robot mechanisms: simulation of robot manipulators in MATLAB/Simulink environment, simulation in robot control system design, real-time simulation Robot control systems:

dinamična manipualcija z uporabo senzorjev sile, vida in dotika, vodenje robotov z uporabo variabilne podajnosti, optimalno vodenje robotov Redundantni robotski sistemi: dekompozicija naloge, reševanje redundantnosti izogibanje oviram Sodelovanje robotov: kinematika in dinamika dvoročnih robotov, vodenje dvoročnih robotov Praktično usposabljanje: praktična uporaba izbranih metod vodenja na robotih	dynamic manipulation using force, vision and tactile sensors, variable compliance robot control, optimal robot control Redundant robot systems: task decomposition, redundancy resolution, obstacle avoidance Robot cooperation: Kinematics and dynamics of dual-arm robots, control of dual-arm robots Practical training: practical use of selected control techniques on robot systems

Temeljna literatura in viri / Readings:

Izbrana poglavja iz naslednjih knjig: / Selected chapters from the following books:

- B. Siciliano, L. Sciavicco, L. Villani, and G. Oriolo, *Robotics: Modelling, Planning and Control*, Springer-Verlag, London, UK, 2009, ISBN: 978-1-84628-641-4.
- B. Siciliano, and O. Khatib (Eds.), *Springer Handbook of Robotics*, Springer-Verlag Berlin Heidelberg 2008, ISBN: 978-3-540-23957-4.
- L. Sentis, J. Park, and O. Khatib, "Compliant Control of Multicontact and Center-of-Mass Behaviors in Humanoid Robots", *IEEE Transactions on Robotics*, vol. 26, no. 3, pp. 483-501, 2010.
- L. Righetti, J. Buchli, M. Mistry, and S. Schaal, "Inverse dynamics control of floating-base robots with external constraints: A unified view", *2011 IEEE International Conference on Robotics and Automation*, str. 1085-1090, 2011.
- Y. Tassa, T. Erez, and E. Todorov, "Synthesis and stabilization of complex behaviors through online trajectory optimization", *2012 IEEE/RSJ International Conference on Intelligent Robots and System*, str. 4906-4913, 2012.
- J. Lenarčič, T. Bajd, and M.M. Stanišić. *Robot Mechanisms*, Springer Netherlands, 2013, ISBN: 978-94-007-4522-3
- G. Carbone F. Gomez-Bravo (Editors), *Motion and operation planning of robotic systems: background and practical approaches*, (Mechanisms and machine science, 29). Springer, 2015, ISBN: 978-3-319-14704-8

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je osvojiti teoretična in praktična znanja iz robotske kinematike in dinamike, simulacije in vodenja robotov, učenja robotov in uporabe robotov. Poudarek je na sodobnih robotskih sistemih, kot so redundantni mehanizmi, dvoročni robotski mehanizmi in senzorsko podprto vodenje. Študenti bodo pridobili kompetence na področju poznavanja sodobnih raziskovalno-razvojnih dosežkov in trendov na področju inteligentnih robotskih sistemov, zmožnost razvoja in uporabe specifičnih robotskih tehnologij, zmožnost izdelave aplikacij z orodji sodobnih robotskih sistemov in sposobnost načrtovati vodenja robotskih sistemov.	The objective of this course is to gain theoretical and practical knowledge of robot kinematics, dynamics, motion planning and robot applications. The emphasis is on modern robot systems like redundant mechanisms, dual-arm robot manipulators and sensor based control. The aims of the course are to evolve competences to understand R&D achievements and trends in the fields of intelligent robot systems, to be able to develop and use specific robot technologies, be able to create applications using modern robot systems and to design robot control systems.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent, ki bo uspešno končal ta predmet, bo pridobil znanja in razumel zgradbo kompleksnih robotskih sistemov, sisteme vodenja robotov in senzorsko podprto vodenje. Predmet pripravlja študente, da bodo sposobni uporabljati in načrtovati različne načine vodenja robotskih sistemov, načrtovati kompleksne robotske naloge in bodo pridobili znanje uporabe informacijskih tehnologij na področju robotike.	A student who completes this course successfully will know and understand structure of complex robot systems, robot control systems and sensor based control. This course prepares the students to be able to use and to design complex robot control systems, to plan complex robot tasks, and use of information technology in the field of robotics.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminar, konzultacije in seminarska naloga	Lectures, seminar, consultancy and seminar work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Pisni ali ustni izpit	50 %	Written or oral exam
Seminarska naloga	25 %	Seminar work
Ustni zagovor	25 %	Oral defense

Reference nosilca / Lecturer's references:

- M. Deniša, A. Gams, A. Ude, **T. Petrič**. "Learning compliant movement primitives through demonstration and statistical generalization". *IEEE/ASME trans. mechatron.*, vol 21, no 5, pp. 2581-2594, 2016.
- L. Peternel, T. Noda, **T. Petrič**, A. Ude, J. Morimoto, J. Babič. "Adaptive control of exoskeleton robots for periodic assistive behaviours based on EMG feedback minimization". *PloS one*, vol 11, no 2, pp. 1-26, 2016.
- A. Gams, **T. Petrič**, M. Do, B. Nemec, J. Morimoto, T. Asfour, A. Ude, "Adaptation and coaching of periodic motion primitives through physical and visual interaction". *Robot. auton. syst.*, vol 75, part B, pp. 340-351, 2016.
- **T. Petrič**, A. Gams, N. Likar, and L. Žlajpah**. "**Obstacle avoidance with industrial robots". In: G. Carbone, F. Gomez-Barvo (Eds.). *Motion and operation planning of robotic systems : background and practical approaches*, (Mechanisms and machine science, 29). Springer, pp. 113-146, 2015.
- **T. Petrič**, A. Gams, J. Babič, and L. Žlajpah. "Reflexive stability control framework for humanoid robots". *Autonomous Robots*, vol. 34, no. 4, pp. 347-361, 2013.