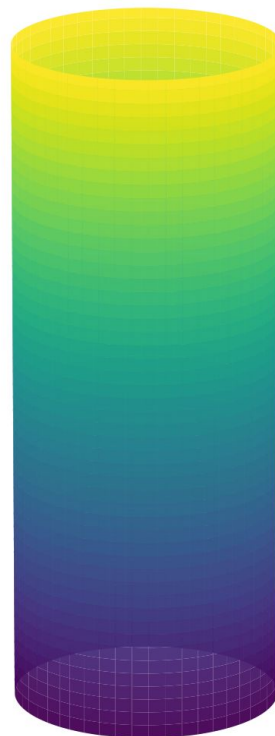
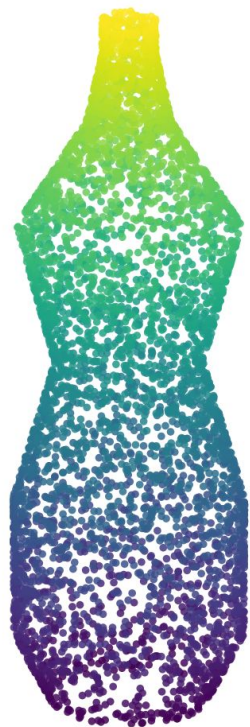


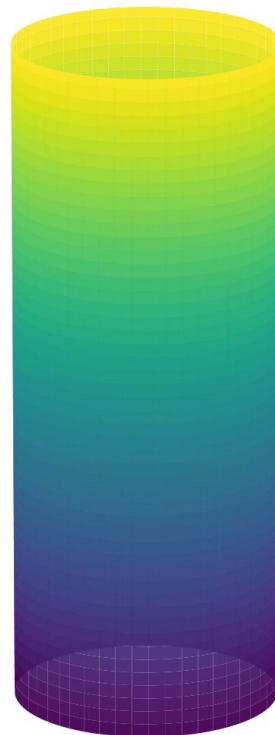
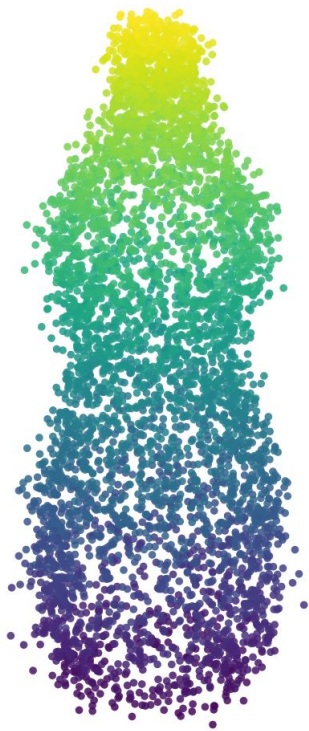
# Robust dexterous grasping through virtual hand/object interconnection

Julien Vanderheyden, Université de Liège

When you grasp a bottle of coke...

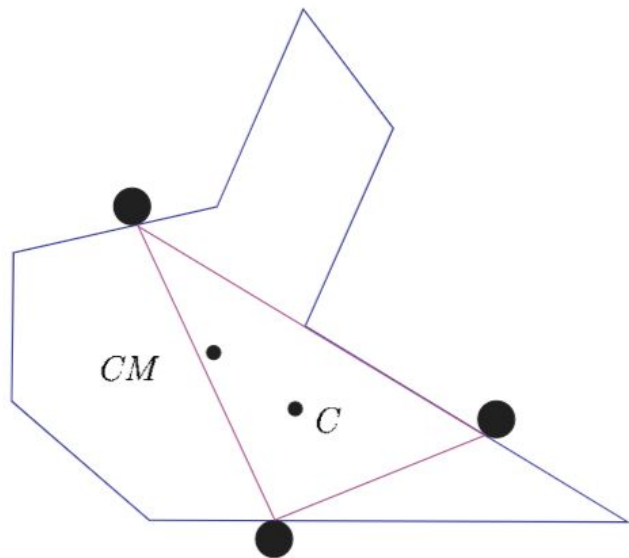


When you grasp a bottle of coke...



