Institute of Mechatronic Systems
Leibniz Universität Hannover

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Machine Learning with Physically Modeled Features for Human-Robot Collaboration

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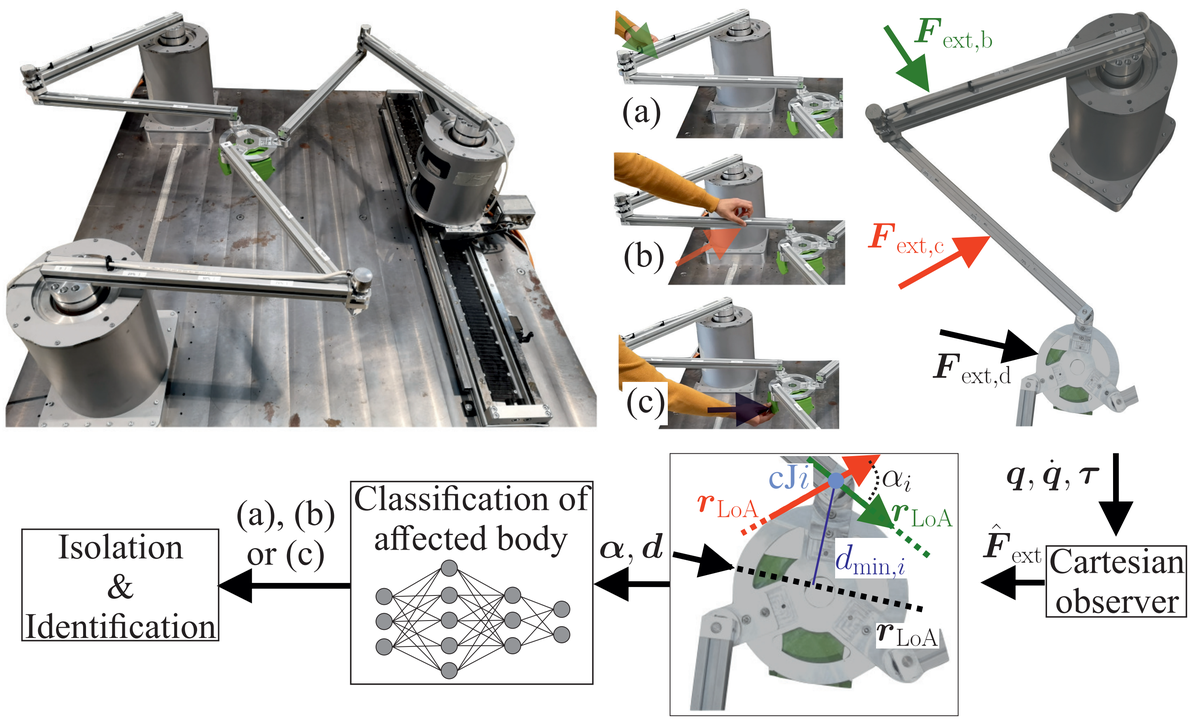
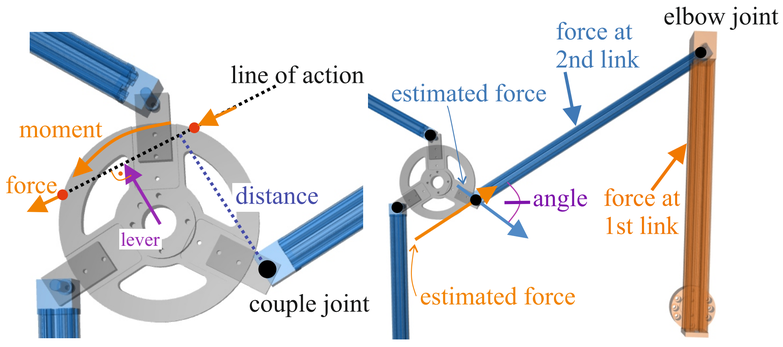
Research Question & Contributions

- Parallel robots are characterized by drives mounted fixed to the base. Reduced moving masses allow higher speeds while maintaining the same energy thresholds regarding human-robot collaboration. Due to the parallel kinematic chains, the risk of collision increases. → **How do collisions affect the dynamics of a parallel robot? Does this insight allow us to estimate the location and force of a collision on the entire structure of a parallel robot?**
- Physically modeled features allow classification and generalization to collisions over the entire robot body in unknown joint angle configurations
- Instead of distributing the particles over the entire robot, the classification result limits the search space of the collision isolation and identification with a particle filter to one body



