

# Grasping in ROS: The Good, the Bad and the Research

**Matei Ciocarlie**



Joint work with: Kaijen Hsiao, Sachin Chitta, Gil Jones, Adam Leeper, Ioan Sutan, Mehmet Dogar, Peter Brook, David Gossow, and the entire Willow Garage team.

# This Talk

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- Overview of available capabilities in ROS
  - pointers to package names → **[www.ros.org](http://www.ros.org)**
  - pointers to publications
- Overview of recent research results
- Not a step-by-step tutorial...

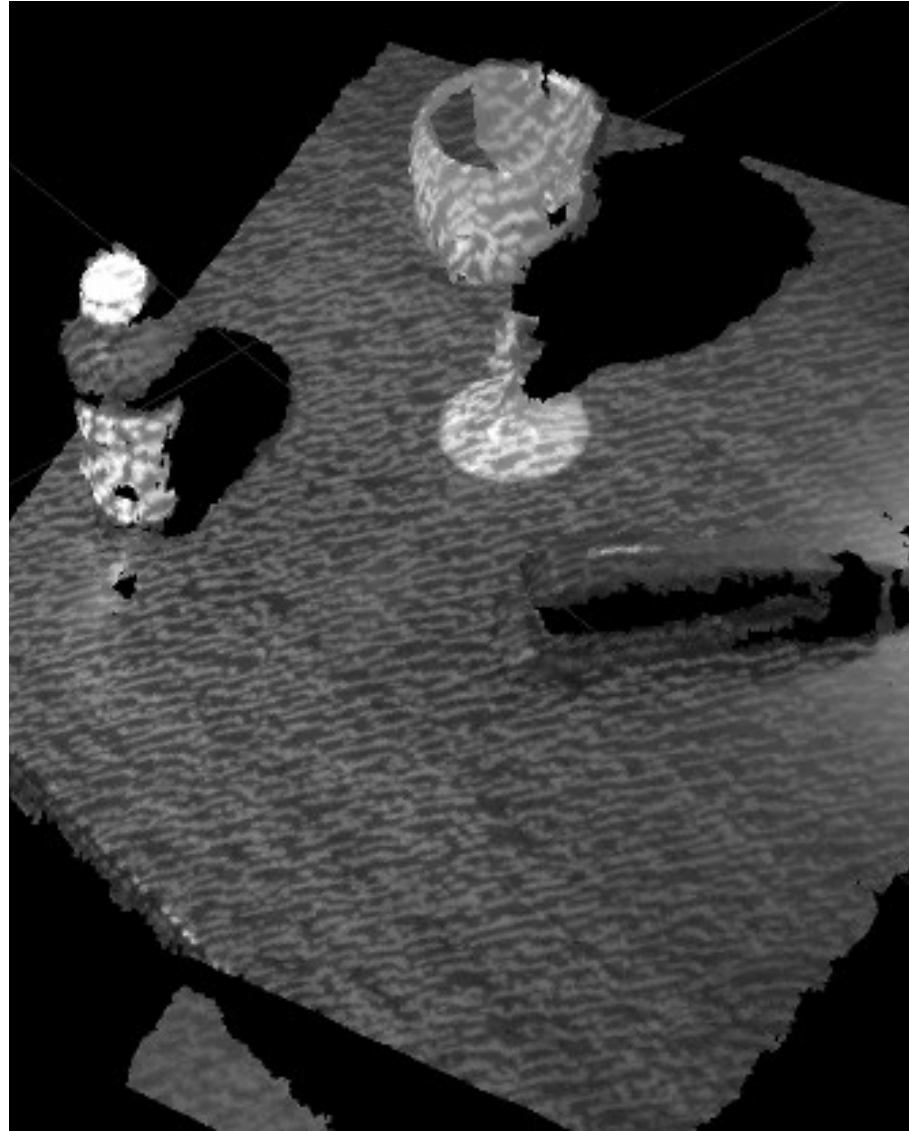
# Outline

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- The Basics...
  - Semantic Perception
  - Grasp Planning
  - Grasping Pipeline and Execution
- ... and Beyond!
  - Grasping in uncertainty and clutter
  - Tiered Human-in-the-Loop grasping
  - Interactive Manipulation
  - Robots for Humanity

# Semantic Perception

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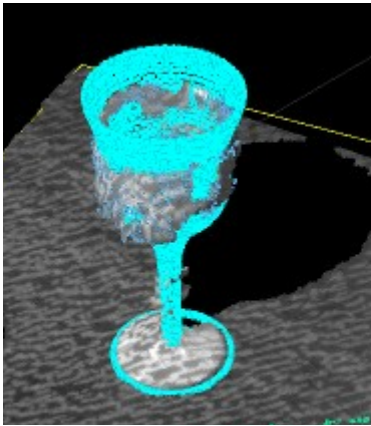


# Semantic Perception

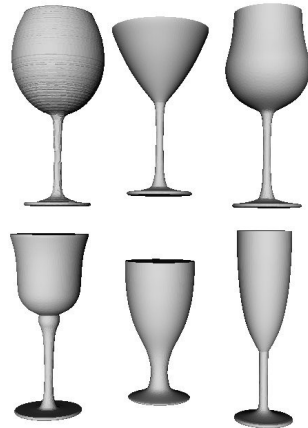
Grasp this...



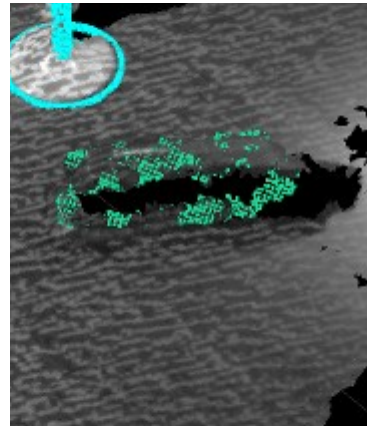
...glass, CAD  
model #9776.



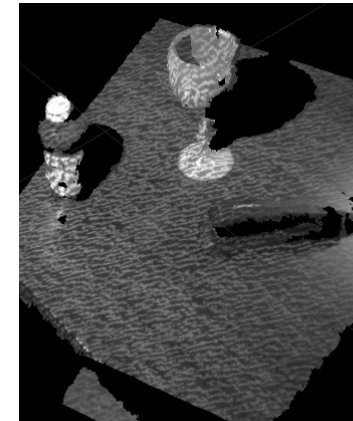
...glass-like  
object.



...blob.