# Existing grasping approaches rely on detailed object model

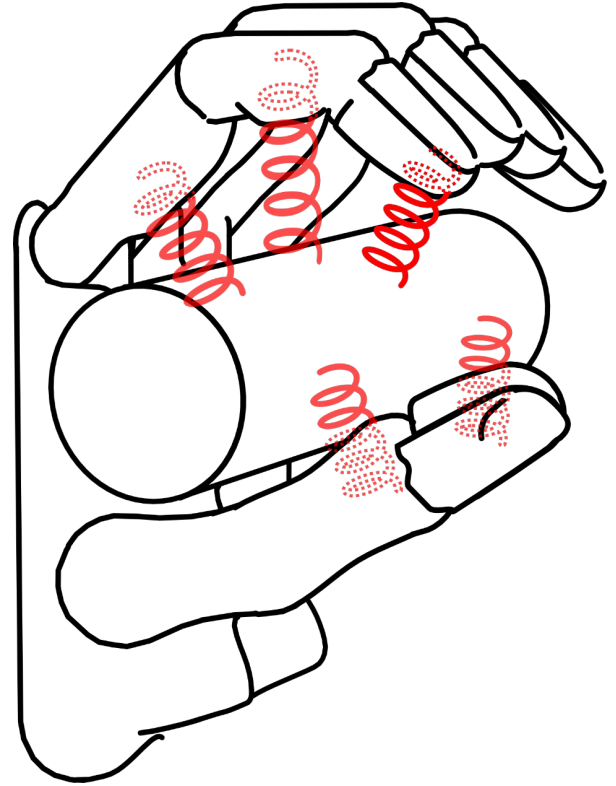
Analytical methods



Data-driven methods



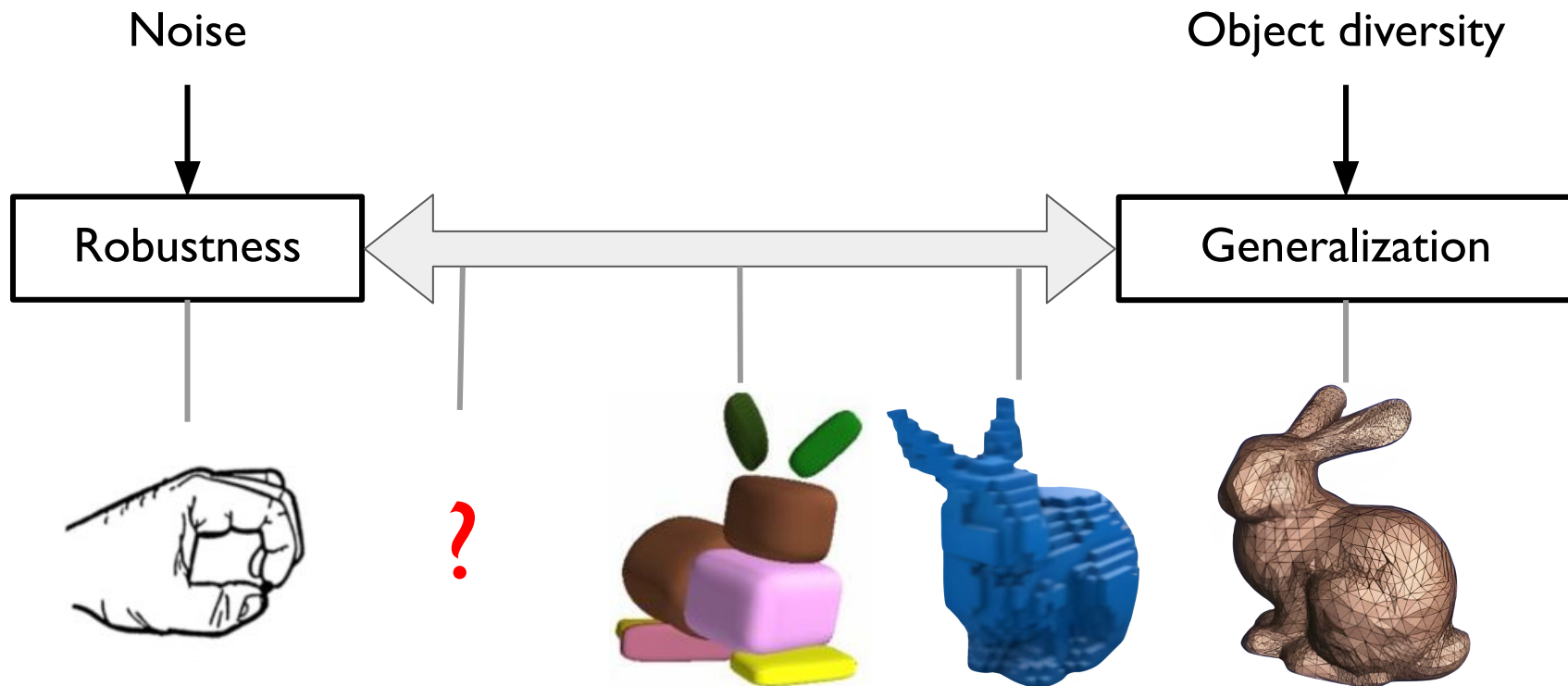
Coupling **compliant control**  
with **simplified object models**  
achieves robust and general grasping



