Refactoring Grasping

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Decomposing the Grasping Problem

Grasping is the act of establishing contact between a robot and an object that enables the robot to exert forces onto the object defined by a manipulation task. This definition includes the acquisition of information necessary to perform such a grasp. Any solution decomposes the grasping problem into factors which emerge from various fields: mechanism design, perception, manipulation, planning, and control. Our idea is to reconsider the well-established separation of those factors.

Our decomposition is motivated by the „mitten thought experiment“. This experiment illustrates that a sensory-deprived subject (blindfolded, wearing a thick mitten to eliminate tactile feedback) is able to grasp a large variety of objects reliably by simply closing the hand, provided that a second experimenter positioned the object relative to the hand.

This thought experiment shows that an appropriate perceptual strategy (the experimenter) in conjunction with a simple compliance-based control strategy (the mitten hand) can lead to outstanding grasping performance.

Our main hypotheses

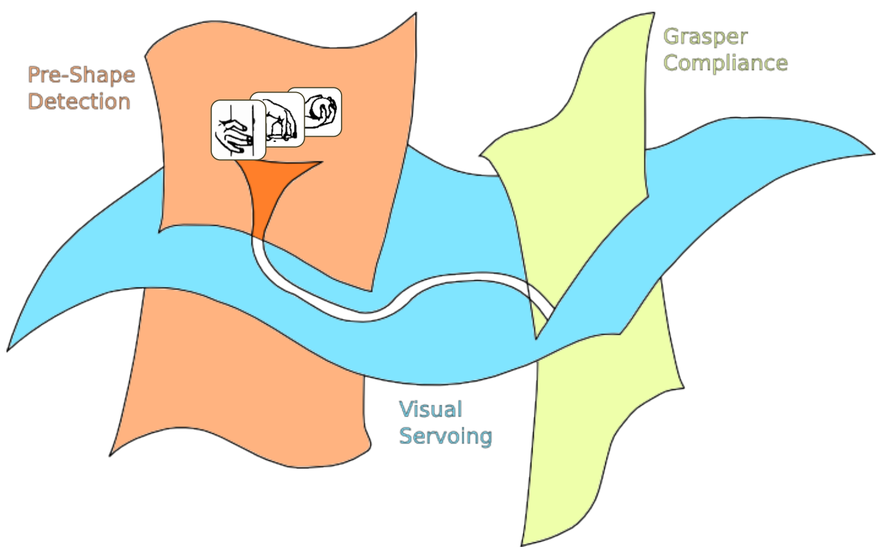
Successful robot grasping…

1. is possible with the simplifications assumed in the „mitten thought experiment“.
2. requires tight coupling of perception and action.
3. is enforced by compliantly controlled mechanisms.

The Interplay between Perception, Planning, Control and Mechanisms

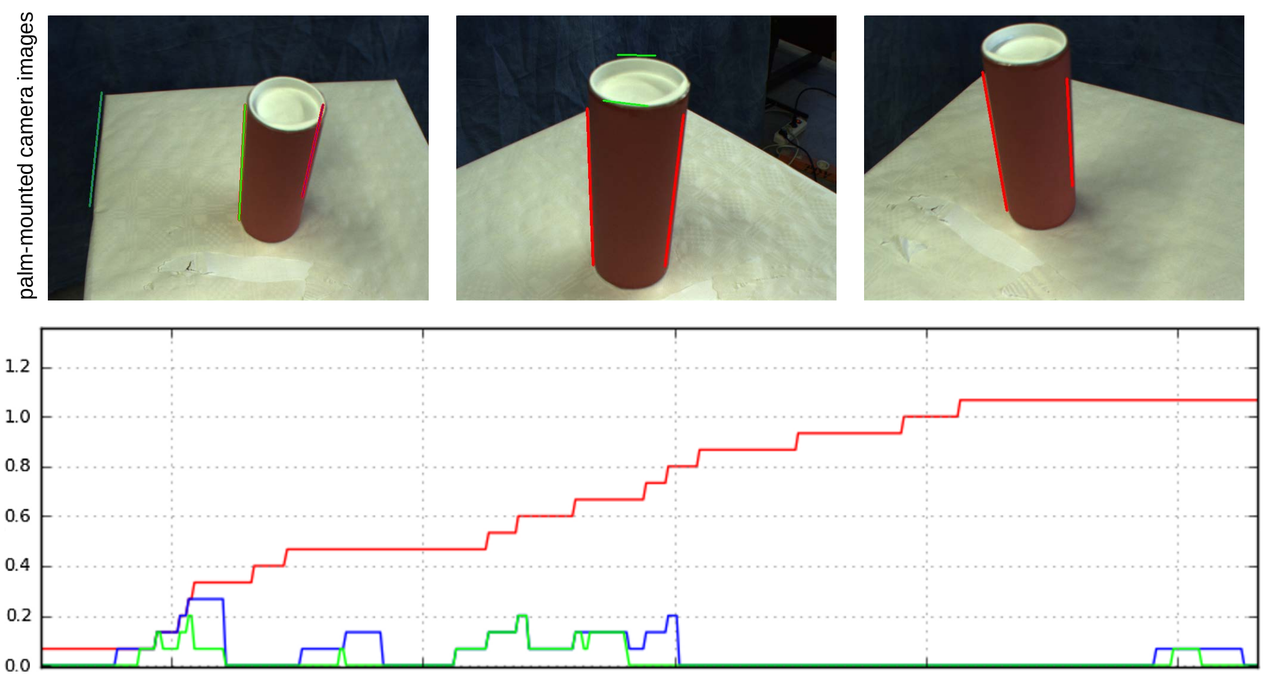
We divide all possible grasp configurations into a small set of grasp pre-shapes. Each one of them is associated with detecting simple and robust visual features. Broad pre-shape classes allow for simple features. This simplifies the planning problem and the perceptual problem at the same time.

