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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Avtonomni mobilni sistemi | | | | | | | | | | | | | | |
| **Course title:** | | | Autonomous mobile systems | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Podiplomski magistrski študijski program druge stopnje Elektrotehnika | | | | | Avtomatika in informatika, Robotika | | | | | | | | 2 | | 1 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Control systems and computer engineering, Robotisc | | | | | | | | **2** | | **1** | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Obvezni – strokovni /  compulsory - professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64272 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| 45 |  | | | 30 | | |  | | | |  | | | 75 | |  | 6 |
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| **Nosilec predmeta / Lecturer:** | | | | | Gregor Klančar | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | Angleški (s konzultacijami v slovenščini) / English (with consultations in Slovenian) | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | Angleški (s konzultacijami v slovenščini) / English (with consultations in Slovenian) | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik predmeta | | | | | | | | |  | Enrolment in the year of the course | | | | | | | |
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| Končana 1. stopnja, priporočljivo naravoslovno tehniške usmeritve. Slednje vključuje osnovna znanja iz:   * Matematike: geometrijske transformacije, osnove verjetnosti (Bayesovo pravilo, funkcija gostote verjetnosti, normalna porazdelitev), matrične operacije, numerične metode za navadne diferencialne enačbe. * Dinamični linearni sistemi: predstavitve modelov (prostor stanj, prenosna funkcija, diferencialna enačba), osnove zaprto-zančnega vodenja. * Dinamika gibanja togih teles * Izkušnje iz programiranja v okolju Matlab in C/C++ | | | | | | | | |  | Finished 1. level of the Study programme, recommended from natural scientist field. This should cover the basics knowledge of:   * Mathematics: geometric translations, vector operations, basics of probability (Bayes rule, probability density, functions, normal distribution), matrix operations, numerical methods for ordinary differential equations. * Dynamic linear systems: model presentations (state space, transfer function, differential equation), basics of closed loop control. * Basics of rigid body motion description * Programming experiences in Matlab and C/C++ | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Pregled avtonomnih mobilnih sistemov in definicija pojma agent, obravnava teh sistemov glede na lastnosti kot so: avtonomija, mobilnosti, načini delovanja agentov, strukture sistemov, pogonski mehanizem, cilji, zaznavanje in interakcije z zunanjim svetom in področja uporabe. Arhitektura agentov in primeri načrtovanja.  Večagentni sistemi (Multi-Agent Systems) kot pod-področje umetne inteligence, predstavitev principov za gradnjo kompleksnih sistemov s pomočjo osnovnih entitet - agentov. Možna področja uporabe, delitve glede na različne lastnosti in zmožnosti ter prednosti in slabosti uporabe takih sistemov.  Modeliranje kinematike, omejitev gibanja in dinamičnih lastnosti mobilnih sistemov. Prikaz na praktičnih primerih mobilnih sistemov.  Različni pristopi vodenja mobilnih sistemov, metode planiranja poti in izogibanja ovir. Vodenje po poziciji, orientaciji, v želeno lego po poti ali trajektoriji. Metode planiranja gibanja, optimalne poti v znanem okolju.  Uporabna senzorika v avtonomnih mobilnih sistemih za namen vodenja in navigacije. Osnovni principi delovanja senzorjev in namen njihove uporabe. Osnovne metode integracije informacij več senzorjev kot so Kalmanov filter, filter delcev in podobni.  Navigacija, gradnja zemljevida neznanega okolja, lokalizacija na osnovi informacij senzorjev in znanega zemljevida okolja, simultana lokalizacija in gradnja zemljevida. Prikaz različnih pristopov z nazornimi demonstracijskimi primeri. | | | | | | | |  | | Overview of autonomous mobile systems and definition of the agent concept. Categorization of such systems regarding their properties such as: autonomy, mobility, different agent performance, systems structures, driving mechanism, goals, sensing and interactions with environment and areas of applicability. Agent’s architecture and some examples of construction.  Multi-Agent Systems (MAS) as a subfield of artificial intelligence, introduction of principles for complex systems construction using agents as basic entities. Possible areas of applications, classification based on different properties and capabilities and properties and disadvantages of such system usage.  Modeling of kinematic, motion constraints and dynamic properties of mobile systems. Demonstration on practical examples of mobile systems.  