MA3A9-15 Data-Driven Mathematical Modelling

26/27

Department
Warwick Mathematics Institute
Level
Undergraduate Level 3
Module leader
Markus Kirkilionis
Credit value
15
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module bridges the gap between traditional mechanistic modeling (physics-based) and modern data science, using data to describe processes, predict behavior, and identify complex system dynamics.

Module aims

(a) Understanding the difference between classical mathematical modeling and modern approaches of data-driven mathematical modelling.
(b) Enabling students to use data-driven modelling techniques, both theoretical and practical, through programming.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

In this module we focus mainly on time series data produced from a possible unknown dynamical

system. The data establish the ground truth, and we like to apply methods that can differentiate between, or reconstruct a dynamical system which is partly or fully unknown.

Introduction: Different Levels Of Unknowns In Mathematical Modelling

Parameter Estimation

Model Selection, Akaike’s Information Criterion

Singular Value Decomposition (DMD)

Koopman Operator Theory

Sparse Identification of Nonlinear Dynamics (SINDy)

Background: Neural Networks and Deep Learning (as needed in this module)

General Physics-Informed Machine Learning

Physics-Informed Neural Networks (PINNs), Neural-Network ODEs (NN-ODEs) and PDEs (NN-PDEs).

Learning outcomes

By the end of the module, students should be able to:

- Understanding the level of uncertainty in dynamic mathematical modelling
- Understanding the core reconstruction methods of dynamical systems from time series data
- Practical knowledge to implement the methods introduced in the module

Indicative reading list

Reading lists can be found in Talis

Subject specific skills

Using module specific code

Transferable skills

Complex modelling and problem solving using data analysis

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Seminars	9 sessions of 1 hour (6%)
Private study	111 hours (74%)
Total	150 hours

Private study description

Homework, assignments, engagement with departmental support and feedback mechanisms, exam preparation

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group A

	Weighting	Study time	Eligible for self-certification
Computational Project	60%		No
Assignments	40%		No

Four assignments with deadlines during the term

Assessment group R

	Weighting	Study time	Eligible for self-certification
Computational Project	100%		No

Feedback on assessment

Feedback on assignments and project.

Availability

Courses

This module is Option list A for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
    - Year 4 of G105 Mathematics (MMath) with Intercalated Year
    - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G100 Mathematics
    - Year 3 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
- Year 4 of UMAA-G107 Undergraduate Mathematics (MMath) with Study Abroad
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year