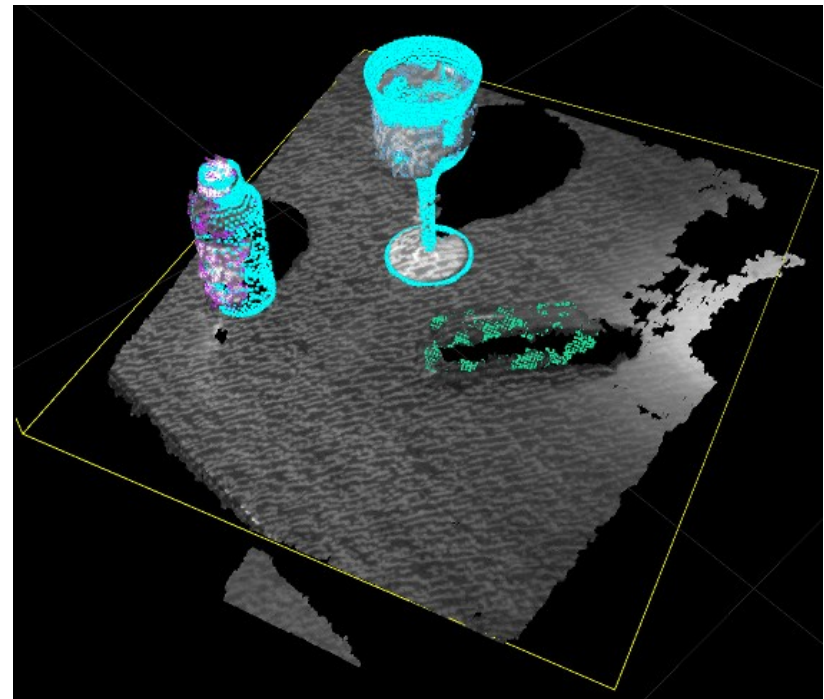
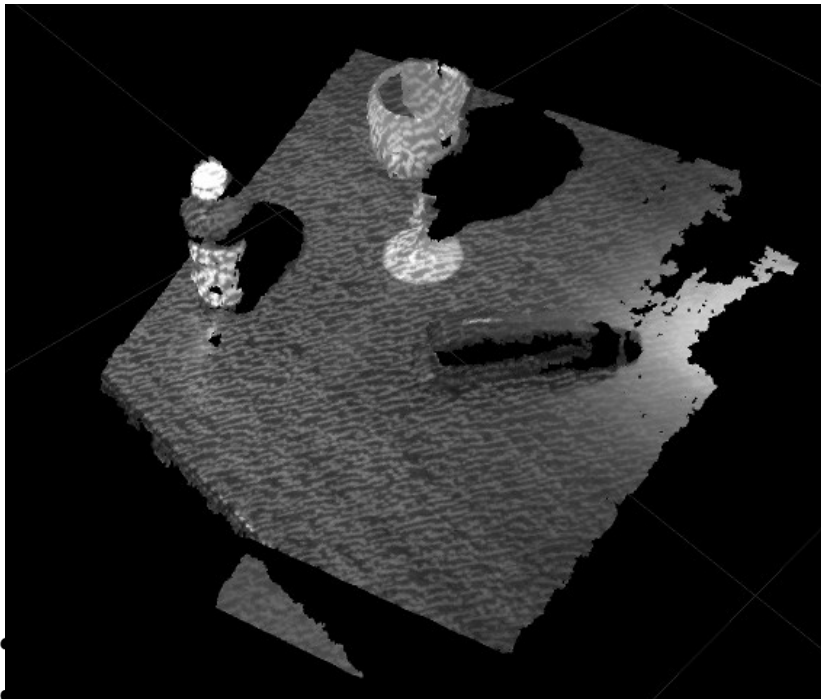
...well,  
anything



# Semantic Perception

## `tabletop_object_detector` package

- plane segmentation
- Cartesian clustering
- 2D ICP-based fitting and recognition
  - rotationally symmetrical objects

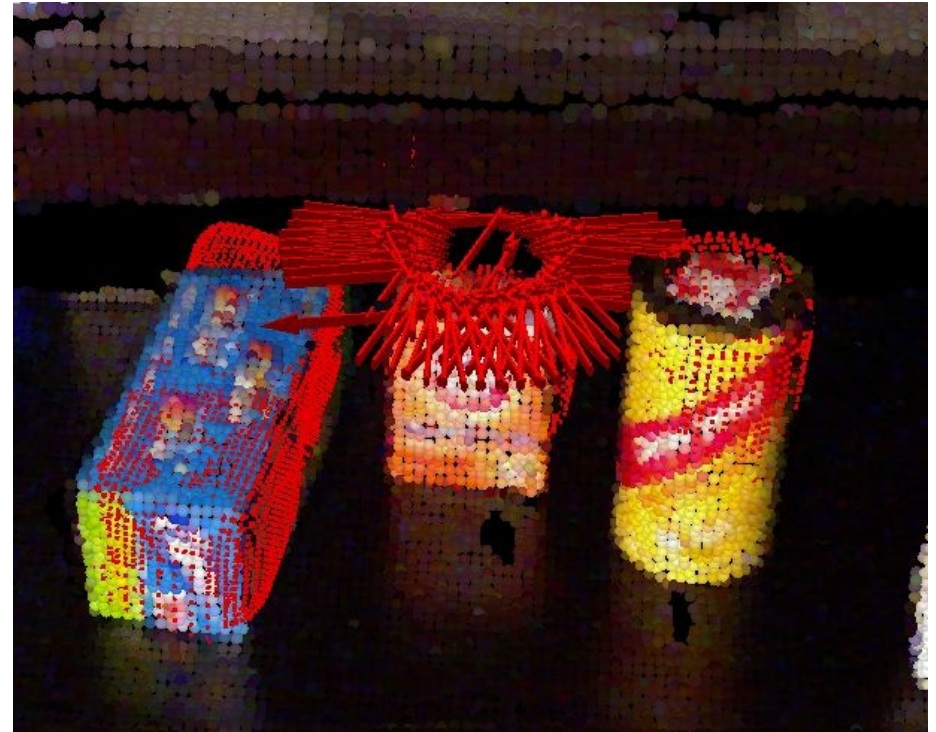




# Semantic Perception

**object\_recognition** stack

- Textured Object Detector (TOD)

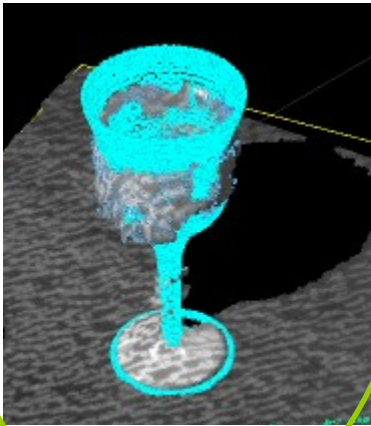


[Ruble, Rabaud, Konolidge, Bradski – ICCV 2011]

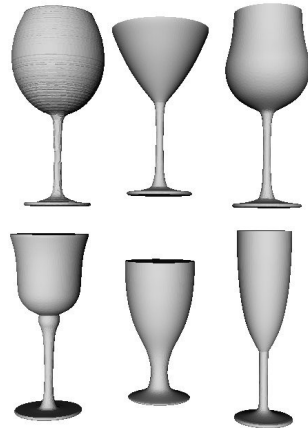
# Semantic Perception

Grasp this...

