# cartesian_controllers

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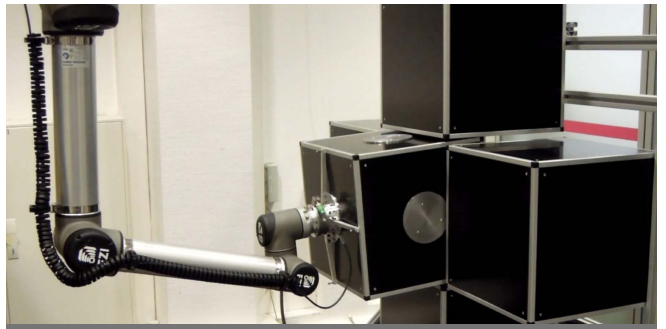
# Why this package?

Closed loop force control

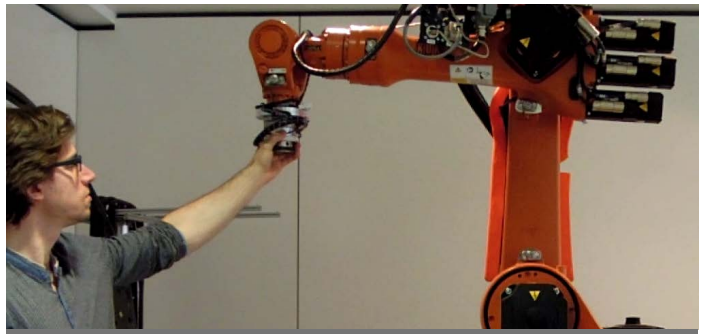
Direct teaching



Contact-rich manipulation

...

Tele-operation



Manual guidance

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- You want task space control
- You don't need collision checking or planning
- You want to use ROS-control

