Whole-Body Compliant Robotic Manipulation

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Motivation & Research Goals

Motivation: Mobile manipulators have the ability to move in and interact with their surroundings. Operating these robots in a "natural" and coordinated way poses interesting control questions.

Research Goal: Achieve safe task-centric control, in which base and arm(s) are coordinated to achieve simultaneous and natural motion.

Background & Methods

We are interested in controlling a dual-armed mobile manipulator in a whole-body compliance setting so to coordinate arms, base, and human operators in (collaborative) tasks.

Task examples

- writing on a hand-held notebook
- writing on a whiteboard
- sweeping the floor
- kinesthetic teaching
- opening doors

Methods

- the mobile base is seen as a "floor end-effector"
- end-effectors are controlled only when relevant
- tasks are defined in a **task frame** with

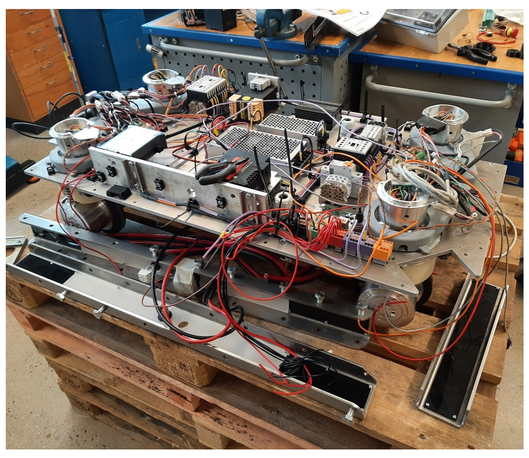
$$v_t = J_t \begin{bmatrix} \dot{q}_{\text{arm}} \\ \dot{q}_{\text{base}} \end{bmatrix} \quad \Longrightarrow \quad \begin{bmatrix} \dot{q}_{\text{arm}} \\ \dot{q}_{\text{base}} \end{bmatrix} = G_t v_t$$

- manipulation tasks have higher default priority
- navigation tasks gain priority when necessary
- compliance is obtained by admittance control

$$M_t \ddot{e}_t + D_t \dot{e}_t + K_t e_t = \tau_t$$

$$\dot{p}_t \leftarrow (v_{\text{des}} + \dot{e}_t) - \kappa \left(p_t - (p_{\text{des}} + e_t) \right)$$

Setup



- ABB Dual-arm YuMi as upper body actuator
- custom-fit wrist-mounted F/T sensors to sense and interact with external forces
- custom-made base for out-of-reach situations
- whole-body controller coordinating all the end-effectors
- custom control stack over ROS (can possibly be ROS-independent)
- mobile base navigation independent from ROS stack (no need for a map)

References

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