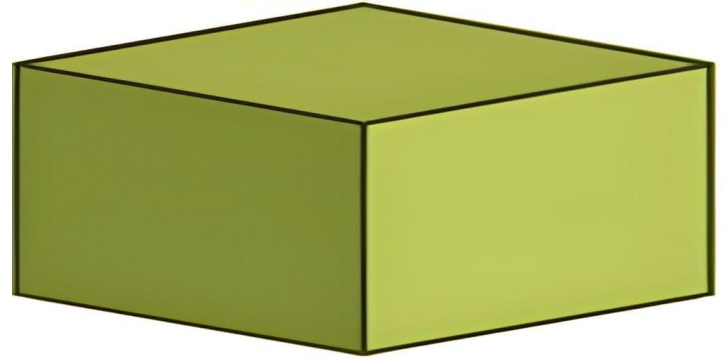
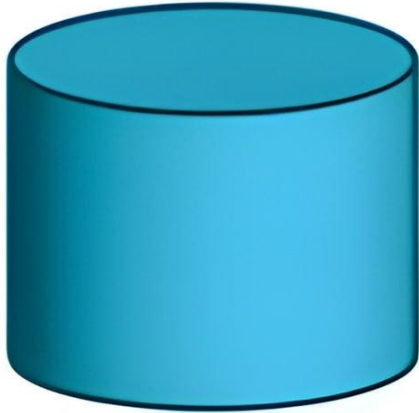
# Outline

- I. Shape primitives
- II. Virtual model control
- III. Experimental validation

# Robustness and generalization are in tension



# *Shape primitives* as minimal object model



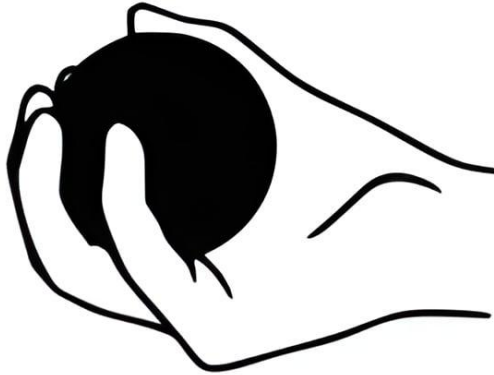
We argue that this representation embeds enough information to enable adaptive grasping while remaining stable under perceptual noise

