Simulation and Control of Heat Problems

Theses and Projects

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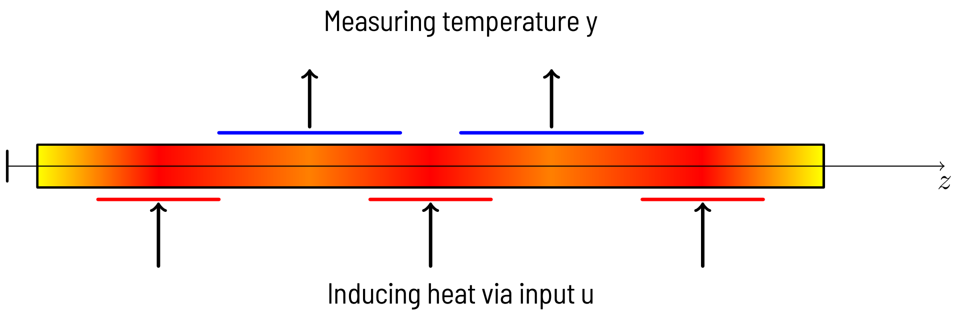

Many technological processes contain or depend on heat conduction and radiation. The temperature of components is crucial for their application: either it has to be reduced to guarantee a service (e.g. cooling of electronic devices) or it has to be increased to assemble or crack chemical components. Therefore, engineers are interested in modeling, simulating and controlling the temperature of certain components. However, problems like unknown or inexact material parameters occur and have to be solved using modern tools. An incomplete list of open tasks is:

- Identification of material properties
- Simulation of heat conduction via numerical methods
- Application of classical control methods (e.g. PID control)
- Development of modern control techniques like Model Predictive Control

You will use software tools like MATLAB®, PYTHON and JULIA as well as further frameworks to develop **simulations**, **artificial intelligence** and **control** algorithms. Please find details on the next page.

Selection of available topics

Modeling and simulation of thermal processes

1. Simulation of linear thermal dynamics using surrogate models (Surrogates.jl), e.g radial basis functions, polynomial chaos expansion (PolyChaos.jl).

2. Development of discontinuous Galerkin methods to simulate quasi- and nonlinear thermal dynamics.

3. Implementation of thermal models using JULIA toolkits for Finite Volume methods (VoronoiFVM.jl) and Scientific Machine Learning (ModelingToolkit.jl, DiffEqFlux.jl).

4. Accelerating numerical simulations of nonlinear and high-dimensional systems using Automatic Differentiation and next-generation numerical solvers.

5. High-Performance computing with Julia: using multi-core and GPU (CUDA.jl, MPI.jl)

Analysis and control of thermal processes

1. Modern control techniques using Scientific Machine Learning (GalacticOptim.jl, DiffEqFlux.jl and ModelingToolkit.jl).

2. Data-driven controller design for high-dimensional thermal dynamics using Dynamic Mode Decomposition (DataDrivenDiffEq.jl).

3. Development of Model Predictive Control methods for linear and quasi-linear thermal dynamics.

4. Nonlinear control theory (e.g. Backstepping, Flatness-based approaches) applied on thermal dynamics.

5. Development of a port-Hamiltonian systems model for linear heat conduction.

Please contact me for specific tasks and questions.

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