Different approaches for control of mobile systems, motion planning and obstacle avoidance. Control to desired position, orientation, pose, following desired path or trajectory. Motion planning methods, optimal path search in known environment.  Sensors used in mobile robotics systems, their principles of operation and usage. Sensors fusion methods such as Kalman filter, particle filter and the like.  Navigation, mapping of unknown environment, localization using sensor information and environment map, simultaneous localization and mapping (SLAM). Different approaches demonstration using clear examples. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. Gregory Dudek, Michael Jenkin: Computational Principles of Mobile Robotics, Cambridge University Press, New York, 2010. 2. Howie Choset, Kevin M. Lynch, Seth Hutchinson, George A. Kantor, Wolfram Burgard, Lydia E. Kavraki, Sebastian Thrun, Principles of Robot Motion: Theory, Algorithms, and Implementations (Intelligent Robotics and Autonomous Agents series), MIT Press, Cambridge, 2005. 3. Sebastian Thrun, Wolfram Burgard, Dieter Fox: Probabilistic Robotics (Intelligent Robotics and Autonomous Agents series), MIT Press, Cambridge, 2006. 4. Michael Wooldridge: An Introduction to MultiAgent Systems, Second Edition, John Wiley & Sons, Chichester, England, 2009. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Predstaviti avtonomne mobilne sisteme,  podati koncept agenta in večagentnih sistemov, primeri ter njihovo načrtovanje,  podati metode za modeliranje, analizo in vodenje mobilnih sistemov,  prikaz uporabne senzorike in načinov obdelave informacij,  prikazati probleme in pristope za navigacijo, lokalizacijo in kartiranje mobilnih sistemov,  predstaviti nekatera programska okolja in njihovo uporabnost v podporo obravnavani tematiki. | |  | | Introduction to autonomous mobile systems,  understanding agent concept in multi agent systems,  methods for modeling, analysis and control of mobile systems,  review of sensors and methods for information processing,  presentation of navigation, localization and mapping (SLAM) problems,  introduction to some programming environments to support the subject. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Znanje in razumevanje: osnovna znanja iz področja avtonomnih mobilnih sistemov in večagentnih sistemov  Uporaba: znanja bodo pridobljena in demonstrirana ob številnih primerih, kar bo poudarilo uporabnostno komponento  Refleksija: praktični primeri bodo ilustrirali teoretična izvajanja  Prenosljive spretnosti: znanja bodo uporabna na številnih področjih, demonstrirana z didaktičnimi napravami in programskimi orodji | | |  | Knowledge and understanding: basic knowledge from autonomous mobile systems and multiagent systems  Usage: obtained knowledge will be demonstrated on practical examples  Reflexion: practical examples will illustrate theoretical knowledge’s  Applicability: obtained knowledge is applicable to many fields, demonstration on didactic apparatus and programming environments | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| predavanja in laboratorijske vaje | | |  | Lectures and laboratory exercises | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Način: laboratorijske vaje in projekt, pisni izpit, ustni izpit.  Ocene od 1 do vključno 5 so negativne, ocene od vključno 6 do 10 so pozitivne.  Pozitivna ocena laboratorijskih vaj je pogoj za pristop k izpitu.  Prispevki k oceni:  laboratorijske vaje in projekt  pisni izpit  ustni izpit | 30%  30%  40% | | | | Type: laboratory exercises and project, written exam, oral exam.  Negative grades: from 1 to 5, positive grades: from 6 to 10.  Positive evaluation of laboratory exercises is a prerequisite for the exam.  Contributions to final grade:  laboratory exercises and project  written exam  oral examination |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. KLANČAR, Gregor, TESLIĆ, Luka, ŠKRJANC, Igor. Mobile-robot pose estimation and environment mapping using an extended Kalman filter. International Journal of Systems Science, vol. 45, no. 12, str. 2603-2618, 2014. 2. KLANČAR, Gregor, BLAŽIČ, Sašo, MATKO, Drago, MUŠIČ, Gašper. Image-based attitude control of a remote sensing satellite. *Journal of intelligent & robotic systems*, ISSN 0921-0296, vol. 66, no. 3, str. 343-357, 2012. 3. G. Klančar, D. Matko, S. Blažič. A Control Strategy for Platoons of Differential-Drive Wheeled Mobile Robot. Robotics and Autonomous Systems, vol. 59, no. 2, str. 57-64, 2011. 4. KLANČAR, Gregor, ŠKRJANC, Igor. A case study of the collision-avoidance problem based on Bernstein-Bézier path tracking for multiple robots with known constraints. Journal of Intelligent & Robotic Systems, vol. 60, no.2, str. 317-337, 2010. 5. Klančar, G., I. Škrjanc. Tracking-error model-based predictive control for mobile robots in real time. Robotics and Autonomous Systems, vol. 55, no. 6, str. 460-469, 2007. | | | | | |