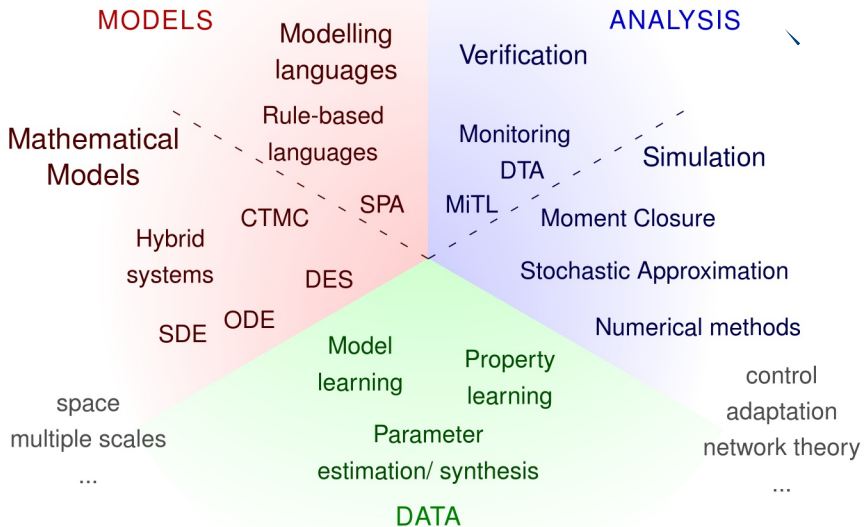


OUTLINE

- 1 INTRODUCTION BY EXAMPLES
- 2 COURSE TOPICS: AN OVERVIEW
- 3 MODELLING: AN INTRODUCTION

A MAP OF COURSE TOPICS




COURSE TOPICS: WORD OF WARNING

In the following slides, I will present a list of possible topics. However, the following warnings apply:

- 1 The list is **by no means** exhaustive. If you want to discuss something different (a different theoretical approach, other case studies), feel free to ask and negotiate.
- 2 The list is long, and we will not cover all the material.
- 3 We will not cover the material in full detail. I would rather like to **introduce you to the main ideas**, so you can explore the topics you like more (if any).
- 4 Question-marked topics (?) are less likely to be covered than the ones without question mark.

TOPICS: MATHEMATICAL MODELLING

- Introduction to Stochastic processes (CTMC)
- Introduction to ODE collective models
- Introduction to stochastic hybrid automata 
- (?) Introduction to SDE

TOPICS: MODEL ANALYSIS

- Stochastic simulation
- (?) Importance sampling
- (?) Batch estimation of steady state means
- Connecting CTMC and ODE: mean-field and fluid approximation
- Moment closure techniques
- Linear-Noise Approximation
- (?) Diffusion approximation
- Connecting CTMC and SHA: hybrid mean field
- (?) Discrete Event Simulation
- (?) Multiple time scales
- (?) Moment-based density reconstruction

TOPICS: MODELLING LANGUAGES

- (?) An introduction to (stochastic) process algebras.
- (?) PEPA (Performance Evaluation Process Algebra)
- (?) Bio-PEPA (Systems biology fork of PEPA)
- (?) Rule-based languages: κ -calculus (good for biochemical networks with complex protein complexes).
- *PETRI NETS*

TOPICS: DATA INTEGRATION

- Introduction to parameter fitting: maximum likelihood and bayesian methods
- Parameter fitting for stochastic models - likelihood approximation
- Parameter fitting for stochastic models - Bayesian methods
- (?) Parameter fitting for CTMC - variational methods
- (?) Parameter fitting for CTMC - qualitative data and Gaussian Processes Optimisation

TOPICS: VERIFICATION

- Introduction to temporal logics (CTL/LTL) and model checking
- (?) Continuous Stochastic Logic (CSL) and Stochastic Model Checking for CTMC
- Metric Temporal Logic (MiTL), real time verification for dynamical systems, and statistical model checking for CTMC
- Smoothed Model Checking and system design
- (?) Mean-field model checking
- (?) Linear Noise Model checking

SPACE AND NETWORK MODELLING

- (?) Explicit models of interactions networks: dynamical network theory.
- ? Mean field approximation for network processes.
- (?) Modelling space: introduction.
- (?) Reaction-Diffusion equations (PDE)
- (?) Reaction-Diffusion master equation and Poisson representation
- (?) Logical space: locations and patches

CASE STUDIES

- Systems/synthetic biology: gene networks, signalling networks, ...
- Epidemiology: epidemic spreading, network epidemics, ...
- Computer systems: queueing networks, ...
- Ecology: prey-predator dynamics, ant foraging,
- Crowd modelling: “el bottellón”, emergency egress, ...
- Smart cities: smart grids, bus networks, bike sharing
- ...