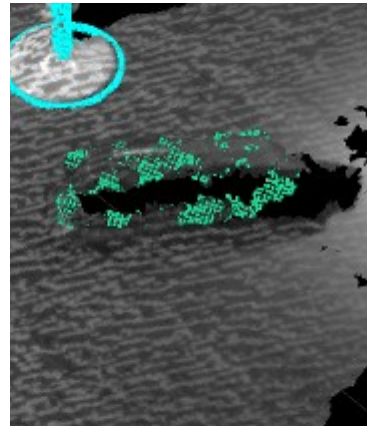
...glass, CAD  
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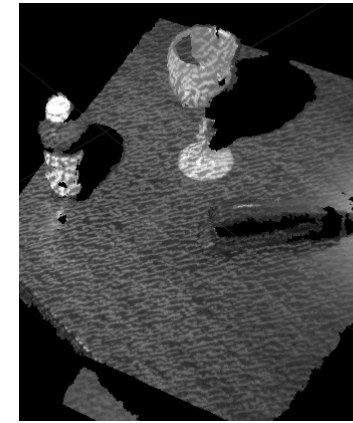
...glass-like  
object.



...blob.



...well,  
anything





# Household Objects Database

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- Real-life objects from major retailers
  - Target / IKEA / common household
  - graspable with one or two hands



IKEA / Target

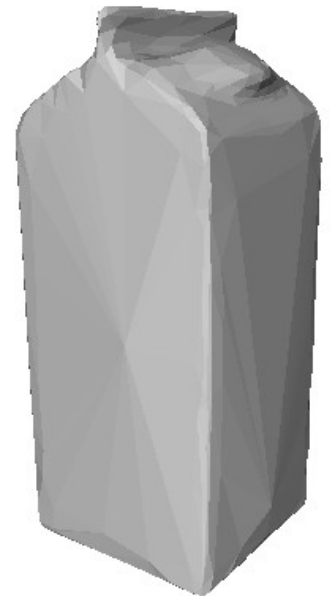
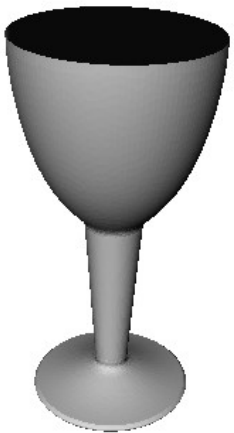


Household

# Household Objects Database

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- Real-life objects from major retailers
- Triangular meshes
  - surfaces of rotation
  - 3DSOM shape from silhouettes
  - TOD model construction



# Household Objects Database

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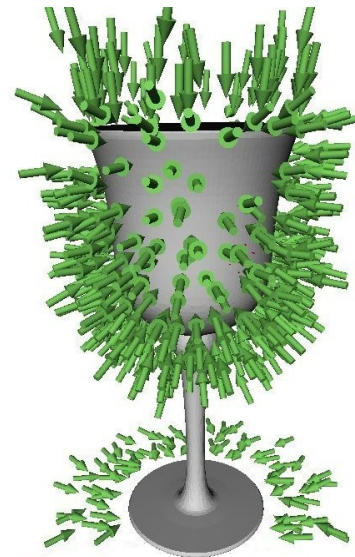
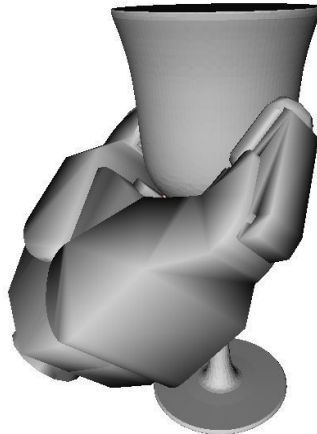
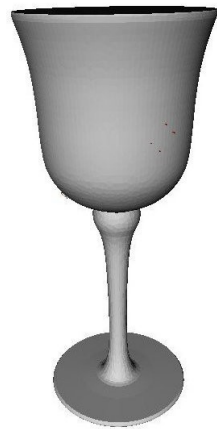
- Real-life objects from major retailers
- Triangular meshes
- Metadata
  - maker and model name (where available)
  - barcode (where available)
  - category tag and description

9362	1	{cup}	IKEA	900.444.86cu	IKEA	cup, coffee, white, 365+, 7oz		3dsom
9363	1	{plate}	IKEA	901.163.79	IKEA	plate, beige, MOTTO, 24.5cm		3dsom
9364	1	{container}	IKEA	901.125.07	IKEA	container, plastic, sandwich, white/red,		3dsom
9365	1	{glass}	Target	200.03.1152	Target	glass, clear, polycarbonate, wine	9200031152	3dsom
9366	1	{glass}	Target	200.03.1301	Target	glass, clear, polycarbonate, wine, 8oz	9200031301	3dsom
9367	1	{glass}	Target	200.01.3598	Target	glass, wine, polycarbonate, translucent	9200013598	3dsom

# Household Objects Database

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- Grasp points for the PR2 and other grippers
- Computed in simulation
  - simulated annealing search
  - align gripper pads to object surface
- 4 hours / object
  - approx. 600 grasps / object



