UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Vodenje, modeliranje in simulacija robotskih sistemov
Course title:	Control, Modelling and Simulation of Robotic Systems

Študijski program in stopnja Study programme and level	Modul Module	Letnik Academic year	Semester Semester
Informacijske in komunikacijske tehnologije, 2. stopnja	Inteligentni sistemi in robotika	1	2
Information and Communication Technologies, 2nd cycle	Intelligent Sytems and Robotics	1	2

Vrsta predmeta / Course type	Izbirni / Elective
Univerzitetna koda predmeta / University course code:	IKT2-618

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike	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:	slovenščina, angleščina / Slovenian, English

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):**
Uvod v modeliranje in simulacijo sistemov: Sodobna orodja za modeliranje in simulacijo, modeliranje in simulacija dinamičnih sistemov, sprotna simulacija, vizualizacija in navidezna resničnost, uporaba orodja MATLAB/SIMULINK. Modeliranje in simulacija robotskih mehanizmov: Zgodovinski pregled simulacije v robotiki. Simulacija na različnih področjih robotike. Simulacija robotskih sistemov v okolju MATLAB/Simulink. Simulacija in vizualizacija robotskih sistemov z uporabo splošnih orodij za simulacijo dinamičnih sistemov in grafičnih jezikov.	Introduction: system modelling and simulation Modern modelling and simulation tools, modelling and simulation of dynamic systems, real-time simulation, visualization and virtual reality, MATLAB/SIMULINK simulation tools. Modelling and simulation of robot mechanisms: Historical view of simulation in robotics. Simulation in different fields of robotics. Simulation of robot manipulators in MATLAB/Simulink. Simulation and visualization of robot systems using general dynamic engines and graphic languages. Integrated environment for dynamic simulation of robot manipulators:

Integrirano okolje za dinamično simulacijo robotskih manipulatorjev: Zgradba in vmesniki, vključitev robota v simulacijsko zanko, primeri uporabe. Vodenje robotskih mehanizmov: Načrtovanje gibanja, vodenje po poziciji in hitrosti, vodenje po sili, vodenje v sklepih in vodenje v prostoru naloge, optimalno vodenje. Vodenje redundantnih robotskih sistemov: Dekompozicija naloge, reševanje redundantnosti, izogibanje oviram.	Structure and interfaces, manipulator-in-the-loop simulation, simulation examples. Robot control systems: Trajectory planning, position and velocity control, force control, joint space and task space control, optimal control. Control of redundant robot systems: Task decomposition, redundancy resolution, obstacle avoidance.

Temeljna literatura in viri / Readings:

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

- L. Sciavicco and B. Siciliano. *Robotics: Modelling, Planning and Control*, Springer-Verlag, London, UK, 2009, ISBN: 978-1-84628-641-4.
- T. Bajd, M. Mihelj, J. Lenarcic, A. Stanovnik and M. Munih, *Robotics (Series: Intelligent Systems, Control and Automation: Science and Engineering)*, Springer, 2010, ISBN 978-90-481-3775-6
- J. Lenarčič, T. Bajd Bajd and M.M. Stanišić. *Robot Mechanisms*, Springer Netherlands, 2013, ISBN: 978-94-007-4522-3
- P. Corke, *Robotics, Vision and Control*, Springer-Verlag Berlin Heidelberg, 2011, ISBN: 978-3642201431
- *The MathWorks: MATLAB The Language of Technical Computation: Getting Started with MATLAB*, Natick, 1984-2018.
- *The MathWorks: SIMULINK Dynamic System Simulation for MATLAB*, Natick, 1990-2018.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je, da študentje pridobijo teoretično in praktično znanje s področja modeliranja, simulacije in vodenja robotskih sistemov. Študentje se bodo naučili uporabljati simulacijska orodja. Spoznali bodo simulacijska orodja in postopke modeliranja robotskih sistemov ter uporabo simulacije pri načrtovanju gibanja robotov in sintezi sistemov vodenja za robotske sisteme. Te tehnike bodo preizkusiti tudi na realnih robotskih sistemih. Študentje si pridobijo osnovno teoretično in praktično znanje o vodenju robotov na različnih nivojih in o izvedbah sistemov vodenja na robotskih sistemih. Naučili se bodo uporabljati in vključevati različne senzorske sisteme v sisteme vodenja. Usposobiti študente za razumevanje sodobnih robotskih sistemov. Pridobljeno znanje bo omogočilo uporabo znanstvenih metod za reševanje kompleksnih znanstveno-raziskovalnih nalog, vodenja razvojnih in raziskovalnih programov, kot tudi za razvoj in uporabo sodobnih robotsko podprtih proizvodnih	The objective of this course is to gain basic theoretical and practical knowledge in the field of modeling, simulation and control of robot systems. Students will learn how to use simulation tools. They will become familiar with the simulation tools and modelling methods of robot systems and will learn how to use simulation for the robot motion planning and the design of robot control systems. They will use these techniques on real robots. Students will gain the basic theoretical and practical knowledge of robot control systems at different levels and their implementation on real robots. They will learn how to include different sensors systems in robot control system. The students will be qualified to understand modern robots systems. The gained knowledge will allow the use of scientific methods for solving the complex scientific and research tasks, to guide R&D projects, and also to develop and use the contemporary robot based production technologies with the goal to modernize the production, to increase the quality and the productivity.

tehnologij s ciljem modernizacije proizvodnje, povečanja kvalitete in produktivnosti.	

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent, ki bo uspešno končal ta predmet bo pridobil znanja in razumel: • modeliranje in simulacijska orodja • robotsko manipulacijo • osnove vodenja robotskih sistemov Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili: • spretnost komuniciranja na tehniškem področju, pri pisanju poročil in ustnem poročanju • obvladanje raziskovalnih metod in strategij • sposobnost reševanja problemov: analiza, sinteza, predvidevanje rešitev in posledic • uporaba informacijskih tehnologij na področju robotike • sposobnost uporabe znanja v praksi • avtonomnost v strokovnem delu • zavezanost profesionalni etiki in regulativi • kooperativnost, sposobnost dela v skupini Predmet pripravlja študente, da bodo sposobni: • uporabljati modeliranje in simulacijska orodja pri načrtovanju robotskih sistemov • načrtovati robotske naloge • načrtovati osnovne načine vodenja robotskih sistemov	A student who completes this course successfully will know and understand: • modelling and simulation tools • robot manipulation • basics of robot control Students successfully completing this course will acquire: • communication skills in writing technical reports and oral presentations • mastering the research methods and strategies • the ability to solve problems: analysis, synthesis and prediction of solutions and consequences • use of information technology in the field of robotics • the ability to apply the theory into practice • autonomy in the professional work • liability to professional ethics and regulatory body politics • cooperation, ability to work in team This course prepares the students to be able: • to use modelling and simulation tools for design of robot systems • to plan robot tasks • to design basic robot control systems

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji, laboratorijsko delo, konzultacije, individualno delo.	Lectures, seminars, laboratory work, consultancy, individual work.

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

Reference nosilca / Lecturer's references:

- L. Peternel, **T. Petrič**, J. Babič. “Robotic assembly solution by human-in-the-loop teaching method based on real-time stiffness modulation”. *Auton. robots*, vol 42, no 1, pp. 1-17, 2018.
- L. Peternel, **T. Petrič**, E. Oztop, J. Babič, “Teaching robots to cooperate with humans in dynamic manipulation tasks based on multi-modal human-in-the-loop approach”. *Auton. Robots.* vol 46, no 1/2, pp. 123-136, 2014.
- **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.
- 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.