**Study Programme:** Applied Mathematics – Data Science

**Course Unit Title:** Statistics theory for learning and signal processing

**Course Unit Code:** МДС17

**Name of Lecturer(s):** Danijela Rajter-Ćirić

**Type and Level of Studies:** Master Academic Degree

**Course Status (compulsory/elective):** Elective

**Semester (winter/summer):** Summer

**Language of instruction:** English

**Mode of course unit delivery (face-to-face/distance learning):** Face-to-face

**Number of ECTS Allocated:** 6

**Prerequisites:**

Basics of linear algebra and probability

**Course Aims:**

- Understanding of a wide range of statistical metrics, methods, and analytical techniques for machine learning and signal processing

**Learning Outcomes:**

- Ability to select a suitable statistical method for a given research problem
- Ability to apply the taught statistical methods on a given research problem
- Ability to validate/assess, and give guarantees, for various machine learning/signal processing approaches based on the taught statistical metrics

**Syllabus:**

*Theory*

Estimation: Minimum variance unbiased estimation, Cramer-Rao lower bound, Maximum likelihood estimation, Bayesian estimation, Unbiasedness, Asymptotic efficiency, Asymptotic normality; Detection: Binary hypothesis testing, M-ary hypothesis testing, Neyman-Pearson optimal detection, Average error probability-optimal detection; Concentration inequalities: Markov, Chebyshev, Chernoff, Hoeffding, Efron-Stein; Large deviations: Cramer theorem, Gartner-Ellis theorem, Stein's lemma, Chernoff's lemma; Minimax theory: Le Cam's method, Fano's method; Risk minimization: Tsybakov's noise conditions, Surogate loss functions.

*Practice*

Application examples in telecom, electric grid (smart grid), machine learning, sensor networks, etc.

**Required Reading:**

Selected parts of the following books:

14. Larry Wasserman: All of Statistics: A Concise Course in Statistical Inference, Springer, 2014
15. Harry L. Van Trees: Detection, Estimation, and Modulation Theory, John Wiley, 2001.
16. Louis L. Scharf: Statistical Signal Processing: Detection, Estimation, and Time Series Analysis, Addison-Wesley, 1991
17. Amir Dembo, Ofer Zeitouni: Large Deviations Techniques and Applications, Springer, 2009

| **Weekly Contact Hours:** 5 | **Lectures:** 2 | **Practical work:** 3 |
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| **Teaching Methods:**<br>Lectures; revisions of the material; active students' participation in problem solving; knowledge tests – colloquia; homeworks. | | |
| **Knowledge Assessment (maximum of 100 points):** 100 | | |

| **Pre-exam obligations** | points | **Final exam** | points |
|---|---|---|---|
| Active class participation | | written exam | 40 |
| Colloquia + Homeworks | 30 (Colloquia) + 30 (Homeworks) | oral exam | |
| Preliminary exam(s) | | ……. | |
| Seminar(s) | | | |

The methods of knowledge assessment may differ; the table presents only some of the options: written exam, oral exam, project presentation, seminars, etc.