# Three grasps from human taxonomy cover most household objects

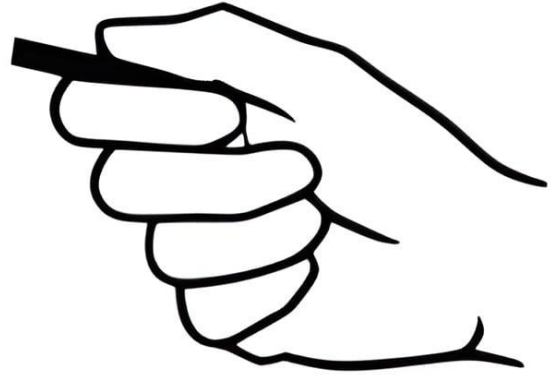
Medium wrap



Power sphere



Lateral pinch



# Outline

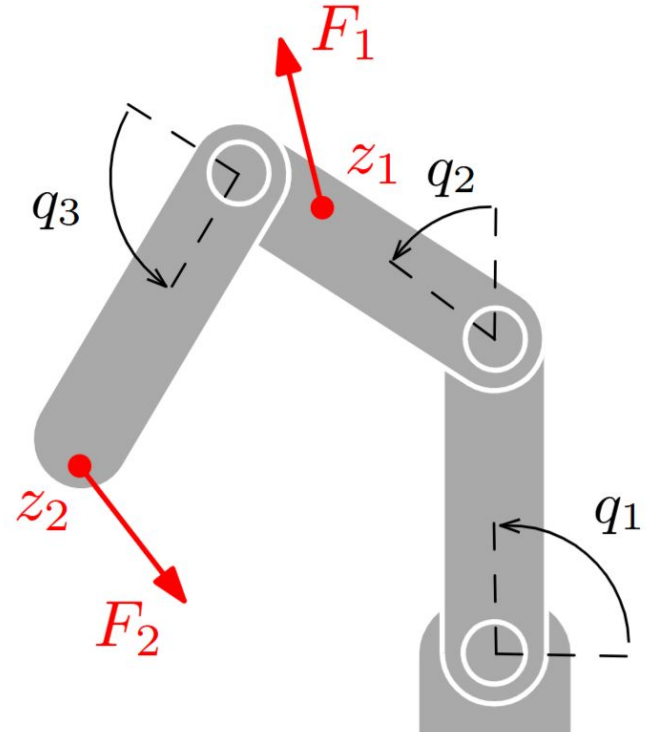
I. Shape primitives

II. Virtual model control

III. Experimental validation

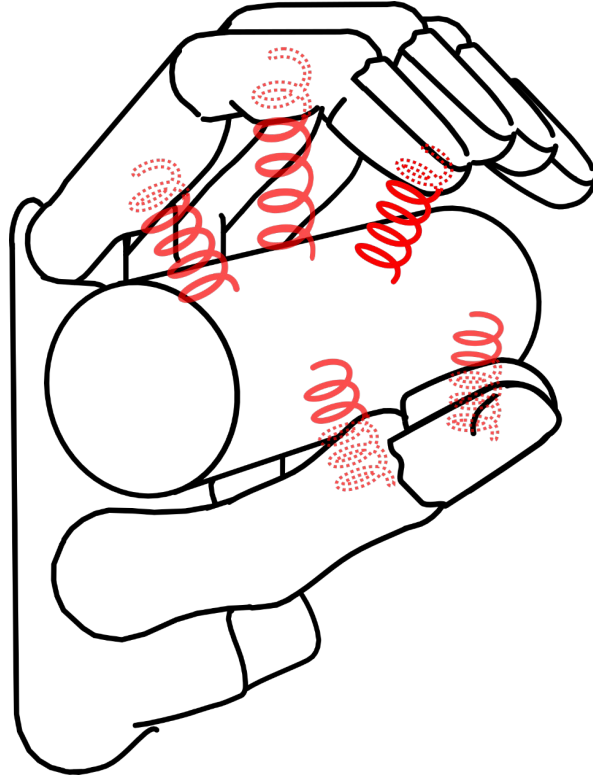
# VMC : intuitive impedance control through mechanical analogy

The robot and the controller are seen as **interconnected systems** exchanging energy with **mechanical elements** (springs and dampers)

