

## Stochastic algorithms

UFC/DC  
SA (CK0191)  
2018.1

### Content

Deterministic  
Markov functions  
Stochastic Markov  
functions

### Logistic

Evaluation

# Stochastic algorithms

## Intro

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# General content

## Stochastic algorithms

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## General content

Consider the general problem of system analysis and controller design

- We have at our disposal a wealth of knowledge
- Deterministic system and control theory
- We can investigate the system structure and modes of response
- We can design compensators that alter these characteristics
- We can design controllers that provide appropriate inputs
  - To generate desired system responses

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## General content (cont.)

Why do we need to go beyond these results?

- Why stochastic models?

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## General content (cont.)

To observe the actual system behaviour, we construct measurement devices

- They output data signals, proportional to variables of interest

These signals and the known inputs are the only available information

- Information discernible about the system

If we design a controller, these signals are the only available inputs

- Direct inputs to the controller

## General content (cont.)

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No mathematical system model is considered perfect

- Only dominant/critical modes are modelled
- Computationally feasible (light)

Systems are not only driven by our control inputs

- Disturbances that we cannot control
- Disturbances that we cannot model

Sensors are not perfect nor they are complete

- Not all interesting information
- No exact reading and noise
- Own system dynamics

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## General content (cont.)

We cannot assume perfect knowledge of all quantities or perfect control

We must develop a system model that accounts for uncertainties

- ↪ How to optimally estimate the quantities of interest?
- ↪ How to optimally control the system to perform?

How to evaluate the performance of these estimates and control?

## General content (cont.)

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2018.1

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The course is an introduction to modelling of dynamic processes

- Deterministic and stochastic state-space models
- Deterministic and random Markov functions

We overview of dynamic system analysis and probability theory

# Deterministic Markov functions

## General content

# Deterministic Markov functions

Deterministic Markov systems/models and their classification

- Input-output and state-space representation
- ↪ Focus on state-space models

General properties of deterministic systems

- Dynamical/Instantaneous
- Linear/Nonlinear
- Stationary/Nonstationary
- Proper/improper
- With/Without delay

# Deterministic Markov functions (cont.)

The analysis of state-space models only in the time-domain

- ↪ Linear and stationary models

A general scheme to determine the state transition matrix

- ↪ **The Sylvester expansion**

A general procedure to solve the analysis problem

- ↪ **The Lagrange formula**

Similarity transformations and canonical forms

- ↪ **Diagonalisation**
- ↪ **Jordan's form**

The system modes and their interpretation

# Stochastic Markov functions

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### Content

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### Logistic

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## Stochastic Markov functions

Stochastic Markov system/models, their classification and their properties

- Continuous-time continuous-state Markov processes
- Continuous-time discrete-state Markov processes
- Discrete-time discrete-state Markov processes

Main focus on discrete-time discrete-state processes

## Stochastic Markov functions (cont.)

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### Evaluation

Analysis of discrete-time discrete-state Markov processes (chains)

- General concepts and definitions
- **Classification of states**
- **Irreducibility**

Some important matrices

- **Fundamental matrix**
- **Reachability matrix**
- **Potential matrix**

Some important distributions

- **Steady-state distribution**
- **Stationary distribution**
- **Limiting distribution**

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## Stochastic Markov functions (cont.)

Analysis of continuous-time discrete-state Markov processes

- General concepts and definitions
- **Transition probabilities**
- **Transition rates**

Some important distributions

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## Stochastic Markov functions (cont.)

Continuous-time continuous-space (general) Markov processes

- **General Markov state density function**
- **Chapman-Kolmogorov equations**
- **Kramers-Moyal equations**
- **The Markov propagator**

**Time-integral and time-evolution of Markov processes**

- General moment evolution equations

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## Stochastic Markov functions (cont.)

The continuous propagator and its characterising functions

- Time-evolution equations

Three important continuous Markov processes

- The Liouville process
- The Weiner process
- Ornstein-Uhlenbeck process

The Fokker-Planck equation and the Langevin equation

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functions

### Logistic

### Evaluation

## Logistics

### Stochastic algorithms

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## Logistic

SIGAA doesn't know the course location

- Here, mostly

Timetable, as you have known it

- Friday afternoons
- 14 : 00 → 18 : 00
- SIGAA's wrong

I do not care about presence

- If you deliver

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### Evaluation

## Evaluation

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## Evaluation

Two, maybe three, intermediate tests (AP) here in the classroom (70%)

- Train by exercising and participating

One, maybe two, home assignment/project (30%)

To pass the course you need a 5, with 7 you pass earlier (8, I am happy)

- You can have a final test (AF), if you ask