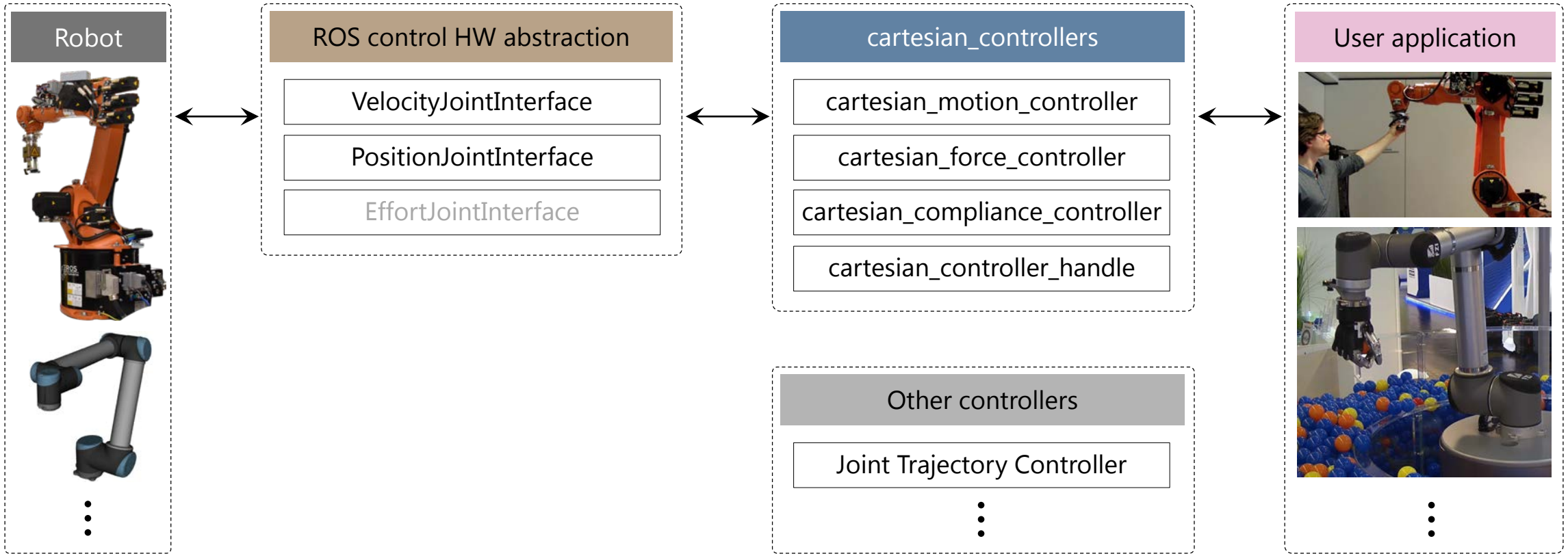
⇩

**cartesian_controllers**

# The setting within ROS Control

## You have:

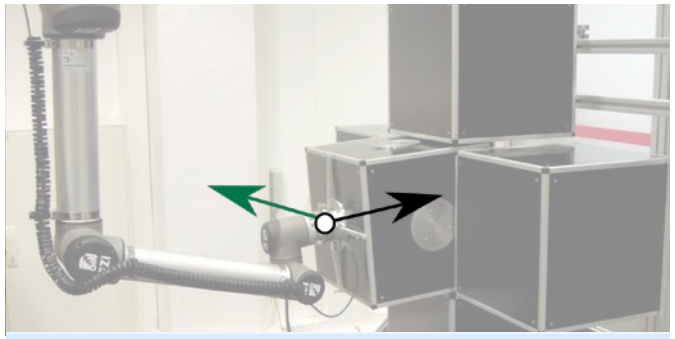
- Joint position/velocity streaming interface
- ROS control HW abstraction
- This cartesian_controllers package
- Application with real-time end effector control



# Three main controllers

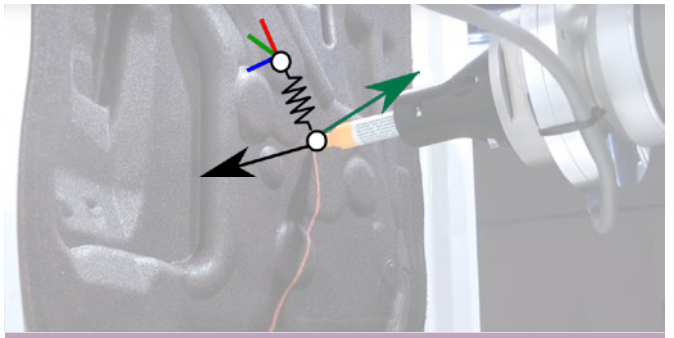
**cartesian_motion_controller**

- You want to follow a moving target
- The targets might be sparsely sampled
- You prefer smoothness over accuracy



**cartesian_force_controller**

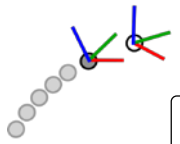
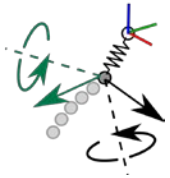
- You want to control the robot with a wrench in contacts
- You have a wrist ft sensor



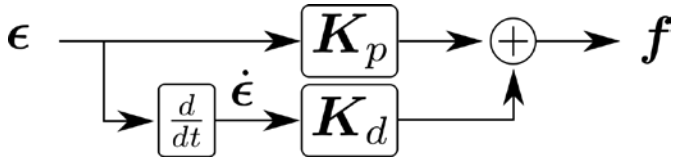
**cartesian_compliance_controller**

- You want to follow a moving target
- You want to react to external disturbances
- You have a wrist ft sensor

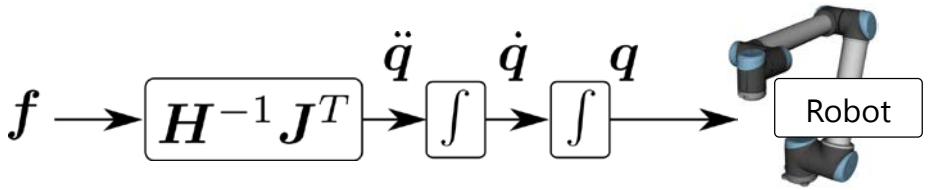
# How do they work?

| Cartesian input | cartesian_motion_controller | cartesian_force_controller | cartesian_compliance_controller |
|---|---|---|---|
|  |  Pose error |  Net force |  Both |

