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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | |
| **Predmet:** | | | **Inteligentni sistemi za podporo odločanju** | | | | | | | | | | | | | |
| **Course title:** | | | Intelligent systems in decision support | | | | | | | | | | | | | |
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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 | | | | | | | 1 | | 1 | | |
| 2nd cycle masters study programme in ELECTRICAL ENGINEERING | | | | | Automation and information | | | | | | | 1 | | 1 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | Izbirni-strokovni / Optional professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | 64258 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** | **0** | | | **30** | | |  | | |  | | | **75** | |  | **6** |
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| **Nosilec predmeta / Lecturer:** | | | | | Igor Škrjanc | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenščina in po potrebi angleščina / Slovene and English, if necessary | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovenščina in po potrebi angleščina / Slovene and English, if necessary | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | |  | **Prerequisites:** | | | | | | | |
| * Vpis v letnik. * Osnovno znanje uporabne matematike (vektorji in matrike, lastni vektorji in lastne vrednosti, linearna algebra). * Osnovna znanja teorije vodenja. | | | | | | | |  | * Enrolment in the year of the course. * Basic knowledge of applied mathematics (vectors and matrices, eigenvectors and eigenvalues, some linear algebra). * Basics of control theory. | | | | | | | |

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| **Vsebina:** |  | **Content (Syllabus outline):** |
| * Uvod v inteligentne sisteme. Prikaz inteligentnih sistemov v raziskovanju podatkov, modeliranju, razvrščanju v biomedicini, razpoznavanju, vodenju in detekciji napak. * Osnovne metode nelinearne lokalne optimizacije, s poudarkom na metodah, ki so uporabne v učenju v inteligentnih sistemih in metode nelinearne globalne optimizacije. * Metode nelinearne globalne optimizacije s primeri: metoda ohlajanja, evolucijskih algoritmov, genetskih algoritmov, metoda delcev, metoda drevesnega iskanja. * Nenadzorovane metode učenja. Metoda glavnih komponent. Uporaba metode glavnih komponent pri identifikaciji, filtriranju, vodenju in detekciji napak. * Metode rojenja. Metode mehkega rojenja: metoda mehkih c-povprečij, metod Gustafson-Kessel, metoda možnih c-povprečij, metoda regresijskega rojenja. * Optimizacija kompleksnosti modelov. Verifikacija in validacija modelov. Eksplicitna in implicitna optimizacija strukture modela. * Statični modeli. Formulacija na osnovi baznih funkcij. Polinomski modeli. * Nevronske mreže. Večplastni perceptron. Gaussove nevronske mreže in aproksimacija funkcij. * Mehki in nevro-mehki modeli. Mehka logika. Tipi mehkih sistemov. Učenje nevro-mehkih sistemov. Ocenjevanje izhodnih parametrov mehkih modelov. Globalna in lokalna estimacija. Različni tipi mehkih regulatorjev. * Nelinearni dinamični sistemi. Klasični polinomski modeli v nelinearnem modeliranju. Dinamični mehki in nevronski modeli. * Intervalni mehki modeli in družine funkcij. * Nadzorovano hierarhično rojenje pri načrtovanju eksperimentov. * Vodenje nelinearnih dinamičnih sistemov. Vodenje z razvrščanjem ojačenj. * Vodenje z nelinearnim internim modelov. Vodenje z regulatorjem dveh prostostnih stopenj. * Nelinearno prediktivno vodenje na osnovi modela. Prediktivno funkcijsko vodenje (PFC) in njegova uporaba na mehkih modelih. * Prediktivno vodenje na osnovi dinamične matrike (DMC). Prediktivno vodenja na osnovi odziva na stopnico. Prediktivno vodenje na osnovi modela v prostoru stanj. * Prediktivno vodenje na osnovi nelinearnega modela in optimizacija. * Adaptivno vodenje in prilagajanje modela. Robustna modifikacija adaptivnih pravil. Modelno-referenčni adaptivni sistemi. Mehki modelno-referenčni adaptivni sistemi. * Odkrivanje in diagnosticiranje napak na osnovi inteligentnih sistemov. |  | * Introduction to intelligent systems. Intelligent systems in data-mining, classification and fault detection. * Basic methods of local nonlinear optimization used in intelligent systems and global nonlinear optimization methods for model identification. * Methods of global nonlinear optimization: simulated annealing, evolutionary algorithms, particle swarm optimization, genetic algorithms, branch and bound algorithms. * Unsupervised learning methods. Principle component analysis. PCA in identification, data filtering, control and fault detection. * Data clustering. Methods of clustering: fuzzy c-means, Gustafon-Kessel fuzzy c-means, possibilistic c-means clustering, method of regression clustering. * Optimization of complex models. Verification and validation of models. Explicit and implicit optimization of model structure. * Static models. Model based on basis function formulation. Polynomial models. * Neural networks. Multilayer perceptron network. Radial basis function networks in function approximation. * Fuzzy and neuro-fuzzy models. Fuzzy logic. Types of fuzzy models. Estimation of fuzzy model parameter. Global and local estimation. Different structures of fuzzy controllers. * Nonlinear dynamical systems. Classical polynomial models in nonlinear modelling. Identification of dynamical fuzzy and neuro-fuzzy models. * Interval fuzzy model and families of functions. * Supervised hierarchical clustering in experiment design. * Control of nonlinear dynamical systems. Gain scheduling control algorithm. * Internal nonlinear model control algorithm. 