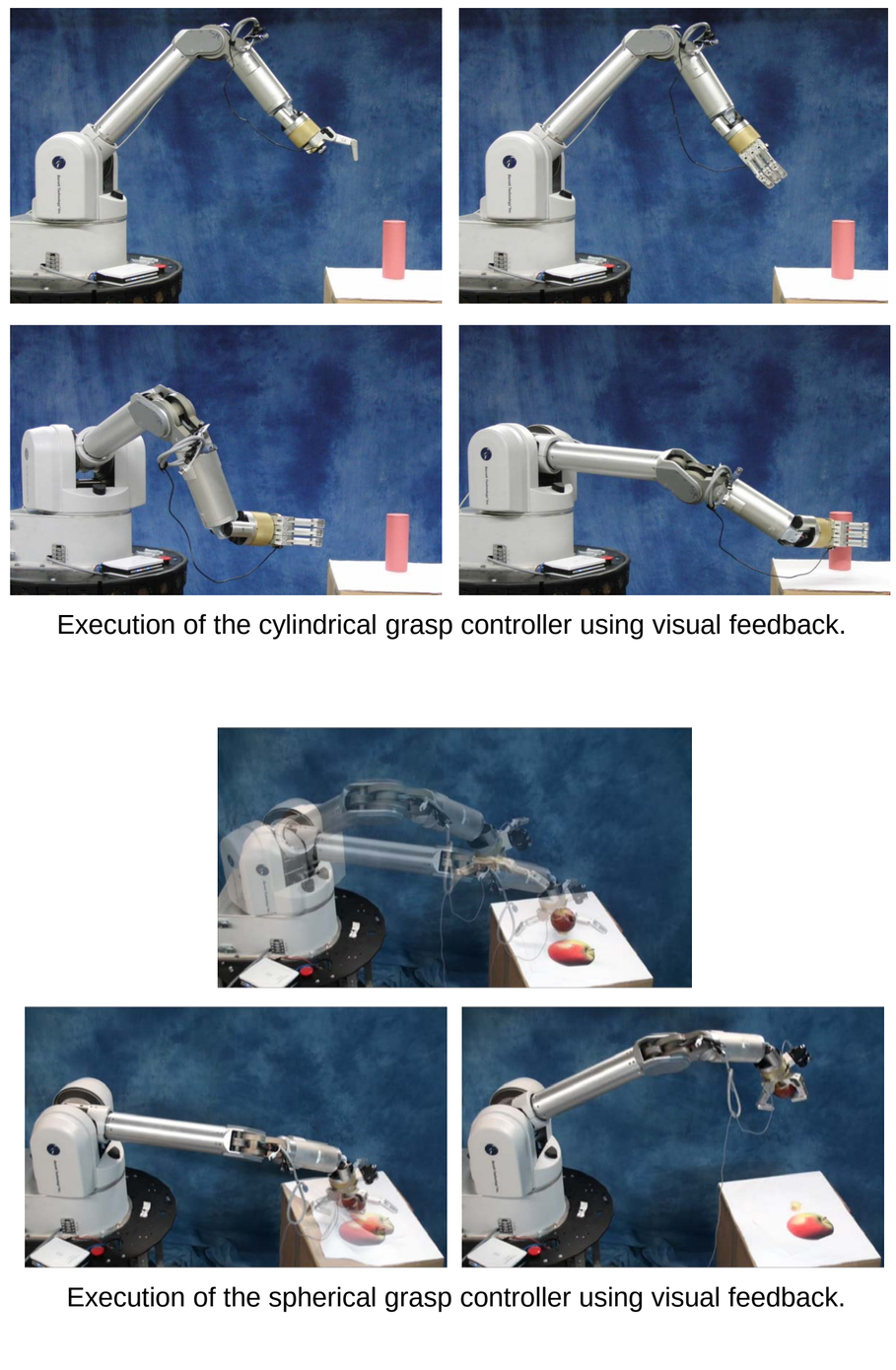
We explore the manifold of possible pre-shapes using those detectors.



