

KOI & EBIKE

OPTIMIZING KINEMATICS STRUCTURES AND IK PARAMETERS BY COMBINING
REACH AND OPTUNA

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Introduction



- REACH evaluates
 - Reachability for a given robot
 - IK solver performance
- Let's use these as optimization objectives
- Each evaluation takes time
 - Low number of optimization trials preferred
 - Hyperparameter optimization library



Image from <https://optuna.readthedocs.io/en/stable/>

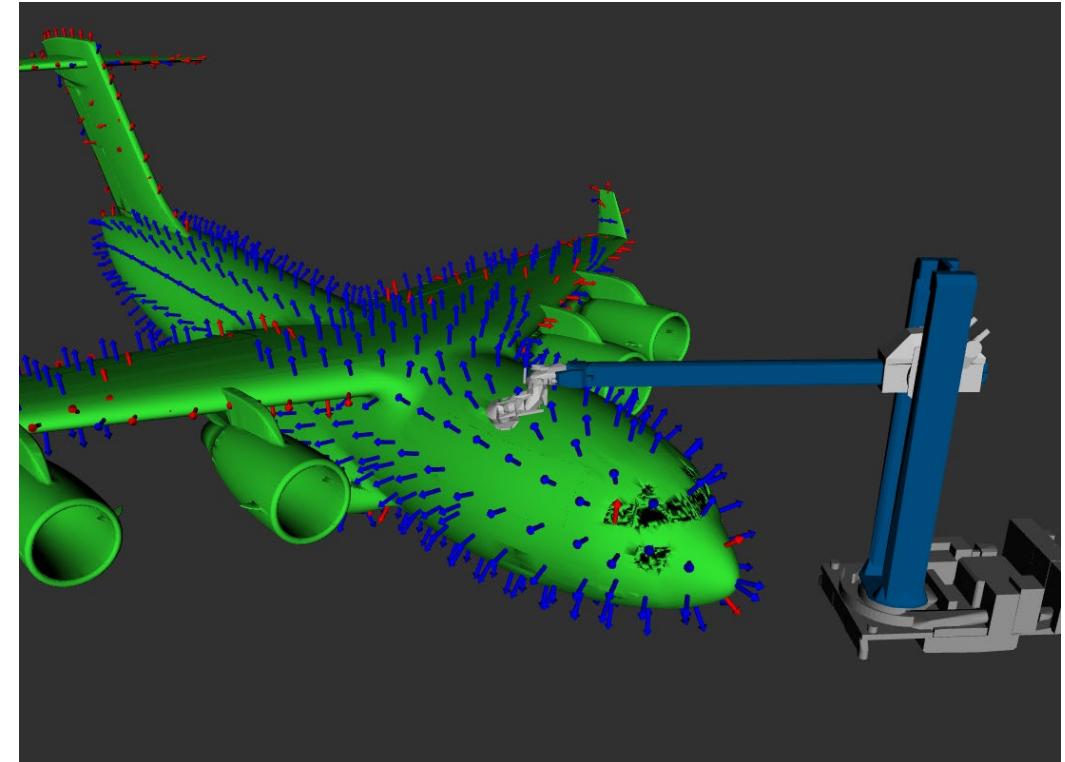
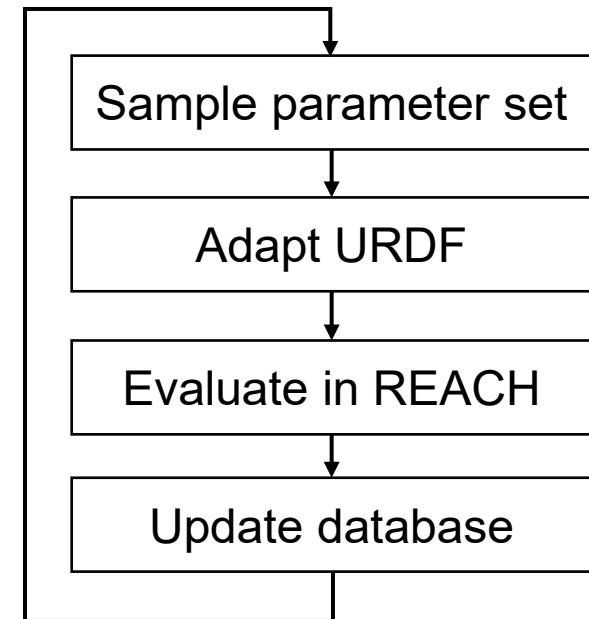
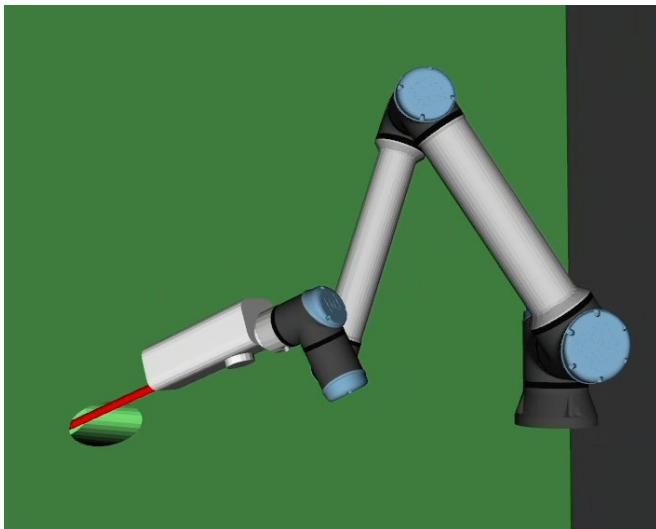
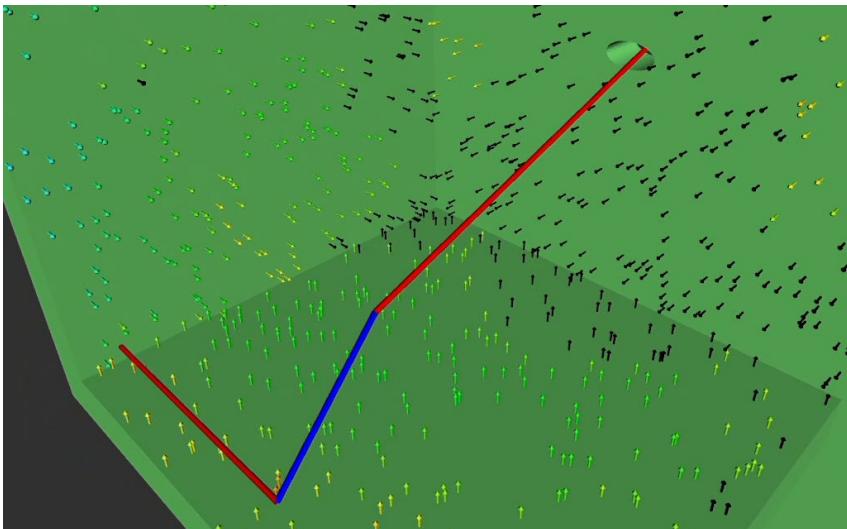


