Stochastic Models

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Description and learning objectives

Many real life system are subject to uncertainty and should therefore be modelled with stochastic models. In this course we focus on the theory and the application of three different classes of stochastic models: Discrete Time Markov Chains, Continuous Time Markov Chains, and Markov Decision Processes. The students should gain knowledge about these models such that they are able to construct these models, and apply them to solve real life problems. For illustration we use among others models of inventory systems, manufacturing systems, maintenance systems, and queuing systems. Students should know how formulas for performance measures can be derived and how they can be computed. Further, the students learn numerical methods to obtain solutions. Additionally, we discuss methods to derive structural results and to obtain optimal policies.

Content

The first block of the course is devoted to Discrete Time Markov Chains. After the introduction of this model class, we study the transient analysis and the long-run analysis of such type of models. We therefore discuss the classification of states and when a Markov Chain is ergodic.

In the second part of the course Continuous Time Markov Chains are investigated. We discuss the flow rate equation method to obtain the equilibrium distribution and enable a long-run analysis of the Markov Chain. Further, the uniformization method is studied, which enables a transient analysis of a continuous time Markov Chain.

In the last block of the course Discrete Time Markov Decision Processes are studied. After the introduction of the model, different numerical methods, like the policy iteration or the value iteration, are discussed to obtain optimal decisions. It is also shown how structural properties about the optimal decisions can be obtained

Structure of the course

Online-Course: 15.3.2021 – 9.4.2021
Language: English

The course will be offered in electronic form. Participants get screencasts, exercises and scientific papers to study the different topics themselves. Three different types of exercises are offered. The first type of exercises should support students to improve their modelling skills. In order to learn how to apply the models, programming exercises have to be done. For all numerical examples in the course R is used, but students can work with the programming language they are familiar with.

Additionally, theoretical exercises are offered to deepen the theoretical knowledge. Finally, students have to study one scientific paper, where one of these model types is used, and have to do an assignment based on the paper.

Virtual meetings are organized during the course to discuss the different topics and to support the participants.

The first meeting will be on

15.3.2021 14.00-16.00

Regular virtual meetings take place at the following dates and times

17.3.2021 14.00-16.00
19.3.2021 14.00-16.00
22.3.2021 14.00-16.00
24.3.2021 14.00-16.00
26.3.2021 14.00-16.00
29.3.2021 14.00-16.00

In the week 6.- 9.April there will be a last session where students have to give a presentation. Students have to be prepared for the virtual meetings. They have to listen to the corresponding screencasts and have to prepare the exercises.

Prerequisites

Participants should have basic knowledge in probability theory (Random variables, discrete and continuous distribution functions, conditional distributions, moments of random variables). The required prior knowledge includes the topics discussed in the first part (chapter 1 – 7) of the book from Stewart, W.J. (2009): Probability, Markov Chains, Queues, and Simulation, Princeton. Additionally, students should have basic programming experience.

Literature

Stewart, WJ. (2009): Probability, Markov Chains, Queues, and Simulation, Princeton.

Tijms, HC. (2003): A first course in stochastic models, Wiley.

Putermann, ML. (2005): Markov Decision Processes – Discrete Stochastic Dynamic Programming,

Grading

Each student has to do a project, based on a scientific paper, where the methods have to be applied. The results have to be presented in the last meeting (6ECTS)

Administration

Students who would like to participate should send an e-mail to office.cdt@wi.tum.de
A maximum number of 15 students can participate.