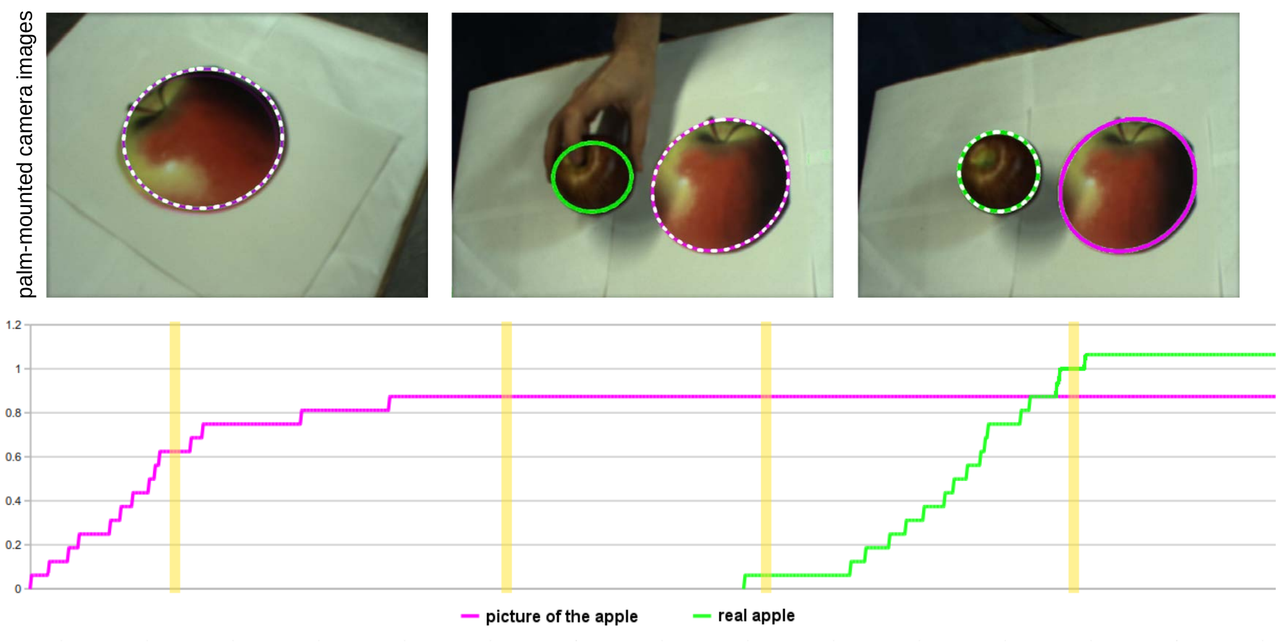
Once we converged to the most likely grasp pre-shape, we apply a visual servoing scheme that leads us onto the solution manifold. These feedback controllers are specified for every pre-shape. Being on the solution manifold means that closing the gripper will always result in a successful grasp. The hardware will absorb the remaining uncertainty due to its compliance.

Preliminary Experiments & Results





Execution of the cylindrical grasp controller using visual feedback.



Execution of the spherical grasp controller using visual feedback.