UČNI NAČRT PREDMETA/COURSE SYLLABUS	
Predmet:	ROBOTSKI SISTEMI V LOGISTIKI
Course title:	ROBOTIC SYSTEMS IN LOGISTICS

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
LOGISTIKA SISTEMOV 2.stopnja		2.	3.
SYSTEM LOGISTICS 2nd degree		2.	3.

Vrsta predmeta / Course type	IZBIRNI
Univerzitetna koda predmeta / University course code:	MAG

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15 e-P 30 a-P		10 e-V 20 a-V	10 LV		65	5

Nosilec predmeta / Lecturer:	TONE LERHER, DARKO HERCOG

Jeziki / Languages:	Predavanja / Lectures:	SLOVENSKI / SLOVENE
	Vaje / Tutorial:	SLOVENSKI / SLOVENE

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisits:
Ni posebnih pogojev.	No special requirements.

Vsebina:	Content (Syllabus outline):
Uvod, osnovne definicije, uporaba robotskih sistemov v logistiki. Industrijski in kolaborativni roboti: zgodovina robotike, osnovne definicije, osnovne komponente robotov, konfiguracije robotov, koordinatni sistemi, delovni prostor (priročni in dosežni), prostostne stopnje, direktni in inverzni kinematični model, senzorji, aktuatorji, prijemala, zgradba robotskega krmilnika, razvojna orodja, programiranje robotov, robotsko komisioniranje z uporabo 2D in 3D strojnega vida, varnost v robotskih aplikacijah, primerjava industrijskih in kolaborativnih robotov. Mobilni roboti (avtonomna in avtomatsko vodena vozila): uporaba mobilnih robotov v logistiki, konfiguracije pogonskega in krmilnega sistema, senzorji, aktuatorji, varnostni laserski skenerji, robotski operacijski sistem (ROS), lokacijski sistemi, navigacijski sistemi, centralno nadzorni sistemi, komercialni sistemi, virtualna robotska eksperimentalna orodja, standardi in direktive. Brezpilotni zrakoplovi (droni): uporaba dronov v logistiki, konfiguracije dronov, senzorji, aktuatorji, lokacijski	Introduction, basic definitions, use of robotic systems in logistics. Industrial and collaborative robots: history of robotics, basic definitions, basic robot components, robot configurations, coordinate systems, workspace (convenient and achievable), degrees of freedom, direct and inverse kinematic model, sensors, actuators, grippers, structure of robot controller, development tools, robot programming, robot commissioning using 2D and 3D machine vision, safety in robot applications, comparison of industrial and collaborative robots. Mobile robots (autonomous and automated-guided vehicles): the use of mobile robots in logistics, configurations of drive and steering systems, sensors, actuators, safety laser scanners, robotic operating system (ROS), location systems, navigation systems, central control systems, commercial solutions, virtual robotic experimental tools, standards and directives. Unmanned aircrafts (drones): the use of drones in logistics, drone configurations, sensors, actuators, location

sistemi, navigacijski sistemi, zemeljski nadzorni sistemi, zakonodaja. Komponente in postavitve prilagodljivih proizvodnih in logističnih sistemov. Modeliranje in simulacija diskretnih dogodkovnih sistemov (discrete event systems - DES). Modeliranje DES z uporabo Petrijevih mrež. Matrični zapis DES. DES analiza in optimizacija z uporabo genetskih algoritmov.	systems, navigation systems, ground control stations, legislation. Components and layouts of flexible production and logistics systems. Modeling and simulation of discrete event systems (DES). Modeling of DES using Petri nets. DES matrix notation. DES analysis and optimization using genetic algorithms.

Temeljna literatura in viri / Readings:

1. E-gradivo predmeta.
2. Mihelj, M., et al. (2019), Robotics, Springer, ISBN: 978-3030102852.
3. Ross, L. T., Fardo, S. W., & Walach, M. F. (2017). Industrial Robotics Fundamentals: Theory and Applications. Goodheart-Willcox, ISBN: 978-1631269417.
4. Günter Ullrich (2016). Automated Guided Vehicle Systems: A Primer with Practical Applications. Springer, ISBN: 978-3662448137.
5. J. Banks, J. S. Carson, B. L. Nelson, D. M. Nicol. Discrete-Event System Simulation (5th Edition), Pearson Education Limited, 2020, ISBN: 978-0136062127.
6. Zhou, M., & Wu, N. (2018). System modeling and control with resource-oriented Petri nets (Vol. 35). CRC Press. ISBN: 978-1439808849.
   D. A. Coley. Introduction To Genetic Algorithms For Scientists And Engineers, World Scientific Publishing Co., 2003.

Cilji in kompetence:	Objectives and competences:
Cilj predmeta je seznaniti študente s poglobljenimi teoretičnimi znanji s področja robotskih sistemov v logistiki. Študenti pridobijo znanja, ki jim omogočajo samostojno reševanje logističnih problemov z uporabo robotskih sistemov.	The objective of this course is to acquaint students with in-depth theoretical knowledge in the field of robotics systems in logistics. Students acquire knowledge that enables them to solve problems in logistics using robotics systems.

