

Data Assimilation

Introducing

Description

- -Basics tools to solve inverse problems (including examples): least-squares (linear, non-linear), regularization.
- -Data Assimilation principles (variational, sequential).
- Bayesian analysis.
- Equivalences between the BLUE:Kalman filter, the MAP and VDA in the Linear-Quadratic-Gaussian case.
- A first application to model identification in experimental mechanics: (i) computation of the measures from image registration and (ii) data assimilation to calibrate constitutive laws.
- -Optimal control of ODEs. Linear-Quadratic case, maximum principle, Hamiltonian.

Small practical: optimal control of a vehicle trajectory.

- -Optimal control of PDEs. Gradient computation, adjoint model, optimality system.
- Variational Data Assimilation (steady-state case, unsteady case). Algorithms (3D-VAR, 4D-Var, variants).
- Examples, practical aspects.
- DA by Physics Informed Neural Networks (PINNs).

Practical (marked): estimation of river bathymetry from water surface measurements (problem arising in spatial hydrology).

Ocean circulation modelling

- Fluid mechanics at the planetary scale, Equilibrium solutions
- Shallow water equations: derivation and description of wave propagation. Applications: Gravity waves, Poincaré Waves, Kelvin Waves
- -Quasi-Geostrophic equations: derivation and description of wave propagation. Applications: Rossby Waves, Gulf Stream.

Objectives

- Standard basic tools to analyze and solve inverse problems.
- How to fuse measurements (datasets) and PDE-based models.
- Set up the optimal control of a system (ODEs and PDEs).
- Compute the gradient of a model output (cost function) in large dimensional cases by the adjoint method.
- Set up a control-like algorithm to identify uncertain parameters and/or calibrate the model (Variational Data Assimilation, 4D-Var).
- Explain the links and differences between VDA, filters





(Kalman etc) and Bayesian estimations.

- Explain what is a Physics Informed Neural Network (PINN).
- -Carry out the non dimensionalization of a system of PDE, use correctly physical units in a PDE system.
- -Carry out the analysis of the dynamics around equilibrium of PDE system with dispersion relations.

Necessary prerequisites

Differential calculus, numerical optimisation, bases of functional analysis and mechanical models, the few classical PDE models (weak forms and FE schemes is a plus), Python programming.

Évaluation

L'évaluation des acquis d'apprentissage est réalisée en continu tout le long du semestre. En fonction des enseignements, elle peut prendre différentes formes : examen écrit, oral, compte-rendu, rapport écrit, évaluation par les pairs...

Practical info

Location(s)



Toulouse

