Type: Masterarbeit /

Contents: experimentell / theoretisch /

Beschreibung:

Title: Scientific machine learning through physics-informed neural networks

We are seeking a highly motivated student to develop a novel framework for Physics-Informed Neural Networks (PINNs) that overcomes current limitations.

Basics of Physics-Informed Neural Networks (PINNs):

PINNs are a powerful machine learning technique that combines the strengths of neural networks and physics. Here's a breakdown:

- **Neural Networks**: These are algorithms inspired by the human brain, capable of learning complex patterns from data.
- **Physics**: Scientific principles governing the behavior of matter and energy.

PINNs leverage the data-driven learning power of neural networks while incorporating physical laws through governing equations (often described by Partial Differential Equations - PDEs). This allows PINNs to:

- **Learn from data**: Analyze existing observations or measurements of a physical system.
- **Enforce physical laws**: Ensure the learned model adheres to established physical principles.
- **Handle complex systems**: Model intricate physical phenomena that might be difficult to solve with traditional methods.

Project Focus:

This project builds upon the foundation of PINNs and aims to develop PINNs model that can model 2 Dynamic Systems:

1. Spring Mass Damper System
2. Inverted pendulum

Furthermore, the models should be:

- **Independent of initial conditions**: Produces accurate results regardless of the system's starting state.
- **Partially independent of external forces**: While the type of force needs to be known, the model should be able to infer the force equation from data.
- **Independent of natural frequency**: Applicable to various systems with different inherent oscillation frequencies.
- **Generalizable**: Analyze the effectiveness of incorporating advanced neural network architectures like Recurrent Neural Networks (RNNs) to increase generalizability.

This thesis will, therefore, focus on the combination of data-driven ML model and Physics behind the dynamic systems to gain the benefits of both worlds. Furthermore, it would be part of the project to evaluate the impact of known physical model, unknown physical model, known inputs to the real physical system, unknown inputs to the real physical system etc. and their pros and cons.

Desired Skills: Background in machine learning. Basic understanding of physics concepts behind Spring Mass Damper System and Inverted Pendulum. Experience with ML libraries (e.g., Python, TensorFlow, PyTorch). Basics in Simulink would be beneficial.

Project Benefits:

- Opportunity to work on cutting-edge research at the intersection of physics and machine learning.
- Hands-on experience in developing and implementing advanced neural network models.
- Develop strong technical skills in machine learning and scientific computing.