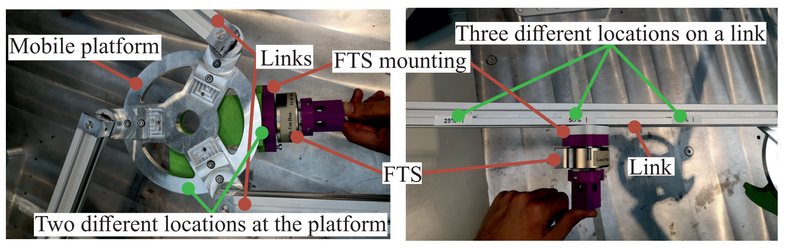
Physical Modeling as Feature Engineering & Data Acquisition

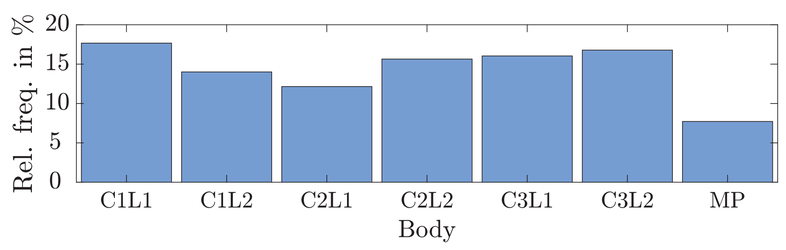
Hypothesis Formulation



- Minimal distance allows to distinguish between platform and chain collisions
- First and second link collisions differ by the angle

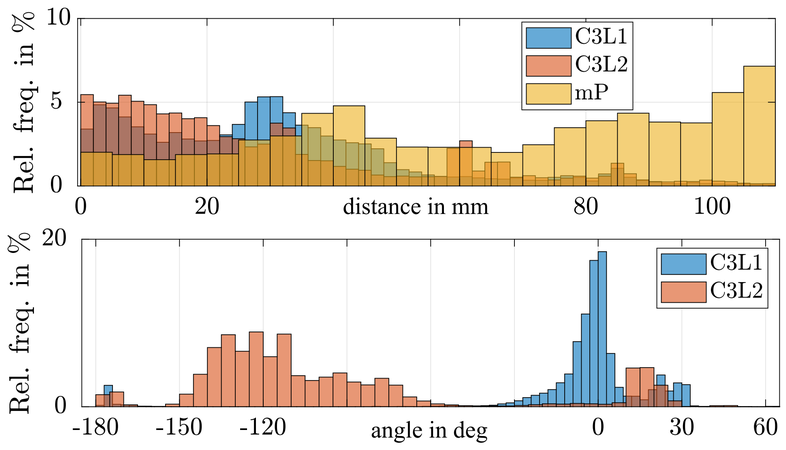
Contact Data Labeling





Seven classes – Six links and one platform

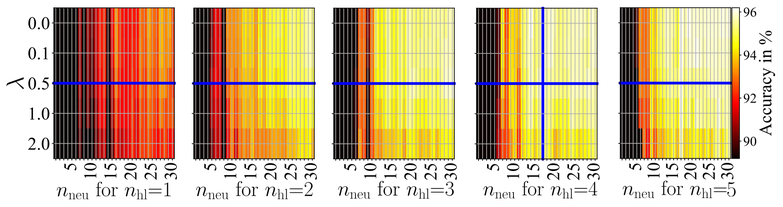
Kinetostatic Analysis



Modeling inaccuracies cause class overlaps and ambiguities

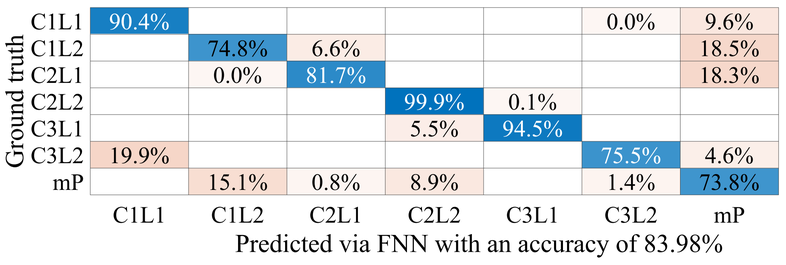
Neural Networks & Particle Filter for Collision Isolation/Identification

Hyperparamter Optimization



- Goal: classifier generalizes to unknown contact cases
- Approach: hyperparameter are regularization factor (λ), number of hidden layers (n_{hl}) and neurons per layer (n_{neu})
- Heatmap with cross-validation results for network structure

Collided-Body Classification



- Feature engineering and classification at 1 kHz
- Confusion matrix with test data of collisions in unknown contact scenarios
- Classification's output decides on the collision isolation and identification

Isolation and Identification