# Household Objects Database

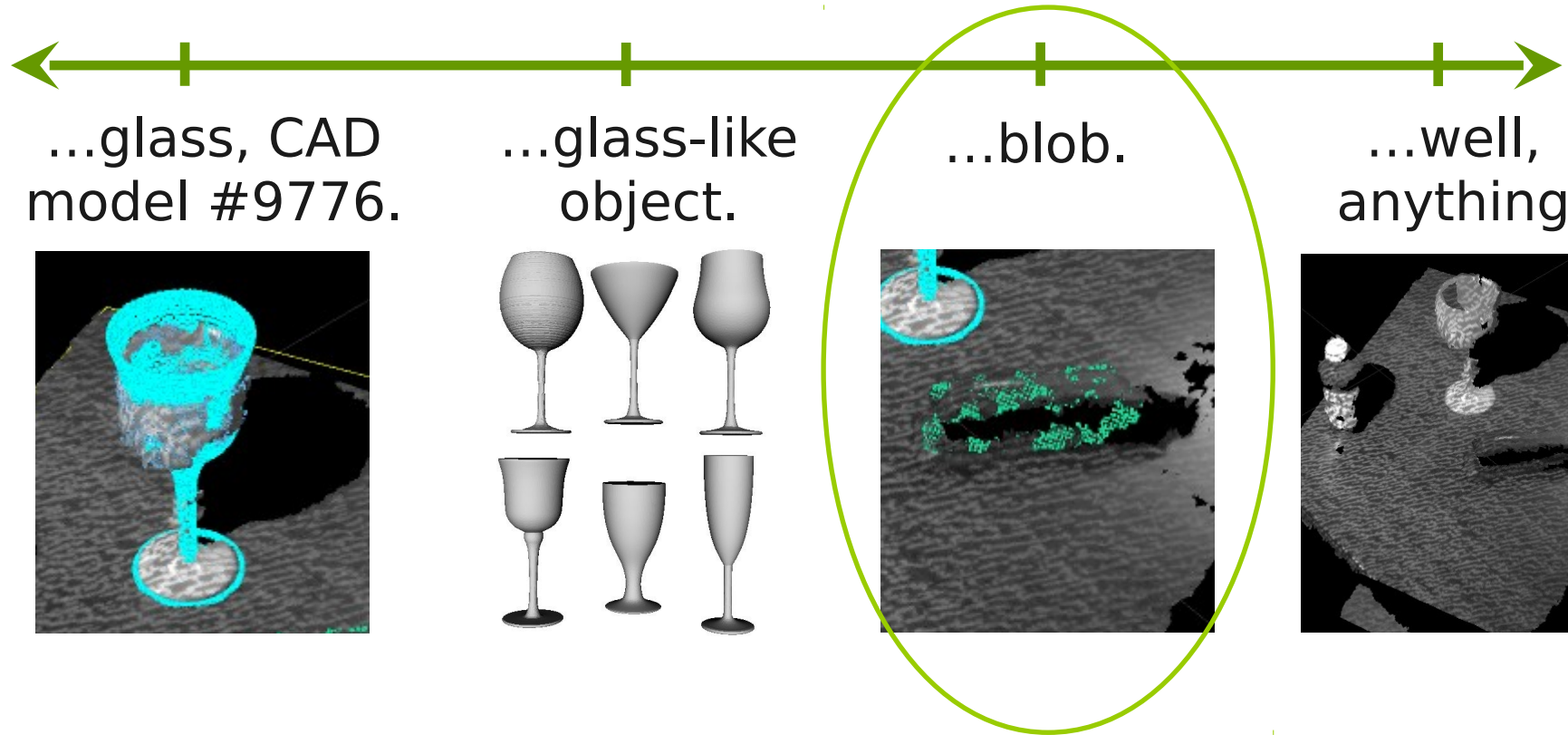
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- Live demo!
  - *Grasplt!* simulator from **graspit\_simulator** stack
  - visualization of database grasps
  - generation of database grasps  
(not yet released and documented...)



# Grasp Planning

Grasp this...

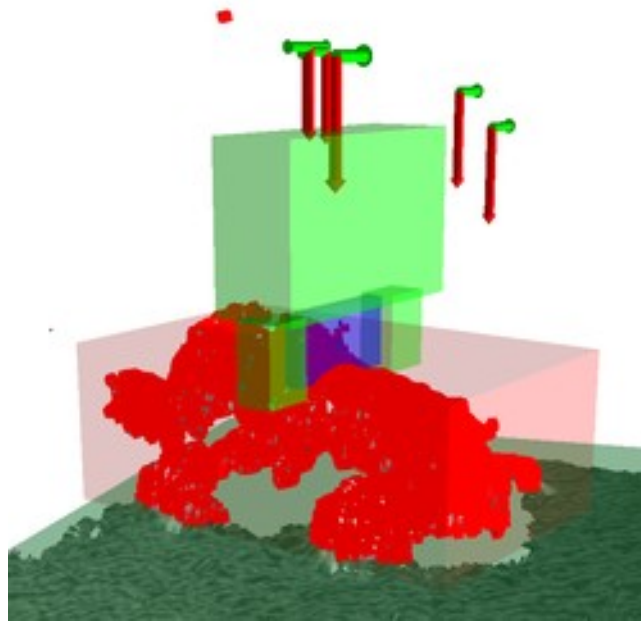


# Grasp Planning for Novel Objects

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## `pr2_gripper_grasp_planner_cluster`

- Plan grasps based on segmented point cloud



[Hsiao, Chitta, Ciocarlie, Jones, IROS'10]

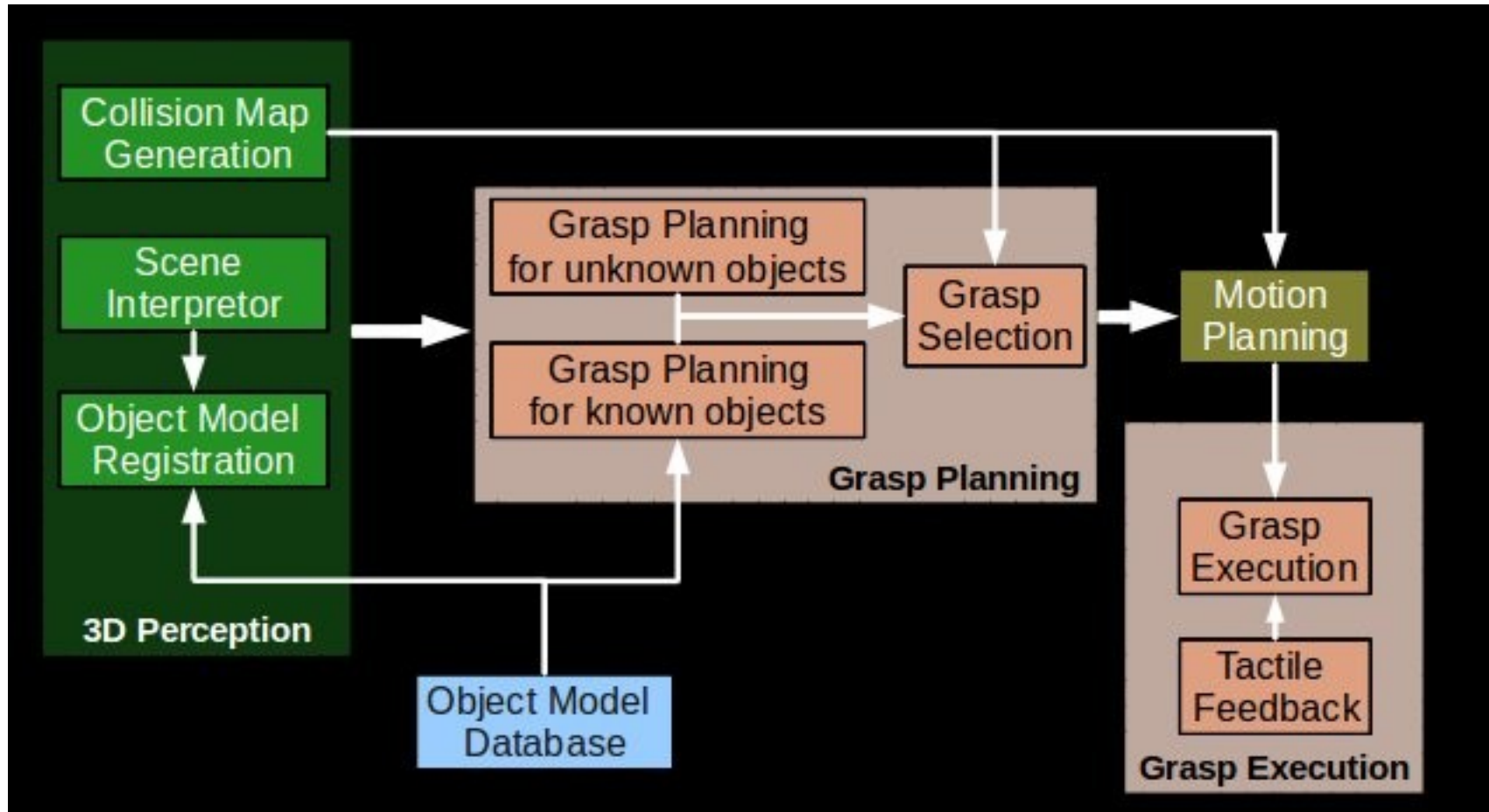
VIDEO!

