UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Novejše matematično statistične metode v naravoslovju in tehniki
Course title:	Contemporary Mathematical and Statistical Methods in Natural Sciences and Engineering

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, Informacijske in komunikacijske tehnologije, Ekotehnologije, Senzorske tehnologije, 3. stopnja		1	1
Nanosciences and Nanotechnologies, Information and Communication Technologies, Ecotechnologies, Sensor Technologies, 3rd cycle		1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: SPL-728

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike Others	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: Prof. dr. Matjaž Omladič

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
Zaključen študij druge stopnje. Potrebna so tudi primerna znanja matematike ter osnovna znanja računalništva in informatike.	Completed second cycle education. Appropriate knowledge of mathematics, and basic knowledge of computer science and informatics is also requested.

Vsebina:	Content (Syllabus outline):
Teorija verjetnosti: (pogojna) verjetnost in neodvisnost, diskretne in zvezne slučajne spremenljivke, matematično upanje in kovarianca, multivariatne skupne, marginalne in pogojne porazdelitve, nekoreliranost in neodvisnost, variančno-kovariančna matrika, slučajni vektorji. Uvod v statistiko: nekatere posebne porazdelitve	Probability theory: (conditional) probability and independence, discrete and continuous random variables, mathematical expectation and covariance, multivariate joint, marginal and conditional probabilities, non-correlated and independent random variables, variance-covariance matrix, random vectors. Introduction to statistics: some special distributions

(binomska, Poissonova, multivariatna, normalna, eksponentna), vzorčenje in statistike (vrstilne statistike, intervali zaupanja, testiranje hipotez, Pearsonov hi-kvadrat, metode Monte Carlo, »Kljukčeva« metoda, metoda največjega verjetja), limitni izreki (zakoni velikih števil, centralni limitni izrek). Bayesova statistika: subjektivne verjetnosti, Bayesove procedure (apriorne in aposteriorne porazdelitve, točkasto in intervalsko ocenjevanje, testiranje, Gibbsov vzorčevalnik). Uporaba matematično statističnih metod v strojnem učenju: Bayesov pristop h konkretnim porazdelitvam (Gaussova, eksponentna družina porazdelitev, neparametrične metode), teorija odločanja (drevesa odločanja, največja koristnost in najmanjše obžalovanje), teorija informacij, metoda podpornih vektorjev (primerjava z diskriminantno analizo), vzpodbujeno učenje, nevronske mreže, globoko učenje. Izvedba učnega načrta se bo prilagajala slušateljem glede na njihovo predznanje, izbrani program in individualno usmeritev študija. Temu je prilagojena tudi seminarska naloga.	(binomial, Poisson, multivariate normal, exponential) sampling and statistics (order statistics, confidence intervals, testing of hypotheses, Pearson's chi-squared test, Monte Carlo methods, Bootstrap method, maximum likelihood method), limit theorems (laws of large numbers, the central limit theorem). Bayesian statistics: subjective probabilities, Bayesian procedures (prior and posterior distributions, point estimation and interval estimation, testing, Gibbs sampler). Applications of mathematical and statistical methods to machine learning: Bayesian approach to some important distributions (Gaussian and exponential family of distributions, non-parametric methods), decision theory (decision trees, maximizing utility and minimizing regret), support vector machines (comparison to discriminant analysis), reinforcement learning, neuron networks including deep learning. Realization of the syllabus will be adjusted to the students enrolled with respect to their previous knowledge and the program of study. Their seminar work will also be adjusted accordingly.