- Apply PD gains and interpret this as a wrench

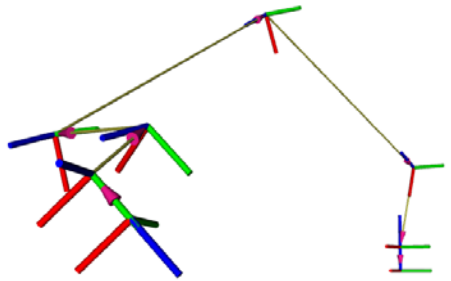



- Mapping from wrench to joint space
- Iterative, forward dynamics solver, based on virtually conditioned twin



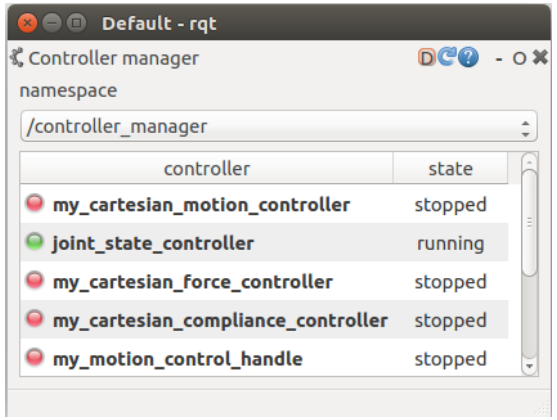
# How to use them?

1 **Before startup**



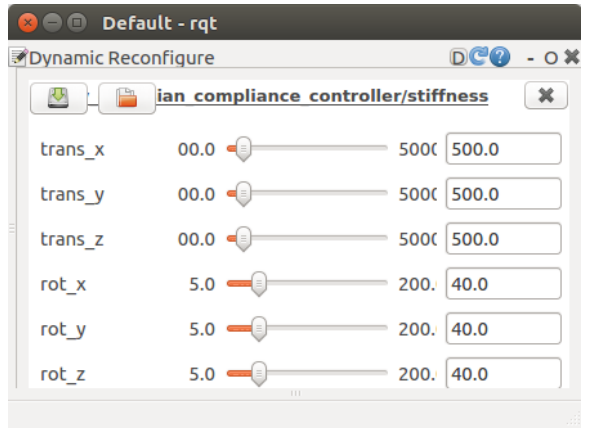
- Kinematic chain (base, tip)
- Sensor & compliance frame
- Controllable joints

2 **Startup and switching**




- Controller manager

3 **Online Configuration**




- Gains, stiffness, solver

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| Control interfaces | cartesian_motion_controller | cartesian_force_controller | cartesian_compliance_controller |
|---|---|---|---|
| User target | geometry_msgs/PoseStamped | geometry_msgs/WrenchStamped | geometry_msgs/PoseStamped<br>geometry_msgs/WrenchStamped |
| Sensor input | | geometry_msgs/WrenchStamped | geometry_msgs/WrenchStamped |

# Recent works using cartesian_controllers

cartesian_motion_controller

- Teleoperation with user motion tracking
- Pilz PRBT

cartesian_force_controller

- Deep-learned contact skill model with force control
- Universal Robots UR10


cartesian_compliance_controller

- Add-on compliance control for door sealing assembly
- KUKA KR16

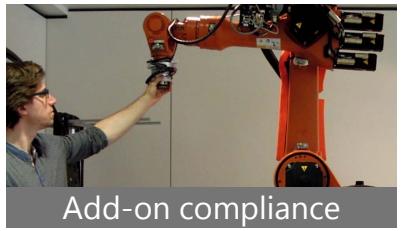
## Further reading

| IK solving for sparse targets | Contact skills with force control | Initial idea |
|---|---|---|
| arXiv: 1908.06252 | arXiv: 1908.06272 (IROS 2019) | DOI: 10.1109/IROS.2017.8206325 |

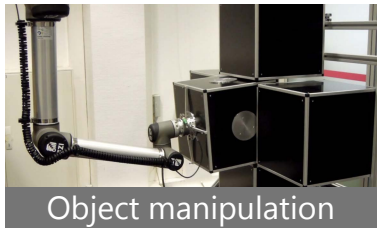
# Summary

You have
- Joint position/velocity streaming interface
- ROS control pipeline
- Application with real-time, direct, task space control


Task space control


Add-on compliance


Closed loop force control


Object manipulation

**cartesian_controllers**
- cartesian_motion_controller
- cartesian_force_controller
- cartesian_compliance_controller
- ⋮

# Thank you

github.com/fzi-forschungszentrum-informatik/cartesian_controllers

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