Type: Masterarbeit / Semesterarbeit

Contents: experimentell / theoretisch /

Beschreibung:

Title: Using Reinforcement Learning and Physics-Informed Neural Networks for control of Robotic Arm Manipulators

We are seeking a highly motivated student to develop a novel framework combining Reinforcement Learning (RL) with Physics-Informed Neural Networks (PINNs) that improves the reliability of RL algorithms. It can potentially increase stability of RL because PINNs enforces the physics of the system in predictions that can reduce generation of infeasible trajectories.

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.

Project Focus:

This project builds upon the foundation of RL and PINNs and aims to develop the control system that can model:

1. 3 DoF Robotic Arm
2. 6 DoF Actual ABB Robotic Arm (based on results from 3 DoF Robotic Arm)

Furthermore, it would be part of the project to:

- **Comparison against RL only approach**: Investigate the impact of adding PINNs in the control algorithm against RL only approach.
- **Comparison against MPC+PINNs approach**: MPC is often considered state of the art approach for control algorithms. Investigate performance of RL+PINNs against MPC+PINNs

- **How to add physical constraints**: Investigate if we can add physical constraints like distance from obstacle, maximum speed etc. into RL or PINNs cost functions to enforce safety.
- **Compare data requirements**: Investigate if adding Physical Information in Neural Networks can help in faster convergence and reduce data requirements.
- **Compare extrapolation and interpolation capabilities**: Investigate if adding physics behind the system can improve the extrapolation and interpolation capabilities of RL.

This thesis will, therefore, focus on the combination of data-driven ML model and Physics behind the Robotic Arms to gain the benefits of both worlds and improve the reliability of the RL predictions. Furthermore, it would be part of the project to evaluate if we can enforce physical constraints to increase safety of cobots using PINNs+RL.

Desired Skills: Background in machine learning and reinforcement learning. Basic understanding of physics behind Multi Link Manipulators. Experience with ML libraries (e.g., Python, TensorFlow, PyTorch). Basics in Simulink would be beneficial. Basics of English is required as thesis would be in English.

Project Benefits:

- Hands-on experience in working with Real ABB Hand Manipulator Robot.
- 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.

Reference Materials:

- https://arxiv.org/abs/2104.02556
- https://arxiv.org/pdf/2209.09025.pdf
- https://www.sciencedirect.com/science/article/pii/S2405896322013118?via%3Dihub