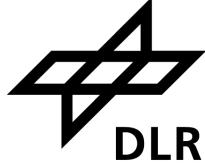
Image from <https://github.com/ros-industrial/reach>



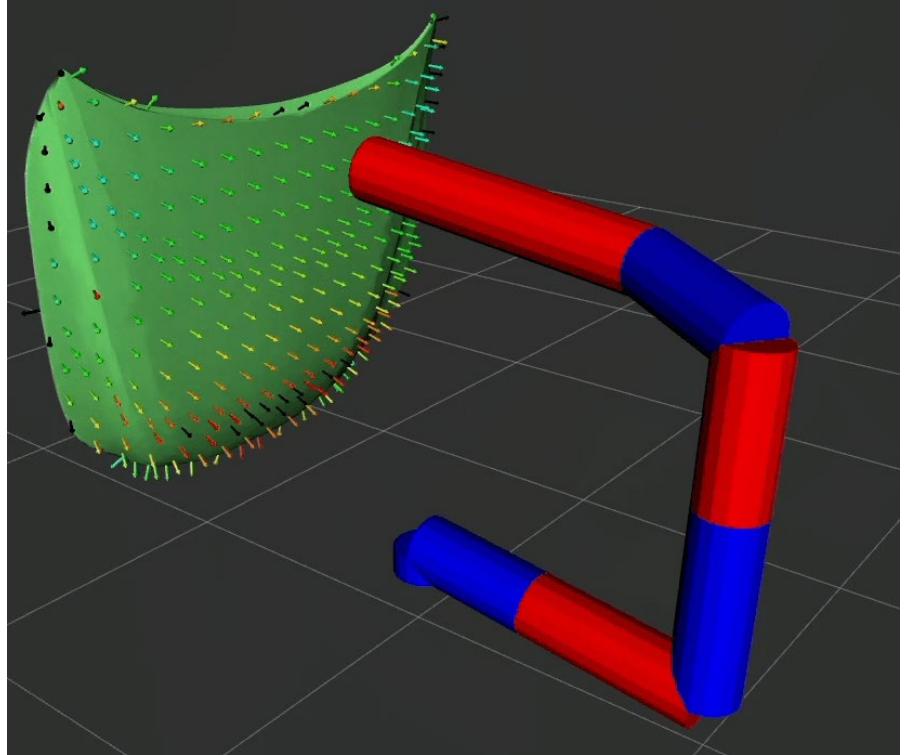
- Goal: optimize the robot structure
- Originally developed to optimize our endoscopic inspection robot



