Robotic Grasping for Daily-Living Manipulation Tasks

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Robot Perception and Action Lab
Grasp for Manipulation

• Manipulating an instrument
  • Task wrench: interactive force and torque between the instrument and environment
  • Instrument motion
Task-Based Grasp Quality Measures
- Efficiently transfer arm motion to instrument motion
- Provide required force and torque
Use a Knife
Use a Knife

Task 1: cutting

Task 2: butter spreading

Task Coverage
Task-Oriented Grasping


• 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

\[ Q_w = \frac{\text{Count}\{O | O \in GWS \cap TWS\}}{\text{Count}\{O | O \in TWS\}} \]
Grasp Definition
Learn thumb placement to reduce search space
Thumb Placement
Evaluation Using Barrett Hand

With thumb placement constraints

Without thumb placement constraints

Use Peter Allen’s Graspit!

Success Rate of Real Execution

A haptic device is used to demonstrate a task.
Grasp Measure Based-on Manipulator Efficiency in Task

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 Arm Motion

M-joint vector of torques from the actuator

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

Manipulator’s motion effort over time

\[ Q_e = \int_{t_0}^{t_n} \tau(t)^T \tau(t) dt \]
An example of task demonstration. Motion and disturbance distribution are captured.
Physical Interaction Data Collection
Instrumental ADLs

• Food preparation
• Basic house maintenance
• Basic housework
• Personal hygiene
• Total: 36 manipulation tasks, around 2000 motion trajectories
Support

This material is based upon work supported by the National Science Foundation under Grants No. 1421418 and No. 1560761.
• Use a spoon to pick up peas
• Hang towel on rack
• Use a spoon to stir water in a cup
• Shake salt shaker
• Plug into a socket
• Hammer a nail
• Transfer straw into a to-go cup with lid
• Putting on or removing bolts from nuts with a nut driver
• Extend and press syringe
References


Thank You!