# Grasp Planning Recap

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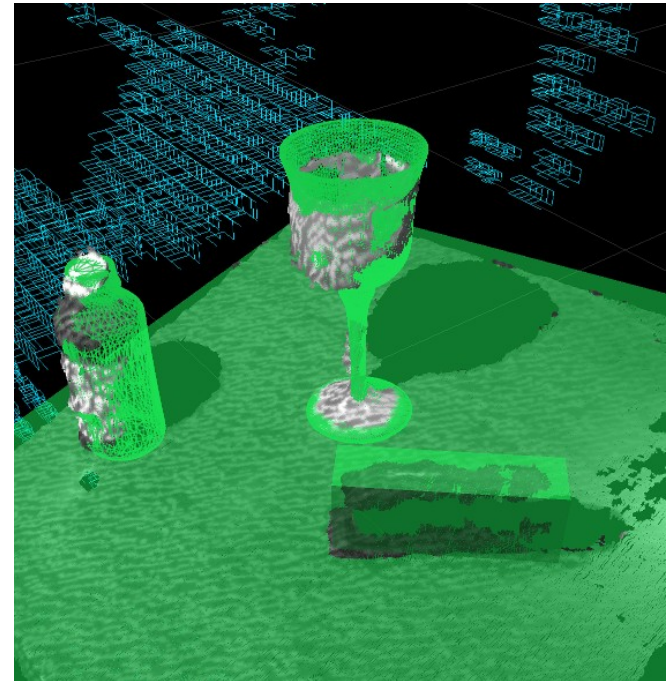
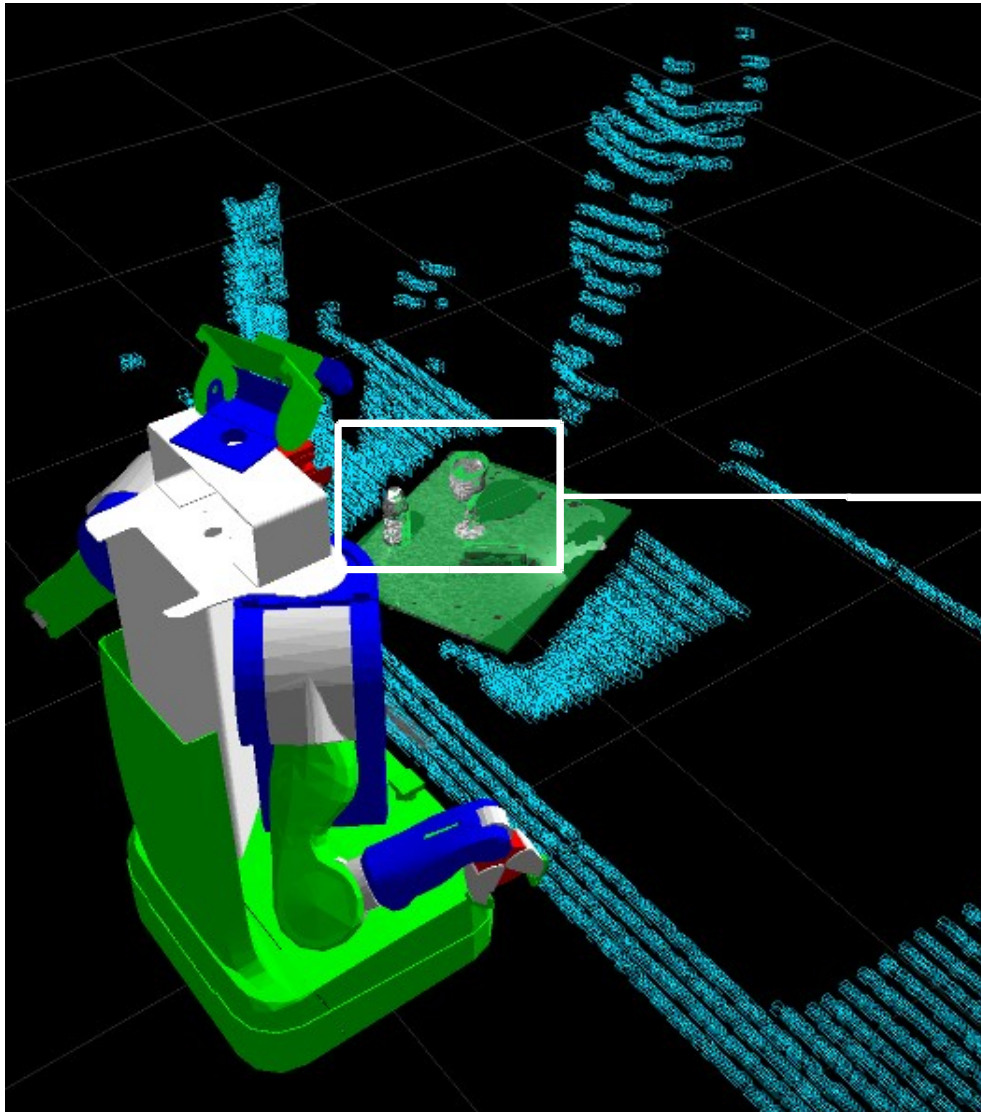
- Grasp planning nodes in packages:
  - **household\_objects\_database**
  - **pr2\_gripper\_grasp\_planner\_cluster**
- Grasp planning service:
  - **object\_manipulation\_msgs/  
GraspPlanning.srv**

# The ROS Grasping Pipeline



[Ciocarlie, Hsiao, Jones, Chitta, Rusu, Sucan – ISER 2010]