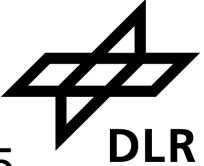
KOI – Arm Demo



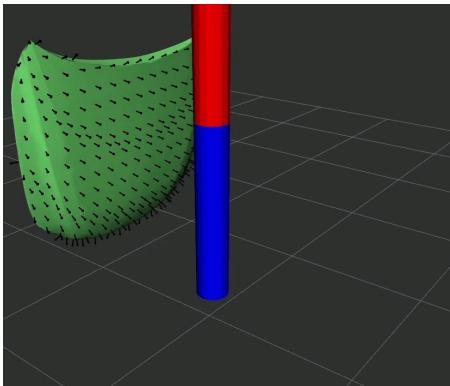
- Demo for a general robot arm
- Parameter
 - Link length
 - Joint axis
 - Number of joints (5 or 6)



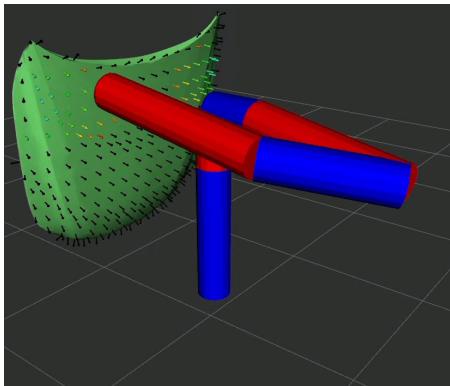