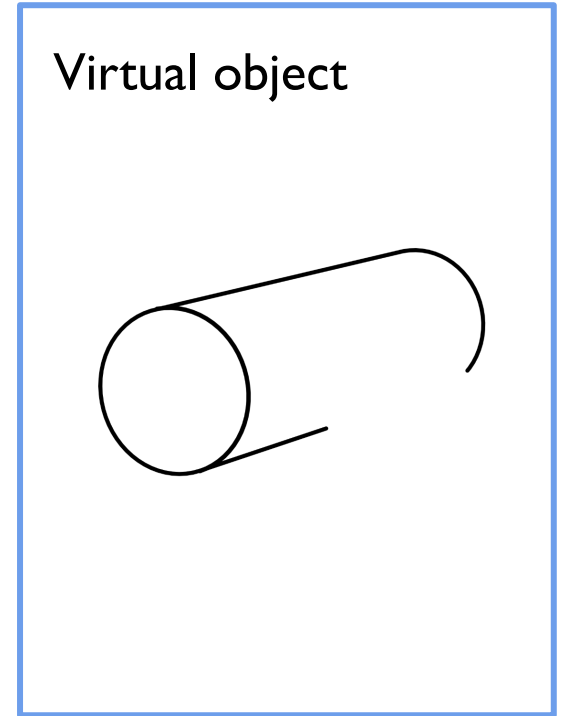
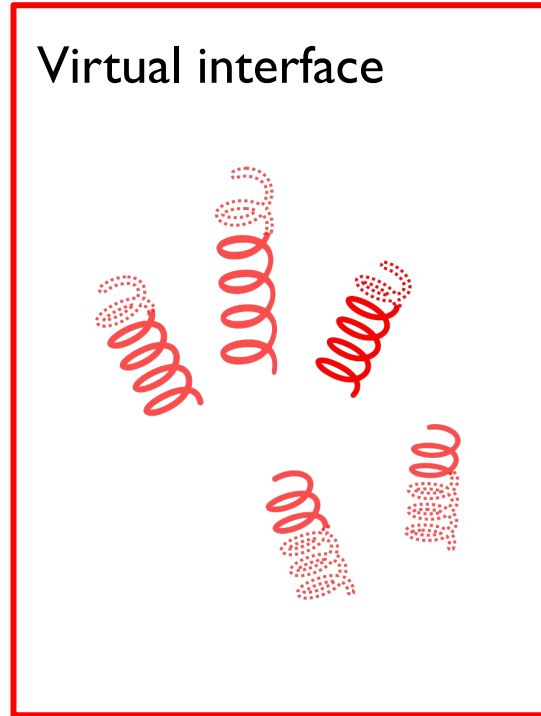
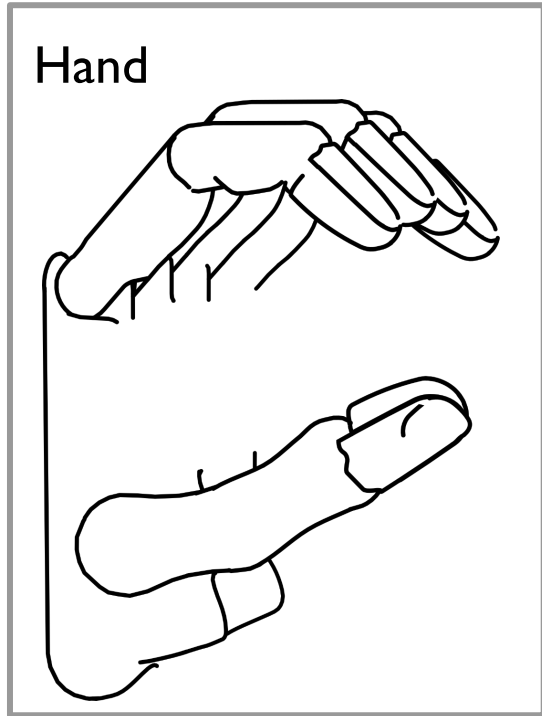


$$\mathbf{u} = \sum_{i=1}^n J_{z_i}(\mathbf{q})^T \mathbf{F}_i$$

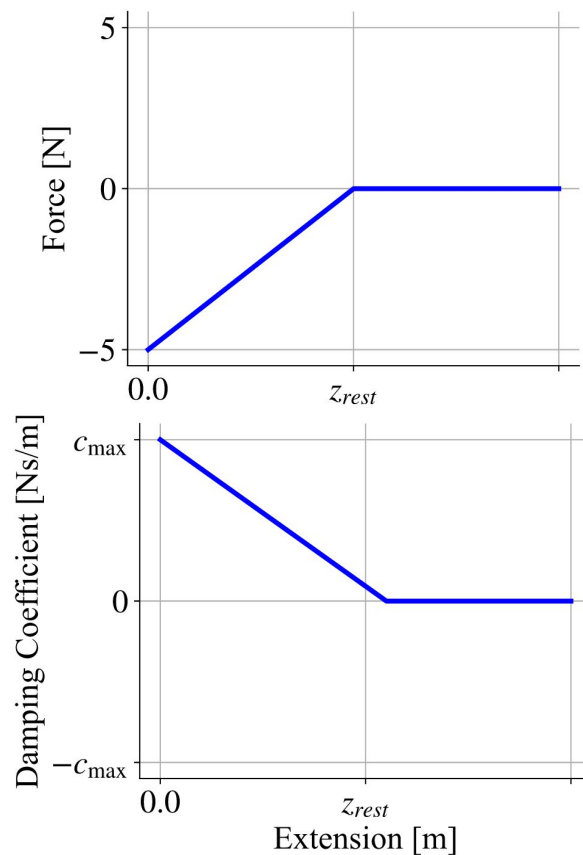
Grasping motion emerges from mechanical coupling,  
not explicit commands