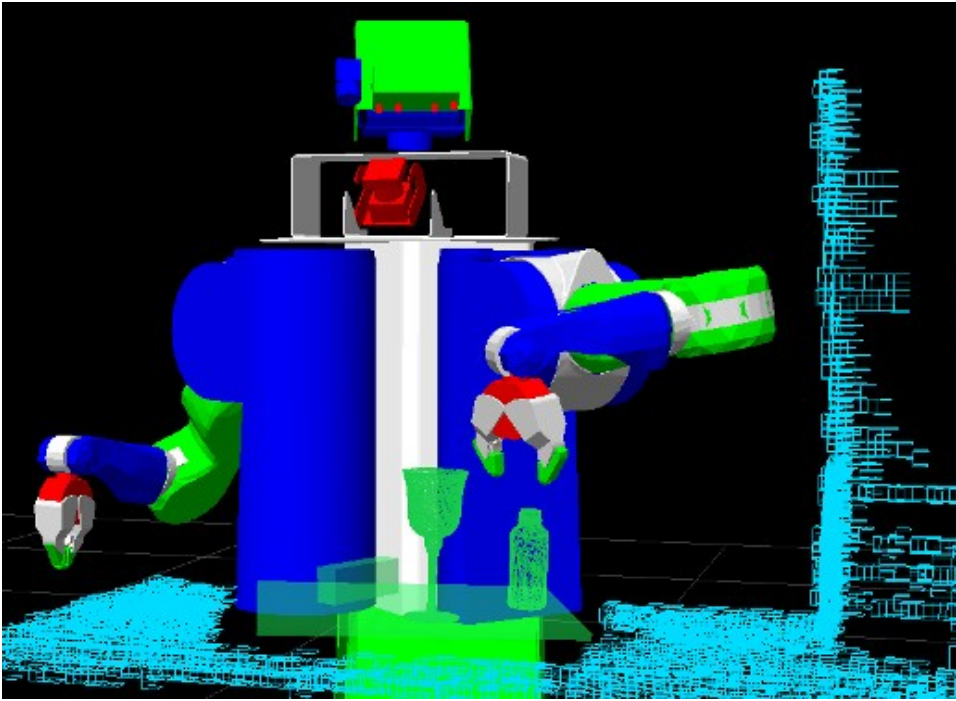
# The ROS Grasping Pipeline



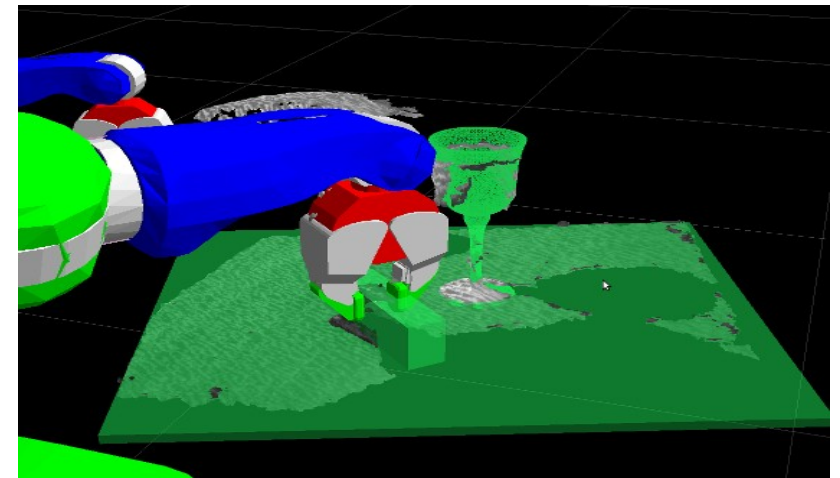
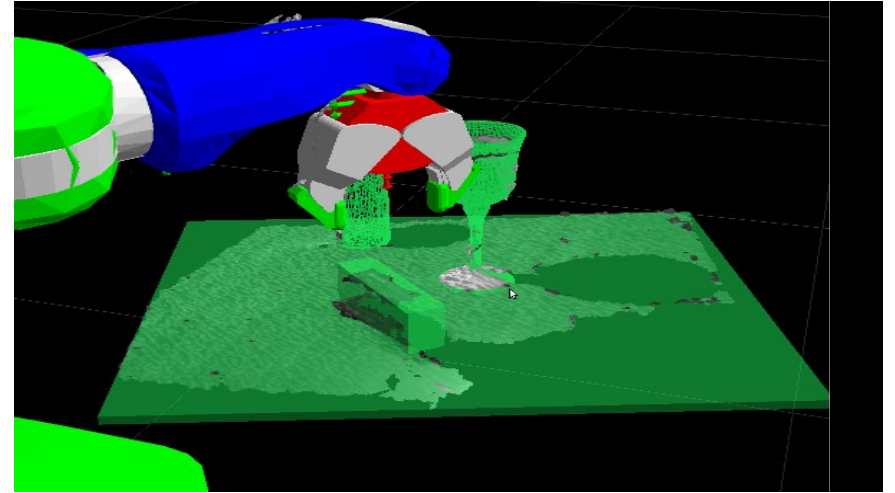


# The ROS Grasping Pipeline

Motion planning



Sampling-based planning



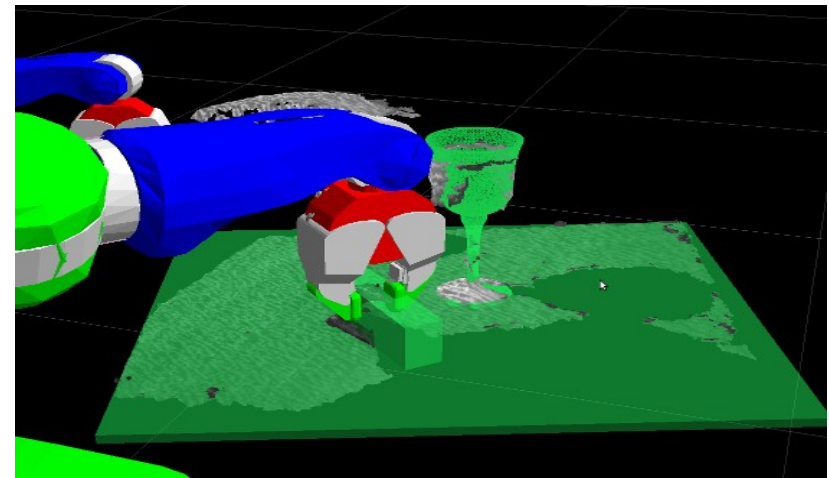
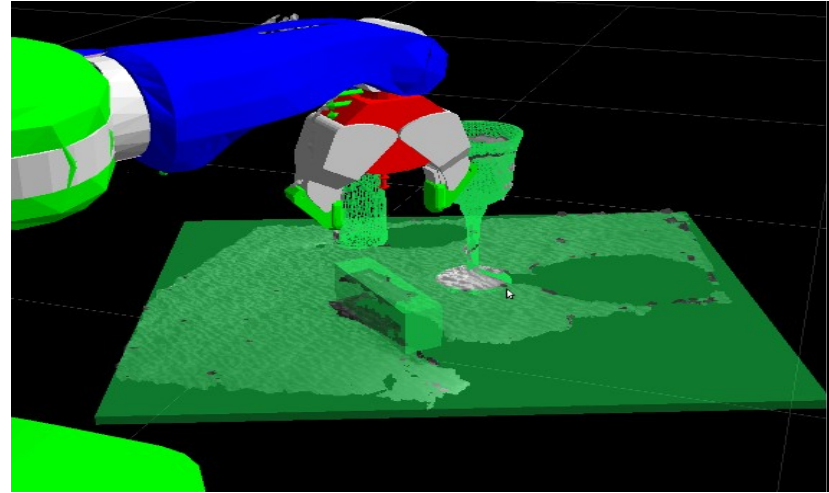
Interpolated IK