KOI – Arm Demo



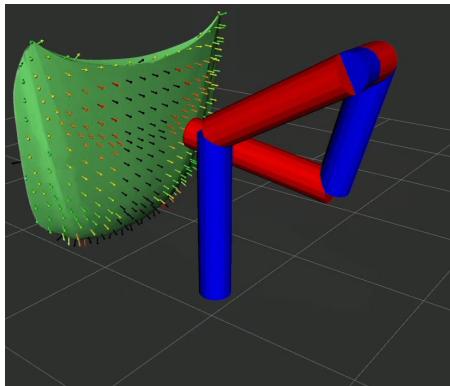
Trial 0



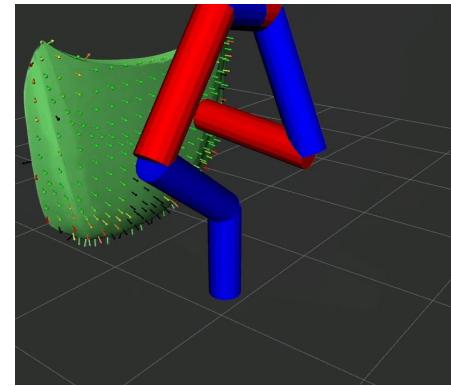
Trial 10



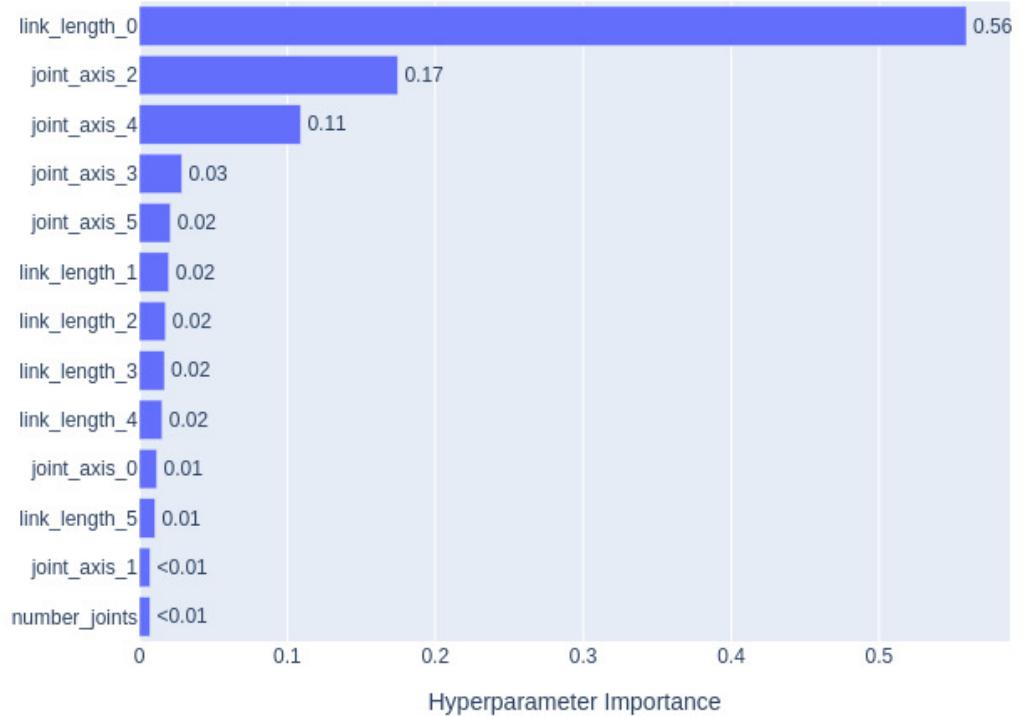
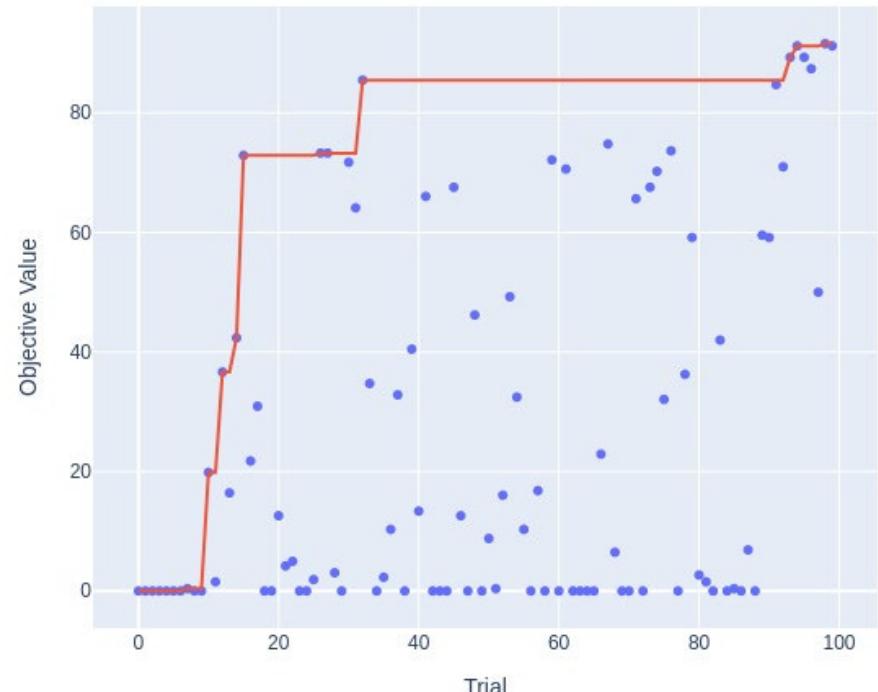
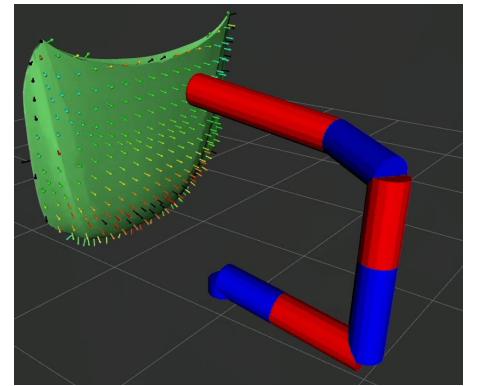
Trial 15