Temeljna literatura in viri / Readings:

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

- Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, New York, 2006
- N. Cristianini, J. Shawe-Taylor*: An Introduction to Support Vector Machines and other kernel-based learning methods*, Cambridge University Press, 2000
- L. R. Foulds: *Optimization Techniques – An Introduction*, Springer-Verlag, New York, 1981
- A. Gelman, A. B. Carlin, H. S. Stern, D. B. Dunson, A. Vehtari, D. B. Rubin: *Bayesian data analysis*, 3rd edition, Taylor & Francis Group, New York, 2013.
- G. Grimmett, D. Stirzaker: *Probability and Random Processes*, 3rd edition, Oxford Univ. Press, Oxford, 2001.
- J. R. Norris: *Markov Chains*, Cambridge Univ. Press, Cambridge, 1999.-
- S. I. Resnick: *Adventures in Stochastic Processes*, Birkhäuser, Boston, 1992.
- J. S. Rosenthal: *A first look at rigorous probability theory*, 2nd edition, World Scientific Publishing Co, Singapore, 2006.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je širitev temeljnih znanj s področja matematike in statistike. Pri obravnavanih verjetnostnih vsebinah ni potrebno globoko	The goal of the course is to broaden the knowledge of mathematics and statistics. It is assumed that the probabilistic background needed is not deeply

teoretično predznanje, so pa pomembne za uporabo. Poudarek je predvsem na ergodični teoriji, ki pomaga razumeti razlog za konvergenco mnogih sodobnih iterativnih metod. Kompetence študenta z uspešno zaključenim predmetom bodo vključevale razumevanje osnovnih pojmov iz obeh področij, poznavanje sodobnih metod in znanje o primerih uporabe na mnogih področjih informatike in tehnike.	theoretical, but good feeling for applications is necessary. The emphasis will be on ergodic theory, which helps understanding convergence of contemporary iterative methods. The competences of the students completing this course successfully would include understanding of basic concepts from both areas, familiarity with state-of-the art methods, and knowledge of application examples in many areas of informatics and engineering.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili: • matematični pristop, ki jim bo pomagal pri abstraktnem načinu premišljevanja • globlje razumevanje optimizacijskih in aproksimacijskih metod, ki so pomembne tako v informatiki kot širše v tehniki • globlje razumevanje verjetnostnega pristopa, še posebno ergodijskih principov • pregled obstoječih nalog in metod na področju optimizacijskih metod • pregled obstoječih nalog in metod na področju markovskih verig s poudarkom na aplikacijah • sposobnost uporabe obstoječih metod na novih problemih s področja informatike in tehnike • sposobnost ugotavljanja primernosti optimizacijskih in stohastičnih metod v uporabi	Students successfully completing this course will acquire: • Mathematical approach that will help them in abstract way of thinking • Deeper understanding of optimization and approximation techniques that are so important in both informatics and engineering • Deeper understanding of probabilistic approach with emphasis on ergodic principles • Overview of existing tasks and methods in the area of optimization • Overview of existing tasks and methods in the area of Markov chains with emphasis on applications • The ability to apply existing methods to new problems in informatics and engineering • The ability to identify whether given optimization and stochastic techniques are appropriate in given applications

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, konzultacije, individualno delo	Lectures, tutorials, consultancy, individual work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Domače naloge	25 %	Homework
Seminarska naloga	50 %	Seminar work
Ustni zagovor	25 %	Oral defense

Reference nosilca / Lecturer's references:

- Durante, Fabrizio; **Omladič, Matjaž**; Oražem, Lovrenc; Ružić, Nina; Shock models with dependence and asymmetric linkages. Fuzzy sets and systems 323 (2017), 152-168.
- Kokol Bukovšek, Damjana; **Omladič, Matjaž**; Linear spaces of symmetric nilpotent matrices. Linear Algebra and its Applications 530 (2017), 384-404.

- **Omladič, Matjaž**; Ružić, Nina; Shock models with recovery option via the maxmin copulas. Fuzzy Sets and Systems 284 (2016), 113–128.
- Mastnak, Mitja; **Omladič, Matjaž**; Radjavi, Heydar. Near-invariant subspaces for matrix groups are nearly invariant. Linear Algebra and its Applications 505 (2016), 269-281.
- Kuzma, Bojan; **Omladič, Matjaž**; Šivic, Klemen; Teichmann, Josef; Exotic one-parameter semigroups of endomorphisms of a symmetric cone. Linear Algebra Appl. 477 (2015), 42–75.