# Grasp Execution

## `object_manipulator`

- check pre-grasp
- compute Int. IK to grasp
  - allows coll. w. object
- compute Int. IK to lift
  - allows coll. w. support
- motion plan to pre-grasp
- execute!

`object_manipulation_msgs/  
Pickup.action`

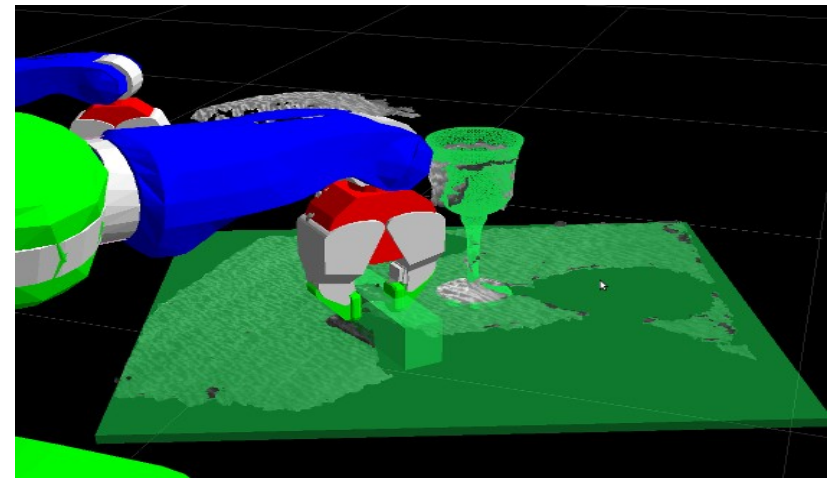
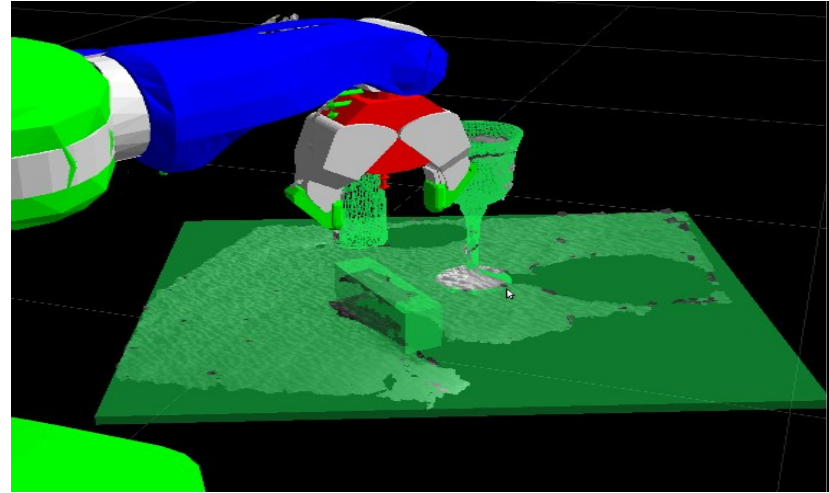


# Place Execution

## `object_manipulator`

- check pre-place
- compute Int. IK to place
  - allows coll. w. support
- compute Int. IK to retreat
  - allows coll. w. object
- motion plan to pre-place
- execute!

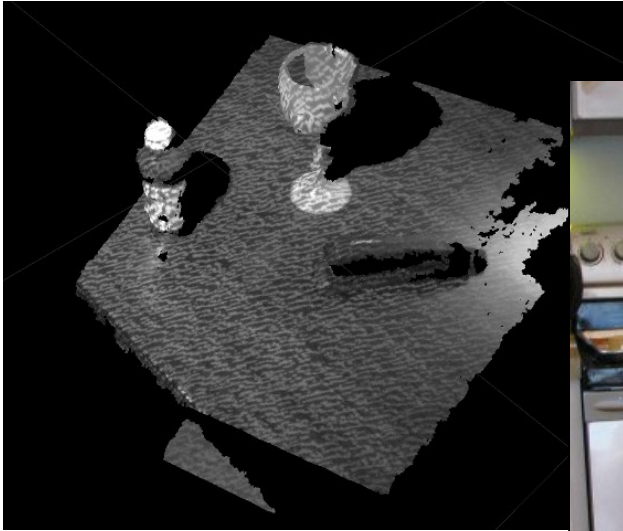
`object_manipulation_msgs/  
Place.action`



# Recent Research Directions

- How do we go from here ...

... to **here**?