Trial 32



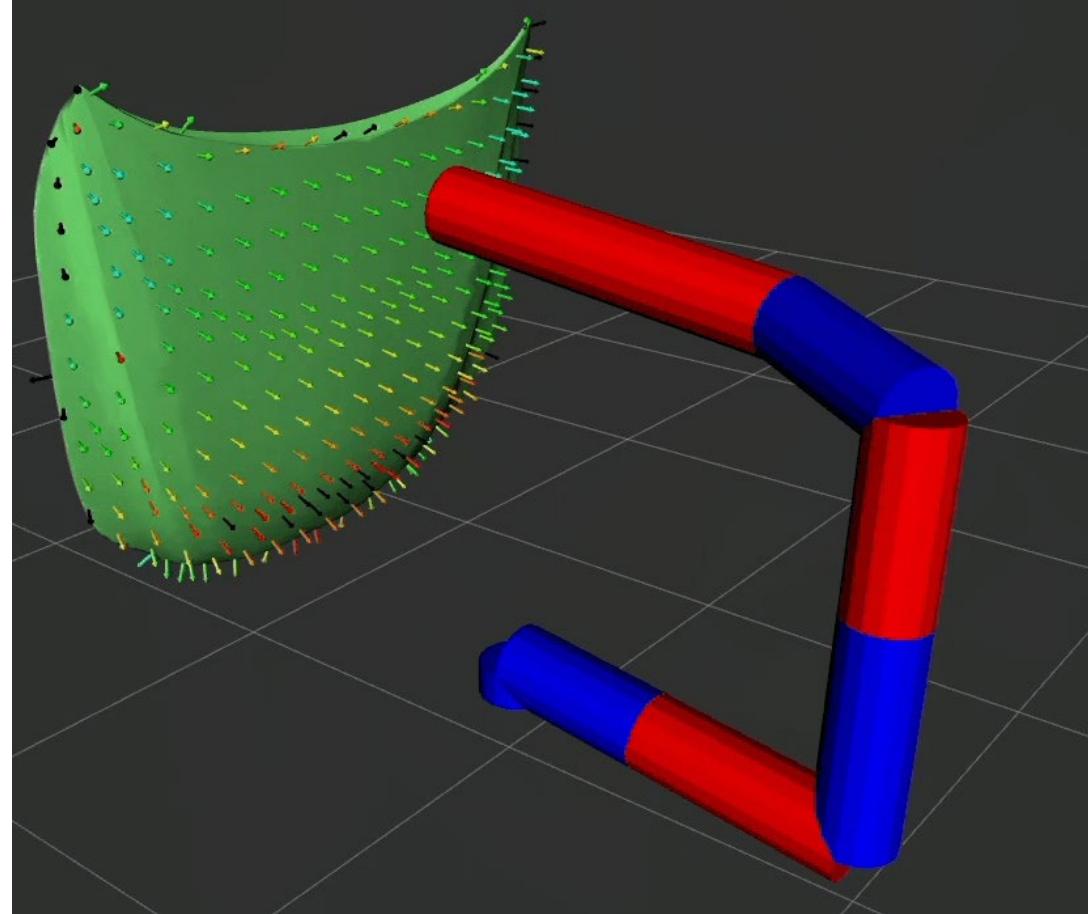
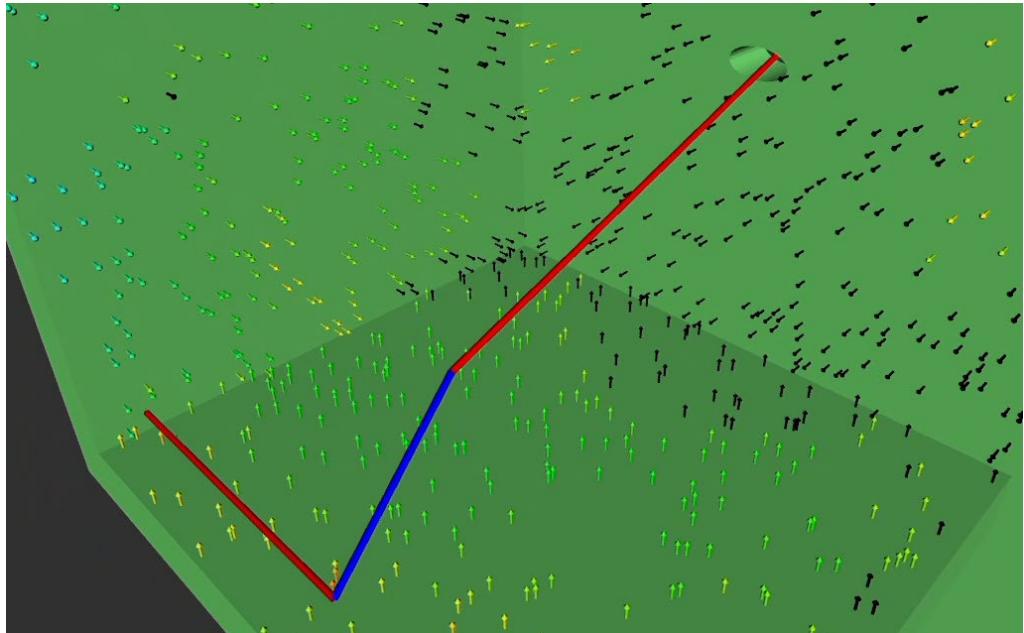
Trial 95