Predvideni študijski rezultati:	Intended learning outcomes:
Po opravljenem izpitu bo študent sposoben: • razumeti in podrobneje razložiti delovanje različnih robotskih sistemov v logistiki, • razumeti, modelirati in simulirati diskretne dogodkovne sisteme, • uporabljati računalniška orodja za modeliranje, simulacijo in analizo diskretnih dogodkovnih sistemov v logistiki. • analizirati in reševati teoretične ter praktične probleme v intralogistiki.	Upon passing the exam, students will be able to: • understand and explain in more detail the principle of operation of different robotic systems in logistics, • understand, model and simulate discrete event systems, • use computer tools for modelling, simulation and analysis of discrete event systems in logistics. • be able to analyse and solve theoretical and practical problems in intralogistics.

Metode poučevanja in učenja:	Learning and teaching methods:

Predavanja: pri predavanjih študent spozna teoretične vsebine predmeta. Del predavanj se izvaja na klasični način v predavalnici, del pa v obliki e-predavanj (e-predavanja se lahko izvajajo na videokonferenčni način ali s pomočjo posebej v ta namen didaktično pripravljenih e-gradiv v virtualnem elektronskem učnem okolju). Vaje: pri vajah študent utrdi teoretično znanje in spozna aplikativne možnosti. Del vaj se izvaja na klasični način v predavalnici, del pa v obliki e-vaj (e-vaje se lahko izvajajo na videokonferenčni način ali s pomočjo posebej v ta namen didaktično pripravljenih e-gradiv v virtualnem elektronskem učnem okolju).	Lectures: Students understand the theoretical frameworks of the course. Part of the lecture course is in a classroom while the rest is in the form of e-learning (e-lectures may be given via video-conferencing or with the help of specially designed e-material in a virtual electronic learning environment). Tutorials: Students enhance their theoretical knowledge and are able to apply it. Part of the seminar is in a classroom while the rest is in the form of e-learning (e-tutorials may be given via video-conferencing or with the help of specially designed e-material in a virtual electronic learning environment).

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
• Opravljene vaje in projektna naloga, • Ustni ali pisni izpit (teoretično znanje).	50% 50%	• Completed home works and seminar (project) work, • oral or written exam (theoretical knowledge).
Opravljene obveznosti e-predavanj in e-vaj so pogoj za pristop k izpitu.		Successful completion of e-lectures and e-tutorials is a prerequisite for entering the exam.

Reference nosilca / Lecturer's references:

1. EKREN, Banu Y., AKPUNAR, Anil, SARI, Zaki, LERHER, Tone. A tool for time, variance and energy related performance estimations in a shuttle-based storage and retrieval system. Applied mathematical modelling. [Print ed.]. Nov. 2018, vol. 63, str. 109-127, ilustr. ISSN 0307-904X. DOI: 10.1016/j.apm.2018.06.037. [COBISS.SI-ID 21531926].
2. KÜÇÜKYAŞAR, Melis, EKREN, Banu Y., LERHER, Tone. Cost and performance comparison for tier-captive and tier-to-tier SBS/RS warehouse configurations. International transactions in operational research, ISSN 1475-3995. [Online ed.]. https://doi-org.ezproxy.lib.ukm.si/10.1111/itor.12864, doi: 10.1111/itor.12864. [COBISS.SI-ID 25139715].
3. RAJKOVIĆ, Miloš, ZRNIĆ, Nenad Đ., KOSANIĆ, Nenad, BOROVINŠEK, Matej, LERHER, Tone. A Multi-Objective Optimization model for minimizing cost, travel time and CO2 emission in an AS/RS. FME Transactions. 2017, vol. 45, no. 4, str. 620-629, ilustr. ISSN 1451-2092. http://www.mas.bg.ac.rs/_media/istrazivanje/fme/vol45/4/23_mrajkovic_et_al.pdf, DOI: 10.5937/fmet1704620R. [COBISS.SI-ID 512851517].
4. D. Hercog, D. Sedonja, B. Recek, M. Truntič, and B. Gergič, Smart Home Solution Using Open Source Home Automation Software and Custom Developed Wi-Fi-based Hardware, Technical Gazette, vol. 27, no. 4, 2020.
5. B. Gergič and D. Hercog, "Design and implementation of a measurement system for high-speed testing of electromechanical relays," Measurement, vol. 135, pp. 112-121, 2019.
6. D. Hercog and B. Gergič, "A Flexible Microcontroller-Based Data Acquisition Device," Sensors, vol. 14, no. 6, pp. 9755-9775, 2014.

Opomba:
Navedene sestavine so obvezna sestavina učnega načrta predmeta kot ga določajo Merila za akreditacijo visokošolskih zavodov in študijskih programov v 7. členu (Ur. l. RS, št. 101/2004).