Course Syllabus: AT.425.EN Advanced System Identification

Instructor: Yuri Shardt (**e-mail**: yuri.shardt@tu-ilmenau.de; **Website**: http://www.tu-ilmenau.de/en/at)

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Office Hours: Please e-mail me for an appointment.

E-Mail Policy: I will respond to all e-mails within 1 workday after arrival. A day runs from 9:00 pm to 9:00 pm the next day. Weekends are excluded from the computation. In the subject header of your e-mails, please place the phrase "[AT.425]" followed by the topic of the e-mail (*e.g. [AT.425]: Question about Lecture 1*), so that I can respond faster to your e-mails.

Course Website: https://www.tu-ilmenau.de/en/university/departments/department-of-computer-science-and-automation/profile/institutes-and-groups/institute-for-automation-and-systems-engineering-fak-ia/automation-engineering-group/teaching/at425-advanced-system-identification

Lecture: **Wednesdays: 11:00 am to 12:30 pm in OEC 2007**

Seminar: Mondays: 5:00 to 6:30 pm in OEC 3009 (every odd week)

The seminar on Monday, October 9th, 2023 is cancelled.

Course Overview

In today's world, where data is relatively easy to get and manipulate, it is essential to understand how to properly use such data to obtain the most value from it. Using data can range from simply displaying it visually to developing models that can be used to predict future behaviour. In order to understand how to use the data, it is necessary to develop a strong understanding of statistics, which underlies almost all data processing methods. Therefore, this course will focus to provide you with the necessary tools to accurately and efficiently use complex, multivariate, time-varying data sets. The primary focus will be on stochastic modelling and process identification. The course has the following 3 main topics:

1) **Review of Regression and Statistics (1 Week; Chapter 3)**
   a. Linear and nonlinear regression
   b. Model validation

    c.   Regression analysis

2) Stochastic Modelling or Time-Series Analysis (6 Weeks; Chapter 5)

    a.   Definition of time series and their properties

    b.   Basic properties of different time-series models

    c.   Parameter estimation for time-series models (Yule-Walker equations and maximum likelihood methods)

    d.   Model validation and prediction using time-series models

    e.   Frequency-based modelling (Fourier transform)

    f.   State-space-based modelling (Kalman filter)

3) Process Identification (5 Weeks; Chapter 6)

    a.   Definition of process identification

    b.   Theoretical analysis of open-loop process identification

    c.   Practical aspects of open-loop process identification

    d.   Closed-loop process identification

    e.   Nonlinear process identification

Prerequisites

I expect that you have knowledge in the following areas:

1) **Math**: Basics in calculus and linear algebra
2) **Statistics**: basic knowledge of statistics including probability theory, expectation operator, confidence intervals, hypothesis testing, parameter estimation, and regression analysis

Grading

Final   100%

For the final, it is acceptable to bring your own copy of the course notes, the textbook, and one dictionary. A calculator without WiFi or electronic communication capabilities is permitted.

It is planned to conduct the final as an in-person examination. However, should it not be feasible, then it will be conducted as a four-hour take-home examination.

Bonus Points

There is a possibility to earn up to 5% extra on the final examination by submitting a correction form for suggestions on how to improve either the German or the English textbook. Each accepted correction has a value of 0.5%.

The procedure for submitting the correction is as follows. For each correction, submit the correction form that is available online and send it to me at least 5 days before the start of the final exam. Should two or more people find the same mistake, then I will give the bonus point to the person who first sent it to me. Please check the online *Errata and Corrigenda* for the current list of noted corrections. Once I have accepted the correction, I will send you a certificate that you will attached to your examination when you write it.

Mailing List for the Course

Please register for the course mailing list using the following link: https://www1.tu-ilmenau.de/fg-at-register/course/ or you can use the QR code below.

Laboratory

For this course, there is an associated laboratory. Information about the laboratory can be found on the course website.

Recommended Book

The course is based on the following book:

- Yuri A.W. Shardt (2022). *Statistics for Chemical and Process Engineers: A Modern Approach*, Springer International Publishing: Cham, Switzerland. (414 pp.) ISBN: 978-3-030-83190-5. doi: 10.1007/978-3-030-83190-5.