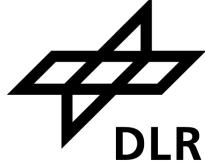
KOI – Arm Demo



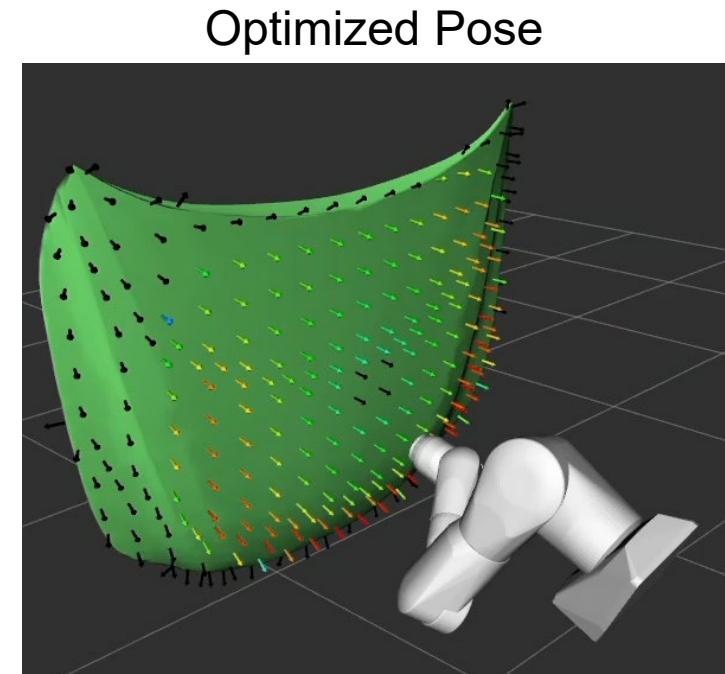
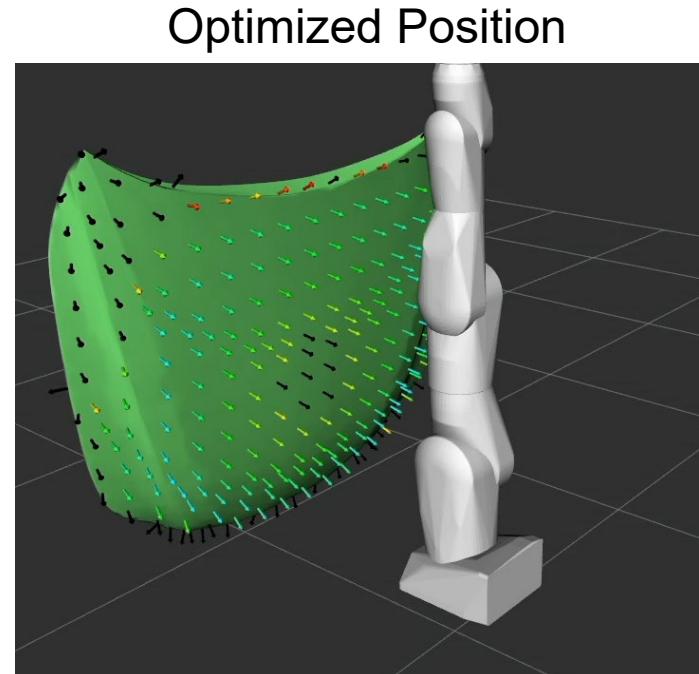
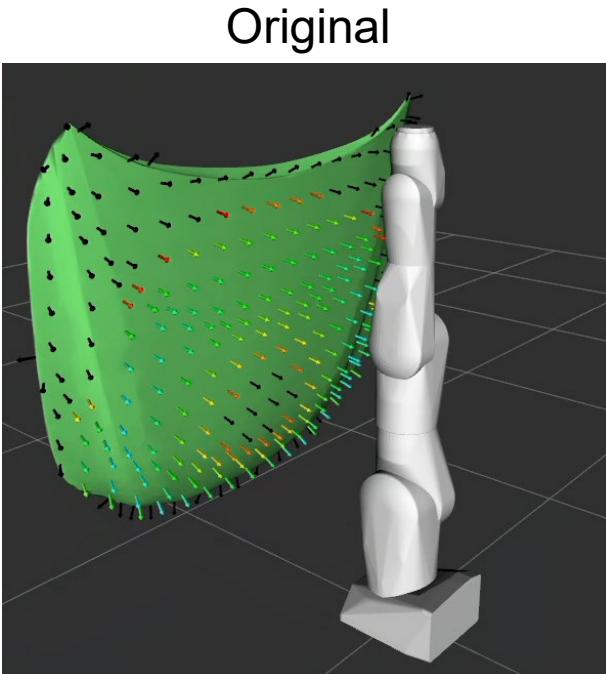
- Possible applications
 - Design of a new (specialized) robot
 - Finding configurations for modular robots

