Z1-PU7	WYDANIE N1

(*faculty stamp*)

COURSE DESCRIPTION

1. Course title: STATISTICS FOR DATA SCIENCE, Markov Models	**2. Course code SFDS_MM**
3. Validity of course description: 2018/2019	
4. Level of studies: MSc programme	
5. Mode of studies: intramural studies	
6. Field of study: CONTROL, ELECTRONIC AND INFORMATION ENGINEERING (MACRO)	(FACULTY SYMBOL) RAU-2
7. Profile of studies: ACADEMIC	
8. Programme: DATA SCIENCE	
9. Semester: 1, 2	
10. Faculty teaching the course: Faculty of Automatic Control, Electronics and Computer Science	
11. Course instructor: Prof. dr hab. inż. Tadeusz Czachórski	
12. Course classification: common courses	
13. Course status: compulsory ~~/elective~~	
14. Language of instruction: English	
15. Pre-requisite qualifications: Algebra and analytic geometry, Calculus and differential equations, Physics, Computer programming, Optimization methods, Numerical methods, Statistics and probability theory, Algorithms and data structures.	
16. Course objectives: The aim of the course is making students familiar with issues related to modeling processes, systems, dynamical phenomena with the use of Markov models. During the lecture overview of multiple applications of Markov models is presented.	

17. Description of learning outcomes:

Nr	Learning outcomes description	Method of assessment	Teaching methods	Learning outcomes reference code
1.	Student understands the notion of stochastic process and Markov process. Understands Markov property.	Credit	Lecture	K2A_W01, K2A_W02
2.	Student understands differences between types of Markov processes.	Credit	Lecture	K2A_W03, K2A_W04
3.	Student understands notions of probability transition matrix, stationary distribution, transient and recurrent states, aperiodicity, ergodicity, reversibility.	Credit	Lecture	K2A_W04, K2A_W10
4.	Student understands constructions of sampling models, Metropolis-Hastings and Gibbs.	Credit	Lecture	K2A_W04, K2A_W10
5.	Student understands constructions and computational algorithms for hidden Markov models.	Credit	Lecture	K2A_W08, K2A_W09, K2A_W10

6.	Student is able to compute evolution of state probability distributions and stationary distributions.	Laboratory tasks	Laboratory	K2A_U01, K2A_U03, K2A_K06
7.	Student is able to estimate parameters of Markov processes.	Laboratory tasks	Laboratory	K2A_U09, K2A_U10
8.	Student is able to use and implement sampling algorithms Metropolis-Hasting and Gibbs.	Laboratory tasks	Laboratory	K2A_U09, K2A_U10, K2A_K01
9.	Student is able to use and implement all algorithms related to hidden Markov models.	Laboratory tasks	Laboratory	K2A_U09, K2A_U10, K2A_K01

18. Teaching modes and hours

Lecture 30 / ~~BA /MA Seminar / Class / Project~~ / Laboratory 30

19. Syllabus description:

Lecture:

1. Introductory topics. Applications of Markov models in scientific research, biology, engineering, automatic control, electronics, information sciences, computer sciences, data transfer, queuing.
2. Random variables, stochastic processes, limited memory processes, Markov processes. Discrete versus continuous time Markov processes, discrete versus continuous states Markov processes, finite versus infinite number of states in Markov processes. Markov property and its consequences.
3. Discrete time Markov chains. Transition probability matrix. Graph representations of states transitions. Probability distributions of states and their time evolution. Invariant and stationary distributions. Transient and persistent states. Aperiodicity and ergodicity.
4. Computational methods for the analysis of Markov chains. Matrix multiplication, eigenvalue decomposition, Perron – Frobenius theory, generating functions.
5. Markov chain with reversed time. Reversibility of Markov chains. Local balance condition. Applications of reversible Markov chains. Metropolis – Hastings algorithm and its applications. Variants of Metropolis – Hastings algorithm. Gibbs sampling. Simulated annealing.
6. Continuous time Markov chains. Chapman – Kolmogorov equation. Transition matrix. Transition intensity matrix.
7. Hidden Markov models. Distributions of emission probabilities. Examples of applications. Viterbi algorithm, forward – backward algorithm, Baum – Welch algorithm.

Laboratory:

1. Simulations of Markov chain models.
2. Estimation of parameters of Markov chains.
3. Reversed – time Markov chains.
4. Metropolis – Hastings algorithm.
5. Hidden Markov models. Vitterbi algorithm.
6. Hidden Markov models. Baum-Welch algorithm

20. Examination: semester NO

21. Primary sources:

William Feller, (1957), An Introduction to Probability Theory and its Applications (Volume 1,2), John Wiley & Sons Inc.

O. Haggstrom, (2002), Finite Markov Chains and Algorithmic Applications, Cambridge University Press

22. Secondary sources:

J.G. Kemeny, J.L. Snell, (1960), Finite Markov Chains, Springer

23. Total workload required to achieve learning outcomes

Lp.	Teaching mode :	Contact hours / Student workload hours
1	Lecture	30/30
2	Classes	/
3	Laboratory	30/30
4	Project	/
5	BA/ MA Seminar	/
6	Other	/
	Total number of hours	60/60

24. Total hours: 120

25. Number of ECTS credits: 3

26. Number of ECTS credits allocated for contact hours: 2

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects):2

26. Comments:

Approved:

…………………………… *(date, Instructor's signature)*

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