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/optional

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:**

<table>
<thead>
<tr>
<th>Nr</th>
<th>Learning outcomes description</th>
<th>Method of assessment</th>
<th>Teaching methods</th>
<th>Learning outcomes reference code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Student understands the notion of stochastic process and Markov process. Understands Markov property.</td>
<td>Credit</td>
<td>Lecture</td>
<td>K2A_W01, K2A_W02</td>
</tr>
<tr>
<td>2</td>
<td>Student understands differences between types of Markov processes.</td>
<td>Credit</td>
<td>Lecture</td>
<td>K2A_W03, K2A_W04</td>
</tr>
<tr>
<td>3</td>
<td>Student understands notions of probability transition matrix, stationary distribution, transient and recurrent states, aperiodicity, ergodicity, reversibility.</td>
<td>Credit</td>
<td>Lecture</td>
<td>K2A_W04, K2A_W10</td>
</tr>
<tr>
<td>4</td>
<td>Student understands constructions of sampling models, Metropolis-Hastings and Gibbs.</td>
<td>Credit</td>
<td>Lecture</td>
<td>K2A_W04, K2A_W10</td>
</tr>
<tr>
<td>5</td>
<td>Student understands constructions and computational algorithms for hidden Markov models.</td>
<td>Credit</td>
<td>Lecture</td>
<td>K2A_W08, K2A_W09, K2A_W10</td>
</tr>
<tr>
<td>6.</td>
<td>Student is able to compute evolution of state probability distributions and stationary distributions.</td>
<td>Laboratory tasks</td>
<td>Laboratory</td>
<td>K2A_U01, K2A_U03, K2A_K06</td>
</tr>
<tr>
<td>7.</td>
<td>Student is able to estimate parameters of Markov processes.</td>
<td>Laboratory tasks</td>
<td>Laboratory</td>
<td>K2A_U09, K2A_U10</td>
</tr>
<tr>
<td>8.</td>
<td>Student is able to use and implement sampling algorithms Metropolis-Hasting and Gibbs.</td>
<td>Laboratory tasks</td>
<td>Laboratory</td>
<td>K2A_U09, K2A_U10, K2A_K01</td>
</tr>
<tr>
<td>9.</td>
<td>Student is able to use and implement all algorithms related to hidden Markov models.</td>
<td>Laboratory tasks</td>
<td>Laboratory</td>
<td>K2A_U09, K2A_U10, K2A_K01</td>
</tr>
</tbody>
</table>

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.

**Laboratory:**

1. Simulations of Markov chain models.
2. Estimation of parameters of Markov chains.
5. Hidden Markov models. Vitterbi 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.

22. Secondary sources:
23. **Total workload required to achieve learning outcomes**

<table>
<thead>
<tr>
<th>Lp.</th>
<th>Teaching mode</th>
<th>Contact hours / Student workload hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lecture</td>
<td>30/30</td>
</tr>
<tr>
<td>2</td>
<td>Classes</td>
<td>/</td>
</tr>
<tr>
<td>3</td>
<td>Laboratory</td>
<td>30/30</td>
</tr>
<tr>
<td>4</td>
<td>Project</td>
<td>/</td>
</tr>
<tr>
<td>5</td>
<td>BA/ MA Seminar</td>
<td>/</td>
</tr>
<tr>
<td>6</td>
<td>Other</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td><strong>Total number of hours</strong></td>
<td><strong>60/60</strong></td>
</tr>
</tbody>
</table>

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:

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(date, Instructor’s signature) (date, the Director of the Faculty Unit signature)