Structure-preserving deep learning of reversible and irreversible dynamics

Bachelor / Master / project / seminar thesis

This thesis project gives you an opportunity to

- learn about cutting-edge research on
  - **combining physical modeling with machine learning**
  - structured and composable representations of physical models
- improve your programming skills (Julia and/or Python)
- frequently discuss questions and exchange ideas with your thesis supervisor

To elaborate, physical modeling here refers to creating computational models of physical systems, which may incorporate elements from classical mechanics and electromagnetism, as well as irreversible processes such as mechanical friction, electrical resistance, and heat transfer. Example systems can be chosen based on your interests.
The considered approaches for combining data-driven techniques with physical modeling based on first principles rely on a structured representation of such models. This structure encodes the underlying conservation laws, particularly the conservation of energy (first law), as well as the non-negative entropy production by irreversible processes (second law). Using a graphical syntax, structured models can be easily combined into more complex systems. To manage complexity and to enable reusability of (sub)systems, the syntax supports hierarchical modeling, meaning that models can broken down into systems of systems, possibly with various levels of nesting. In the context of data-driven modeling, the compositional approach makes it relatively easy to incorporate prior knowledge.
The primary goal of the thesis is to systematically compare some already established approaches for deep learning of such structured models based on a few example systems.

Prerequisites

- genuine interest in the topic
- critical thinking
- systematic mindset
- basic programming skills

If you match those criteria, please contact markus.lohmayer@fau.de.