Task-Based Grasp Quality Measures for Grasp Synthesis

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Grasp for Manipulation

- Manipulating an instrument
 - Task wrench: interactive force and torque between the instrument and environment
 - Instrument motion



Grasp to Facilitate Manipulation

- Maintain a firm grip and withstand and provide necessary interactive wrench on the instrument
- Enable the manipulator to carry out the task most efficiently with little motion effort
- Measure how well a grasp satisfies the objectives

Use a Knife



From WikiHow



Task-Oriented Grasping

- Z. Li and S. S. Sastry. Task-oriented optimal grasping by multifingered robot hands. *IEEE Journal of Robotics and Automation*, 4(1):32–44, feb 1988.
- Nancy Pollard
- Jeff Trinkle, Zexiang Li
- Gerd Hirzinger
- Danica Kragic
- Many others
- Approximate the task wrench space with geometry shapes

Quality Measure: Task Wrench Coverage

- Random in task: density of the task wrench samples
- The count of task wrench observations in the TWS that are covered by GWS
- The count of the total task wrench observations in the TWS







Task 1

Task 2







A haptic device is used to demonstrate a task.

Grasp Measure Based-on Manipulator Efficiency in Task



Instrument trajectory vs. Wrist trajectory

When instrument trajectory is fixed, different grasps will need different wrist trajectories.

Different wrist trajectories needs completely different arm motions.

Grasp => arm motion

Best Grasp Requests Less Motion

M-joint vector of torques from the actuator

$$\tau = M(\mathbf{q})\mathbf{\ddot{q}} + C(\mathbf{q},\mathbf{\dot{q}})\mathbf{\dot{q}} + F(\mathbf{\dot{q}}) + G(\mathbf{q}) + J(\mathbf{q})\mathbf{f}$$

Manipulator's motion effort over time

$$Q_e = \int_{t_0}^{t_n} \tau(t)^T \tau(t) dt$$







Summary

- Consider hands, grasping, and manipulation together
- Grasp should best facilitate manipulation tasks
- Task wrench coverage measure
 - Provide required interactive wrench during a task
- Manipulator efficiency measure
 - Provide the best instrument mounting that requests the least motion effort from the manipulator
- Emphasize on the instrument (tool, objects)
 - Interactive wrench on the instrument
 - Motion of the instrument

References

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