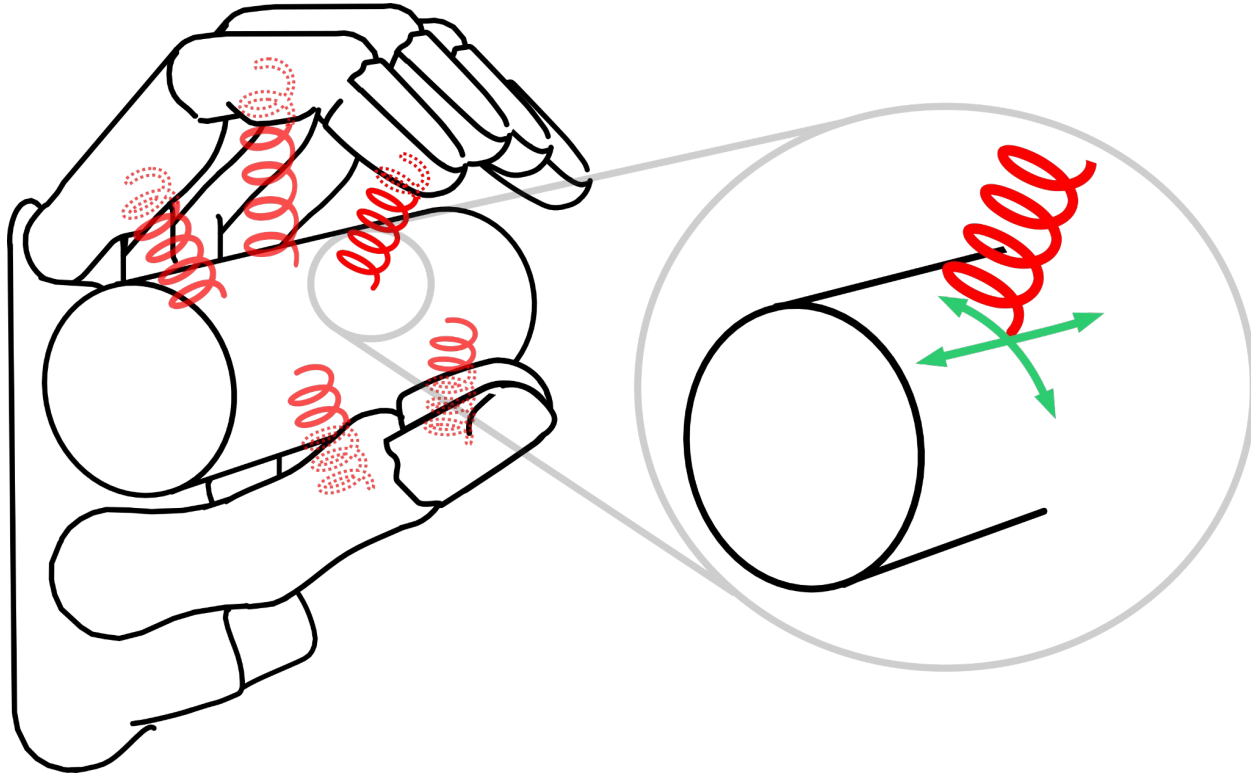
# Grasping motion emerges from mechanical coupling, not explicit commands