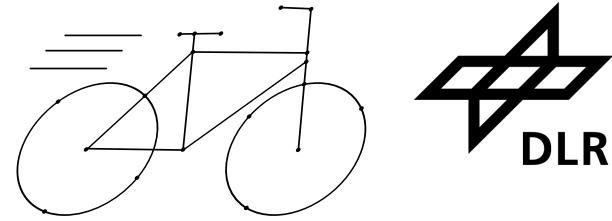


KOI – Robot Positioning Demo

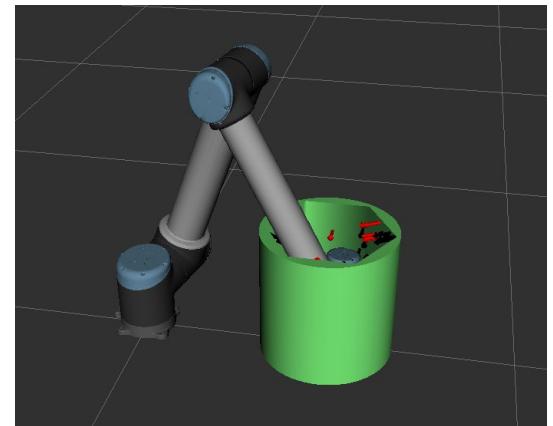
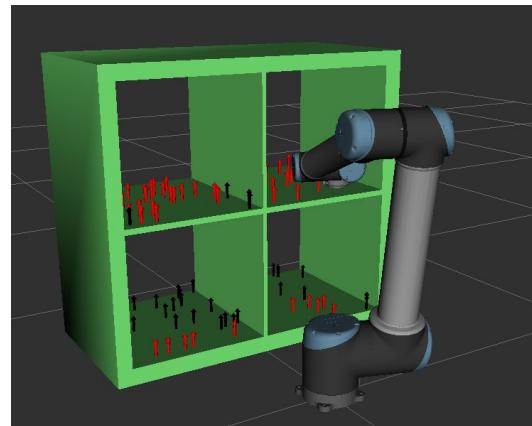
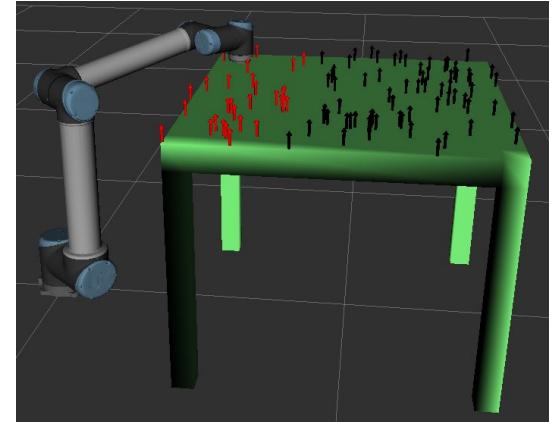
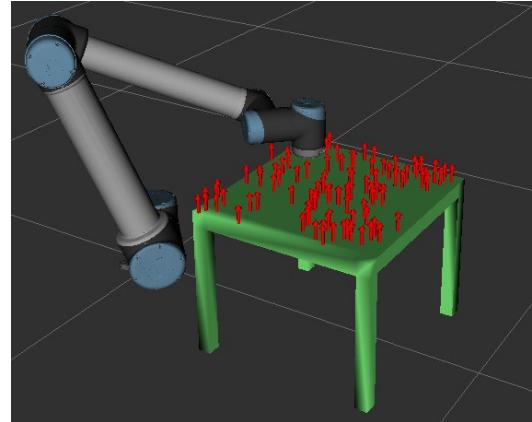


- Optimizing the position / pose of the robot
- Possible applications
 - Design of workcells
 - Positioning of mobile manipulators





- Goal: optimize IK parameters
 - Keep robot identical, change IK
 - Currently only BioIK supported
 - Simple to add other IK solvers
- Benchmarking of different IK solvers
 - KDL, TracIK, BioIK, PickIK
 - Including environment collisions
 - Different scenarios
- Helped identify possible improvements
 - Some already merged

