Course syllabus

Learning-Based Control
Inlärningsbaserad reglering

FRTN75, 7.5 credits, A (Second Cycle)

Valid for: 2024/25
Faculty: Faculty of Engineering LTH
Decided by: PLED F/Pi
Date of Decision: 2024-04-15
Effective: 2024-05-08

General Information

Depth of study relative to the degree requirements: Second cycle, in-depth level of the course cannot be classified
Elective for: BME4, C4, D4-ssr, D4-mai, E4-ra, F4, F4-r, F4-mai, MMSR1, Pi4-ssr
Language of instruction: The course will be given in English

Aim

The course provides fundamental theory and methodology for developing control laws based on measured input and output signal data. The aim of the course is that the students should learn the important principles within the area of learning-based control, and to understand their limitations.

Learning outcomes

Knowledge and understanding
For a passing grade the student must

- be able to understand algorithms for multivariable system identification, including estimations of model errors
- understand the importance of excitation
- uinderstand the basic principle of dynamic programming
- understand the assumptions and approximations behind common variants of reinforcement learning
- understand the fundamental properties and limitations of components based on machine learning, such as neural networks and classifiers.

Competences and skills
For a passing grade the student must

- be able to implement multivariable system identification procedures and perform model choices and determine how to analyse a given dataset
- be able to simulate and use identified models in a multivariable control synthesis
- be able to implement simple adaptive controllers
- be able to apply some variants of reinforcement learning
- be able to implement path-following algorithms based on dynamic programming.

Judgement and approach
For a passing grade the student must

- understand the achievable confidence when using data-driven control methods
- show ability for teamwork and group collaboration during laboratory experiments.

Contents

The development of suitable models for describing dynamical systems is a central problem within automatic control, and it is critical for the development of robust and high performance control laws. When relationships between physical quantities are not fully known, then models and the control laws may instead be generated by measurement data, through system identification, machine learning, or adaptive control. The purpose of the course is to teach the basic principles of how this is done.

The first part of the course is devoted to adaptive control and system identification for systems with several input and output signals. The focus is on state-space models and methods for generating these, including greybox identification. We describe iterative methods for learning, as well as model reduction for the purpose of reducing the dimension of the state space.

The second part of the course is devoted to reinforcement learning. This includes the theory of dynamic programming and various approximate methods thereof. Policy iteration is explained, as well as discrete and continuous path planning.

The third part of the course deals with the usage of complete components for the purpose of control, for instance sensors, that have been developed using machine learning.

Examination details

Grading scale: TH - (U, 3, 4, 5) - (Fail, Three, Four, Five)
Assessment: Written exam (5 hours), three laboratory exercises. In the case of less than 5 registered students, the retake exams may be given in oral form.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Modules
Code: 0121. **Name:** Examination.
Credits: 4.5. **Grading scale:** TH - (U, 3, 4, 5). **Assessment:** Passed exam
Code: 0221. **Name:** Laboratory Work 1.
Credits: 1.0. **Grading scale:** UG - (U, G). **Assessment:** Preparation exercises and approved participation in the laboratory
Code: 0321. **Name:** Laboratory Work 2.
Credits: 1.0. **Grading scale:** UG - (U, G). **Assessment:** Preparation exercises and approved participation in the laboratory

Code: 0421. **Name:** Laboratory Work 3.
Credits: 1.0. **Grading scale:** UG - (U, G). **Assessment:** Preparation exercises and approved participation in the laboratory

Admission

Assumed prior knowledge: FRTF05 Automatic Control, Basic Course.
The number of participants is limited to: 60
Selection: Completed university credits within the programme. Priority is given to students enrolled on programmes that include the course in their curriculum.
Kursen överlappar följande kurser: FRTN15

Reading list

- Lennart Ljung: System Identification: Theory for the user. Pearson Education, 1998, ISBN: 0136566952.
- Lecture slides, exercise material and laboratory manuals are available on the course homepage.

Contact

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Course homepage: https://www.control.lth.se/course/FRTN75