# Non-linear virtual springs and dampers enable contact-like interactions

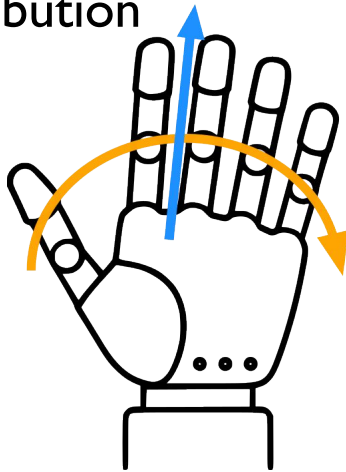


Sliding contact points let the hand adapt to any object size



# Two parameters control the entire finger closure pattern

Inter-phalanges distribution



Inter-fingers distribution

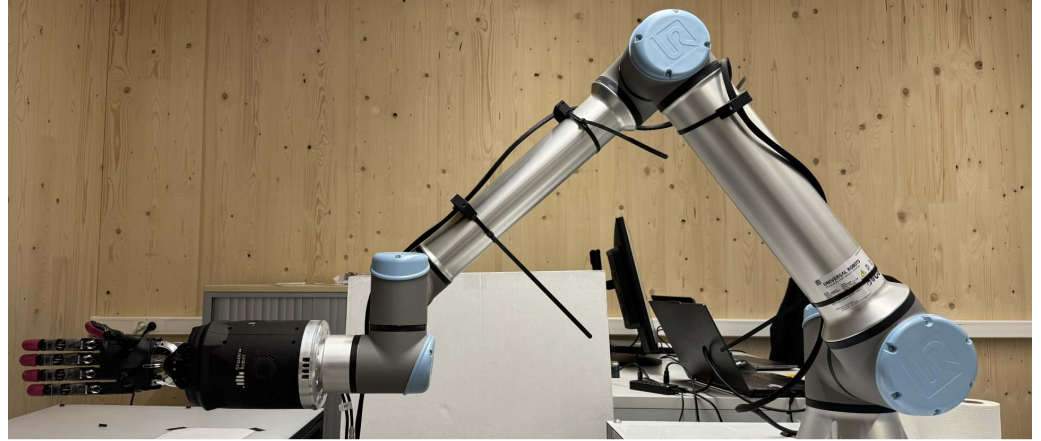


# Outline

- I. Shape primitive
- II. Virtual model control
- III. Experimental validation

# Experimental setup

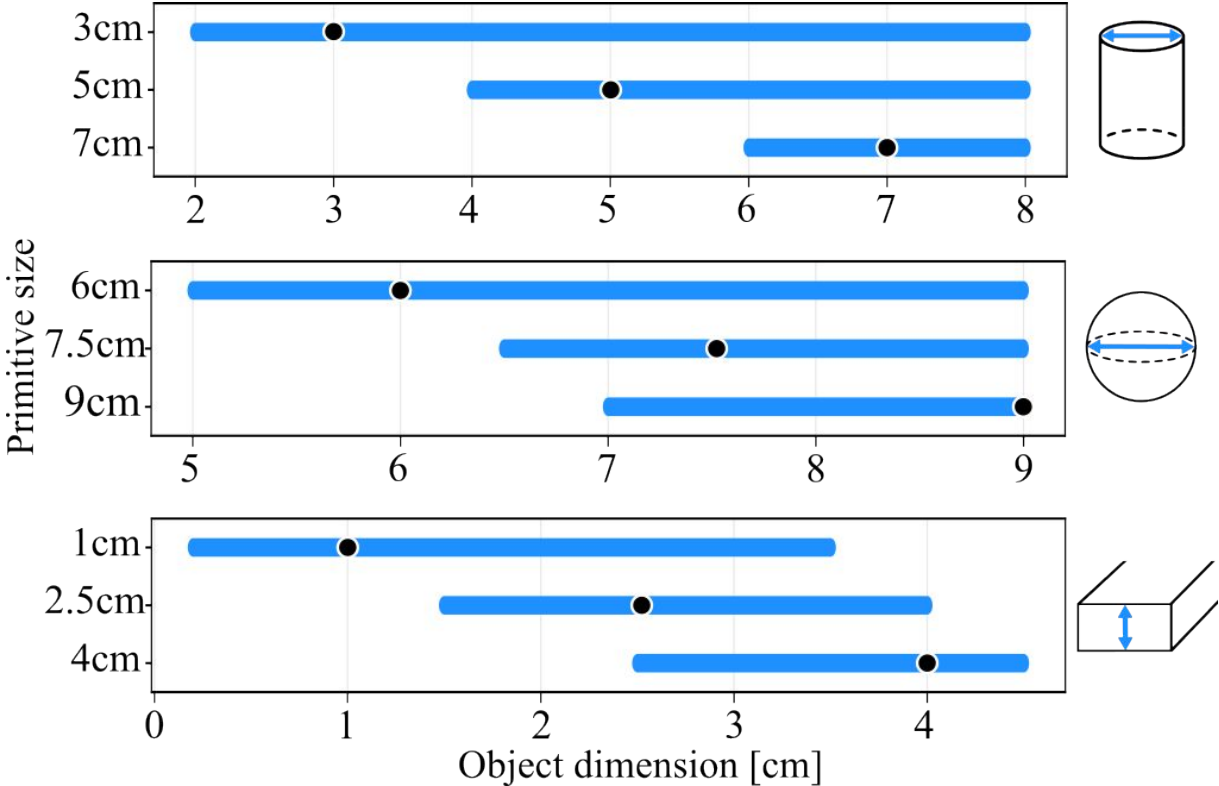
ShadowHand robotic hand



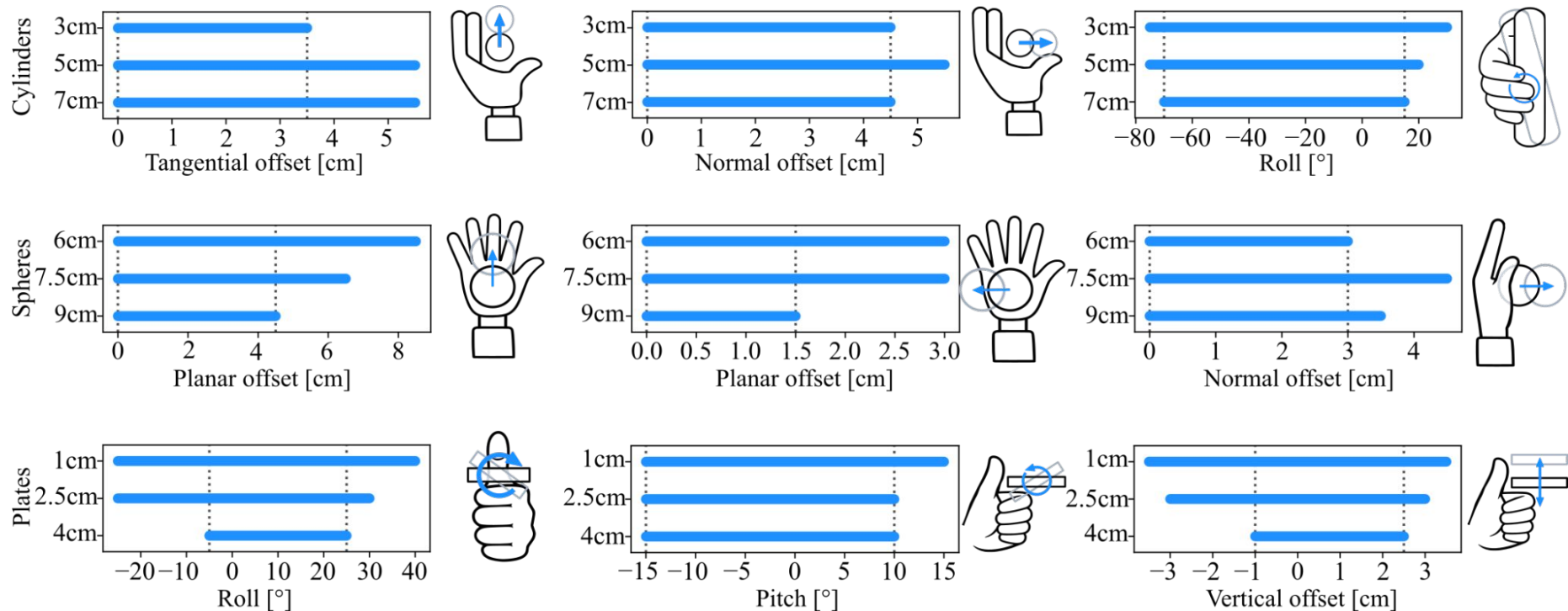
3D printed shape primitives