2DOF control algorithm. * Nonlinear model based control. Predictive functional control (PFC) and fuzzy model based predictive functional control. * Predictive control based on dynamical matrix (DMC). Predictive control based on step response. Predictive control based on state-space model. * Predictive control based on nonlinear model and optimization. * Adaptive control and online adaptation. Robust adaptive laws. Model-reference adaptive systems. Fuzzy model-reference adaptive systems. * Monitoring, fault detection and isolation based on intelligent systems. |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. I. Škrjanc: Inteligentni sistemi pri raziskovanju podatkov in odločanju, skripta v pripravi | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Seznaniti študenta z osnovnimi matematičnimi in računalniškimi načeli izgradnje inteligentnih sistemov za pomoč pri odločanju v sodobnih sistemih. | |  | | To provide students with an understanding of the basic mathematical and computational principles of constructing artificial perception systems, which are an essential part of intelligent systems in automation and control. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Znanje in razumevanje:  Po zaključku tega predmeta bo študent zmožen izkazati znanje in razumevanje:   * gradnje inteligentnih sistemov za podporo odločanju in vodenje, * identifikacije statičnih in dinamičnih modelov z metodami umetne inteligenca, * gradnja naprednih sistemov vodenja na osnovi inteligentnih sistemov.   Uporaba znanja:  Pridobljeno znanje bo študent lahko uporabil pri gradnji modelov za spremljanje, nadzor, napovedovanje, analizo, vodenje in detekcijo in diagnostiko napak. Študent bo zmožen kritično ovrednotiti skladnost med pridobljenim znanjem ter uporabo konceptov v praktičnih primerih.  Prenosljive spretnosti:  Študent si bo pridobil spretnosti:   * uporabe literature ter drugih virov s področja inteligentnih sistemov pri raziskovanju podatkov. * uporaba računalniških razvojnih orodij in okolij za programiranje (pisanje programov programskem okolju Matlab), * reševanja problemov: analiza problema, načrtovanje algoritma, implementacija programa in testiranje programa, | | |  | Knowledge and understanding:  After completing this course the student will be able to demonstrate a knowledge and understanding of the:   * construction of intelligent systems for decision support and control , * identification of static and dynamic models based on intelligent methods, * construction of advanced control systems based on intelligent systems.   The use of knowledge:  The student will be able to use the acquired knowledge to construct technical systems for monitoring, forecasting, analysis, control and fault detection. The student will be able to critically evaluate the consistency between the acquired knowledge and the application in practice.  Transferable skills:   * the use of literature and other resources in the fields of pattern recognition, machine learning and artificial intelligence; * the use of development tools and environments for computer programming (writing computer or using the Matlab development environment), * problem solving: problem analysis, algorithm design, implementation and testing of a program. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| * predavanja, * laboratorijske vaje in projekti, * reševanje domačih nalog. | | |  | * lectures, * laboratory exercises and projects, * coursework. | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| * domače naloge, * laboratorijske vaje in projekt, * pisni izpit, * ustni izpit. | 10%  50%  0%  40% | | | | * coursework, * laboratory exercises and project, * written exam, * oral examination. |
| **Reference nosilca / Lecturer's references:** | | | | | |
| Izvirni znanstveni članek / Original scientific article   1. ŠKRJANC, Igor. Evolving fuzzy-model-based design of experiments with supervised hierarchical clustering. IEEE transactions on fuzzy systems, ISSN 1063-6706. [Print ed.], 2014, vol. , no. , str. 1-12. 2. ŠKRJANC, Igor. Fuzzy confidence interval for pH titration curve. Applied mathematical modelling, ISSN 0307-904X. [Print ed.], Aug. 2011, vol. 35, no. 8, str. 4083-4090. 3. HARTMANN, Benjamin, BÄNFER, Oliver, NELLES, Oliver, SODJA, Anton, TESLIĆ, Luka, ŠKRJANC, Igor. Supervised hierarchical clustering in fuzzy model identification. *IEEE transactions on fuzzy systems*, ISSN 1063-6706. [Print ed.], Dec. 2011, vol. 19, no. 6, str. 1163-1176. 4. BELIČ, Aleš, ŠKRJANC, Igor, ZUPANČIČ-BOŽIČ, Damjana, VREČER, Franc. Tableting process optimisation with the application of fuzzy models. *International journal of pharmaceutics*, ISSN 0378-5173. [Print ed.], Apr. 2010, vol. 389, no. 1/2, str. 86-93. 5. ŠKRJANC, Igor. Confidence interval of fuzzy models : an example using a waste-water treatment plant. *Chemometrics and Intelligent Laboratory Systems*, ISSN 0169-7439. [Print ed.], Apr. 2009, vol. 96, no. 2, str. 182-187. | | | | | |