

Modulbezeichnung: **AI-enabled wireless networks (Alnet)** **5 ECTS**
(AI-enabled wireless networks)

Modulverantwortliche/r: Mehdi Harounabadi
Lehrende: Mehdi Harounabadi

Startsemester: WS 2022/2023	Dauer: 1 Semester	Turnus: jährlich (WS)
Präsenzzeit: 60 Std.	Eigenstudium: 90 Std.	Sprache: Englisch

Lehrveranstaltungen:

AI-enabled wireless networks (WS 2022/2023, Vorlesung, 2 SWS, Mehdi Harounabadi)
Literature review on the application of machine learning in wireless networks (WS 2022/2023, Übung, 2 SWS, Mehdi Harounabadi)

Empfohlene Voraussetzungen:

Motivation:

Rapid growth in the number of connected wireless nodes such as mobile phones, low power IoT devices, connected vehicles, etc. will expand the scale of the next generation of wireless and mobile networks. Moreover, the foreseen use cases like connected autonomous vehicles, smart homes and cities, ultra-fast and reliable industrial wireless networks, etc. will require ultra-low latency and highly reliable communication. Existing and traditional algorithms are not feasible for the optimization and management of such networks to fulfill the requirements of the emerging use cases due to their high complexity, high dynamicity, and the massive amount of the generated data by connected devices. Recently, artificial intelligence (AI) is planned to be utilized as a new paradigm for the design, development and optimization of the next generation wireless and mobile networks. Machine learning (ML) as a subset of AI will be applied to develop intelligent wireless nodes and infrastructures to address the demands of future use cases.

Inhalt:

This course introduces machine learning algorithms such as supervised, unsupervised, reinforcement, deep, and federated learning and their application in the next generation wireless and mobile networks. Different ML use cases are explained which solve problems in different layers of the protocol stack from the physical layer to the application layer. The course includes the following topics:

1. Introduction to machine learning algorithms
2. Python programming language and its ML tools
3. AI-enabled wireless and mobile networks
 - 3.1 Cellular networks and ML use cases
 - 3.1.1 History of 2G to 4G, 5G and 6G vision
 - 3.1.2 ML use cases in physical, MAC and higher layers
 - 3.2 5G-V2X (cellular-V2X) and ML use cases
 - 3.2.1 Sidelink communication as the key enabler
 - 3.2.2 5G-V2X features and use cases
 - 3.2.3 ML use cases in 5G-V2X
 - 3.3 Intelligent wireless networks
 - 3.3.1 Cognitive radio networks
 - 3.3.2 ML use case in wireless networks
4. Standardization activities on AI-enabled wireless networks
 - 4.1.1 3GPP and 5GAA
 - 4.1.2 ETSI Zero touch networks

Exercises:

Literature review on the application of machine learning in wireless networks
The exercise of this course includes a literature review research project where students work individually on a relevant topic. The steps to accomplish the research project are as follows:
A. Select a topic relevant to the application of ML in wireless networks and register it by email
B. Search for the relevant papers and make a list of papers

C. Study the papers and prepare a summary

D. Present the outcomes

Each student should present her/his research study in an intermediate and a final presentation. A summary paper should be written following the "survey papers guideline" using IEEE format. The grade of the research project will be considered as a "Bonus point" (up to 20%) for the final grade.

Lernziele und Kompetenzen:

The students will be able to gain the following competencies after the successful completion of the course:

- Have knowledge on machine learning algorithms, current and the next generation wireless and mobile networks and their use cases
- To know how to develop machine learning algorithms in Python
- Know the most important problems in wireless and mobile networks which can be solved by machine learning algorithms
- Have an insight on the exiting work relevant to the topic of the course
- Learn the procedure of a scientific research study and publication of the outcome

Literatur:

- Dahlman, Erik, Stefan Parkvall, and Johan Skold. 5G NR: The next generation wireless access technology. Academic Press, 2020.
- Sun, Yaohua, et al. "Application of machine learning in wireless networks: Key techniques and open issues." IEEE Communications Surveys & Tutorials 21.4 (2019): 3072-3108.
- Harounabadi, Mehdi, et al. "V2X in 3GPP Standardization: NR Sidelink in Release-16 and Beyond." IEEE Communications Standards Magazine 5.1 (2021): 12-21.
- Xie, Junfeng, et al. "A survey of machine learning techniques applied to software defined networking (SDN): Research issues and challenges." IEEE Communications Surveys & Tutorials 21.1 (2018): 393-430.

Verwendbarkeit des Moduls / Einpassung in den Musterstudienplan:

Das Modul ist im Kontext der folgenden Studienfächer/Vertiefungsrichtungen verwendbar:

- [1] **Advanced Signal Processing & Communications Engineering (Master of Science)**
(Po-Vers. 2020w | TechFak | Communications Engineering (Master of Science) | Gesamtkonto | Technical Electives | AI-enabled Wireless Networks)
- [2] **Advanced Signal Processing & Communications Engineering (Master of Science)**
(Po-Vers. 2021w | TechFak | Communications Engineering (Master of Science) | Gesamtkonto | Technical Electives | AI-enabled Wireless Networks)
- [3] **Informatik (Master of Science)**
(Po-Vers. 2010 | TechFak | Informatik (Master of Science) | Gesamtkonto | Wahlpflichtbereich | Säule der system-orientierten Vertiefungsrichtungen | Vertiefungsrichtung Kommunikationssysteme | AI-enabled Wireless Networks)
- [4] **Information and Communication Technology (Master of Science)**
(Po-Vers. 2019s | TechFak | Information and Communication Technology (Master of Science) | Gesamtkonto | Wahlmodule | Wahlmodule aus dem Angebot von EEI und Informatik | AI-enabled Wireless Networks)
- [5] **Information and Communication Technology (Master of Science)**
(Po-Vers. 2019s | TechFak | Information and Communication Technology (Master of Science) | Gesamtkonto | Wahlmodule | Wahlmodule aus dem Angebot der Technischen Fakultät oder der Naturwissenschaftlichen Fakultät | AI-enabled Wireless Networks)

Studien-/Prüfungsleistungen:

AI-enabled Wireless Networks (Prüfungsnummer: 31721)

Prüfungsleistung, mündliche Prüfung, Dauer (in Minuten): 30

Anteil an der Berechnung der Modulnote: 100%

weitere Erläuterungen:

The exam consists of:

1. The final exam will "NOT" be an oral exam. The exam will be in a written form to evaluate the knowledge and understandings of students from the content of the course and the relevant literature which are introduced in the lectures. The duration of the written exam will be about 90 minutes. To pass the course, at least 50 % of the questions should be answered correctly."
2. Each student should present her/his research study in an intermediate and a final presentation. A summary paper should be written following the „survey papers guideline“ using IEEE format. The grade of the research project will be considered as a „Bonus point“ (up to 20%) for the final grade.
Prüfungssprache: Englisch

Erstabwegung: WS 2022/2023, 1. Wdh.: SS 2023

1. Prüfer: Reinhard German