# Dimensional estimation errors of around 1 cm do not compromise grasp success



# The method remains reliable despite large pose estimation errors



Shape primitives are expressive enough  
to cover a broad range of household objects



x10

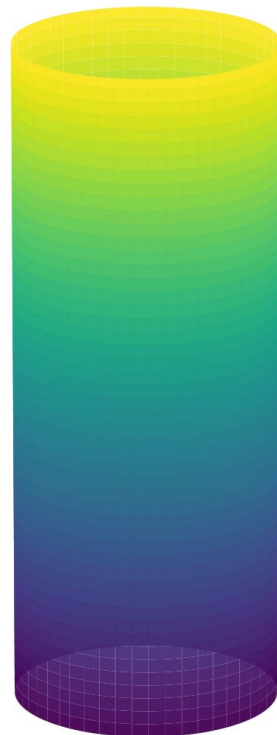
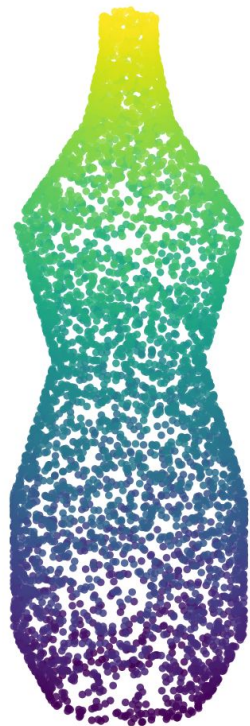


# Take home messages

- I. We approximated the grasped object using shape primitives
- II. We framed the grasp motion as a mechanical interconnection using VMC
- III. This allowed to robustly replicate three human grasps

Raw approximations + robust policies

When you grasp a bottle of coke...



When you grasp a bottle of coke... A cylinder is all you need !