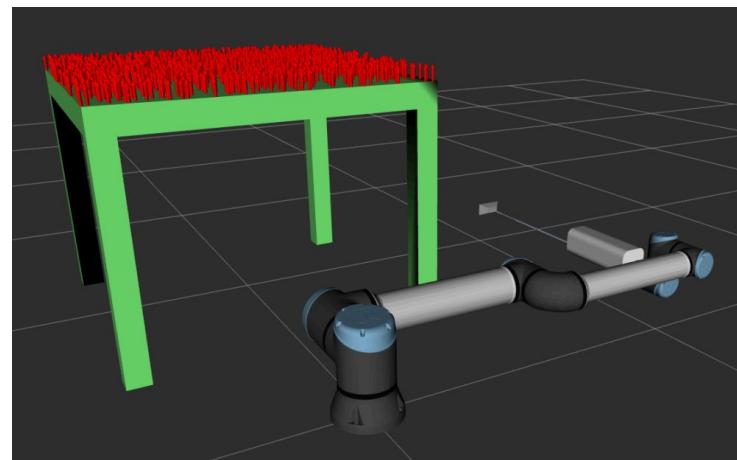
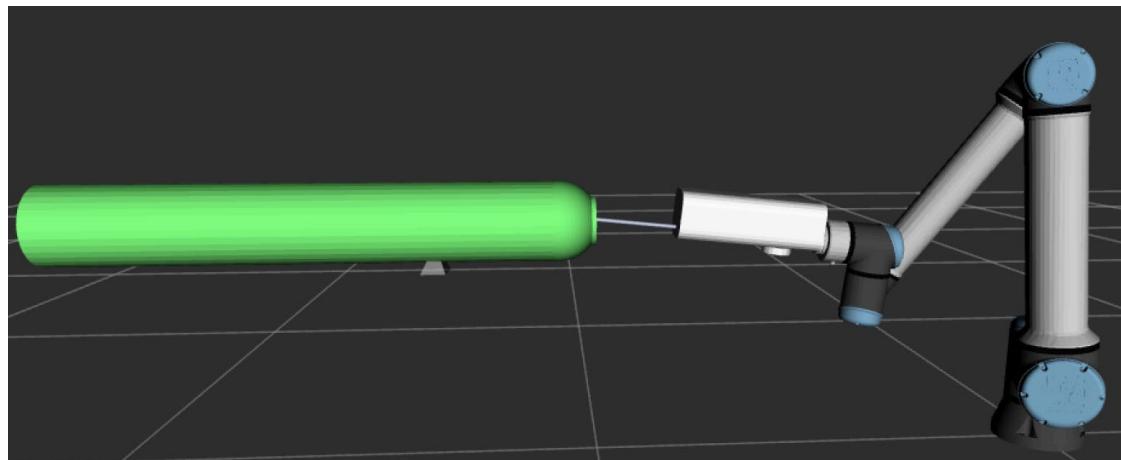
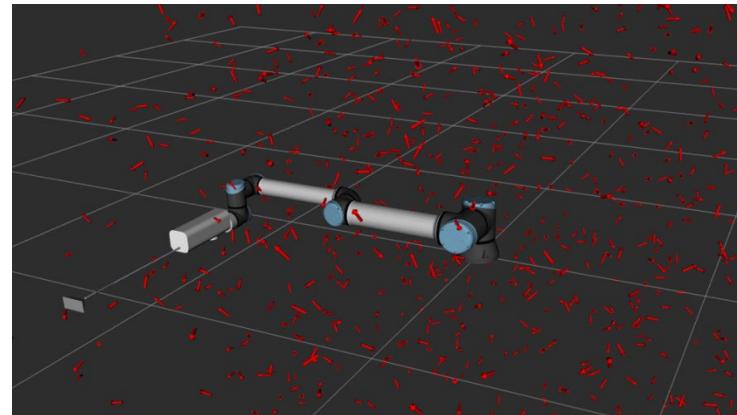


EBIKE – Exemplary Results



- Mean time IK solve time for our endoscopic robot

Scenario	Original param.	Optimized param.
Random	0.54 ms	0.27 ms
Table	6.17 ms	4.98 ms
Tank	71.9 ms	51.8 ms



Questions?

- KOI: <https://github.com/DLR-MO/koi>
- EBIKE: <https://github.com/DLR-MO/ebike>
- Contact: marc.bestmann@dlr.de

Topic: **KOI & EBIKE**
Optimizing Kinematics Structures and IK Parameters by
Combining REACH and Optuna

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Institute: Institute for Maintenance, Repair and Overhaul

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