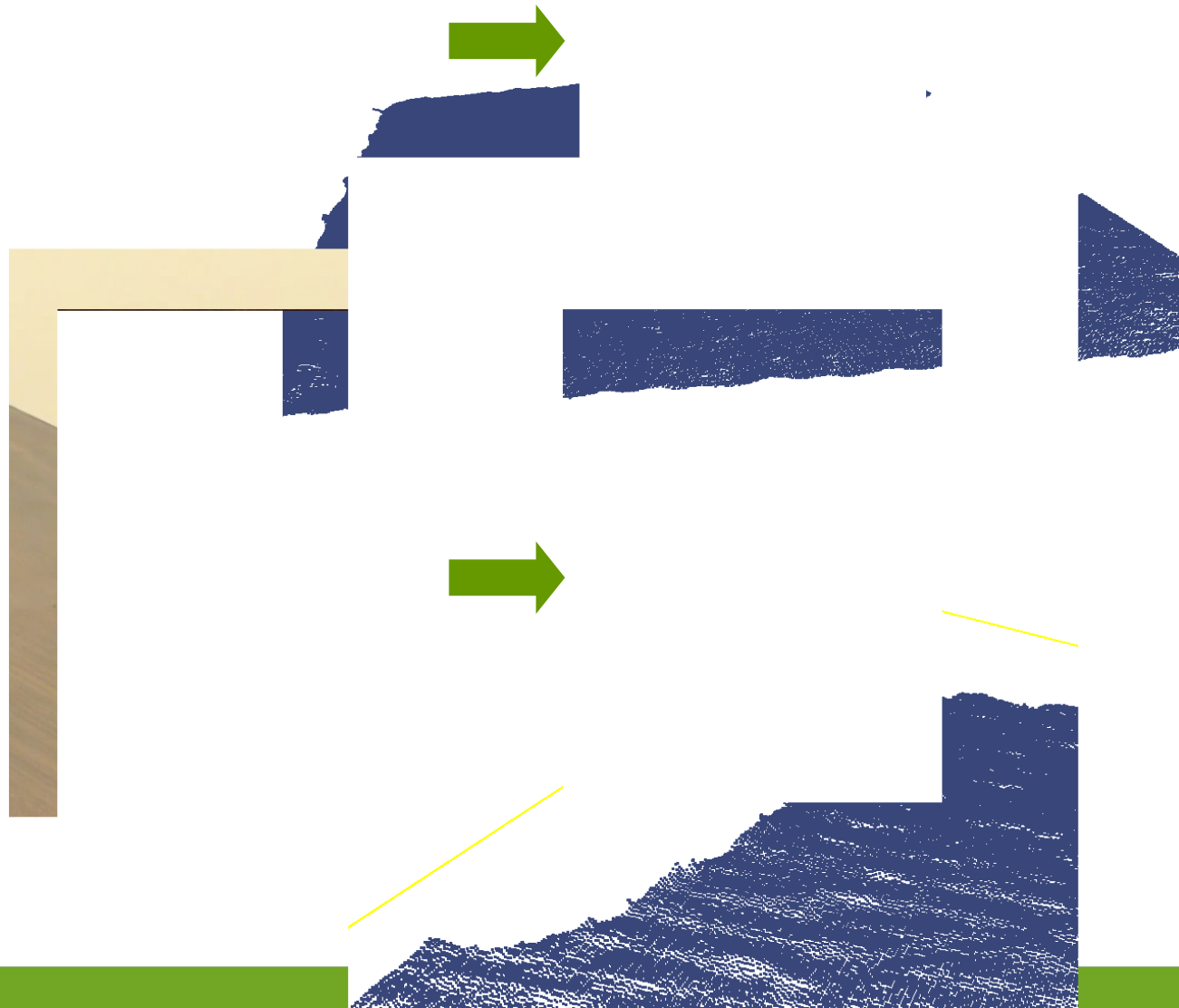


- Grasping in uncertainty and clutter
- Tiered Human-in-the-Loop grasping
- Interactive Manipulation
- Robots for Humanity



# Grasping Under Unc

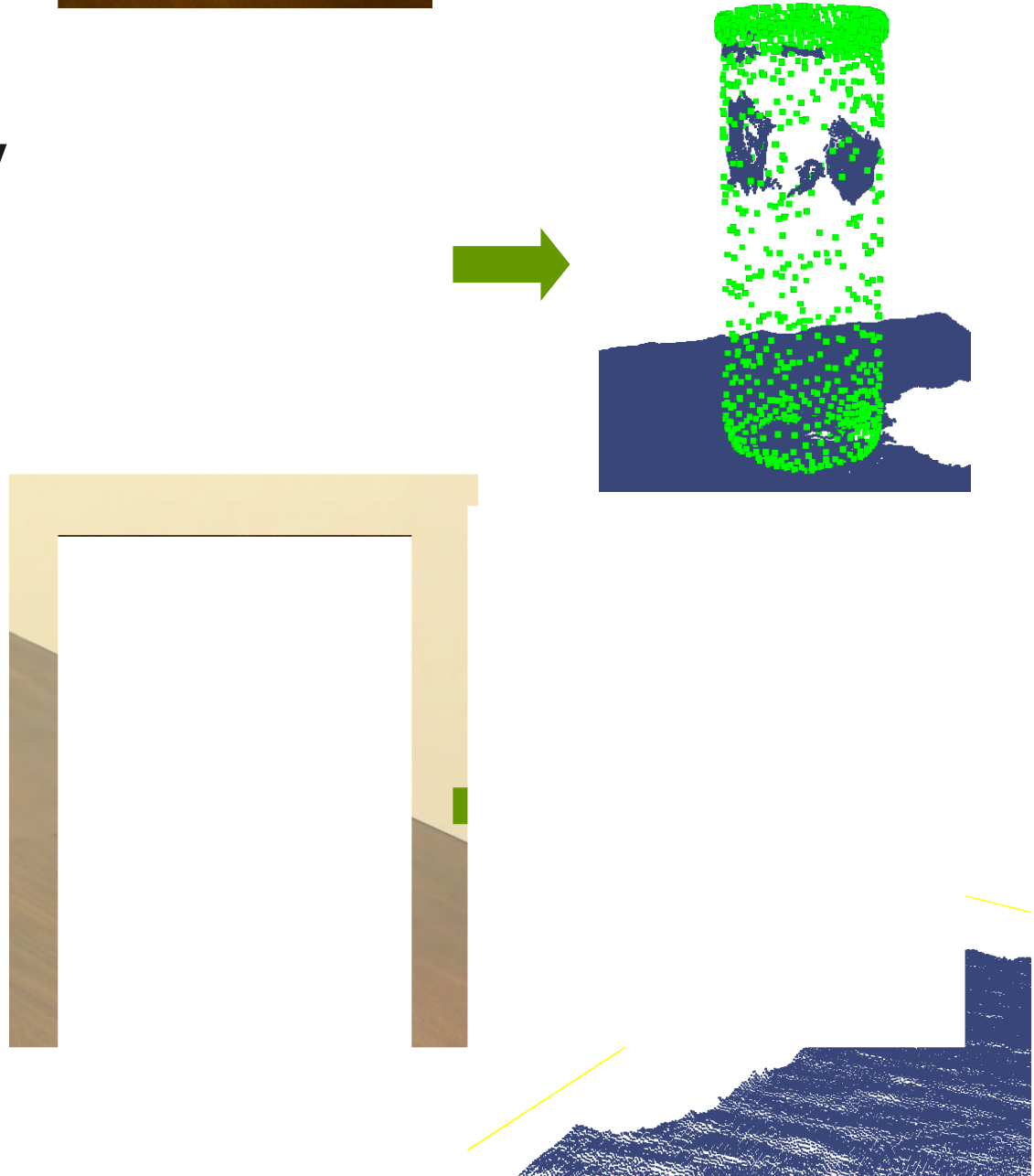
- Objects are observed via noisy sensors
- Recognition methods are not 100% accurate



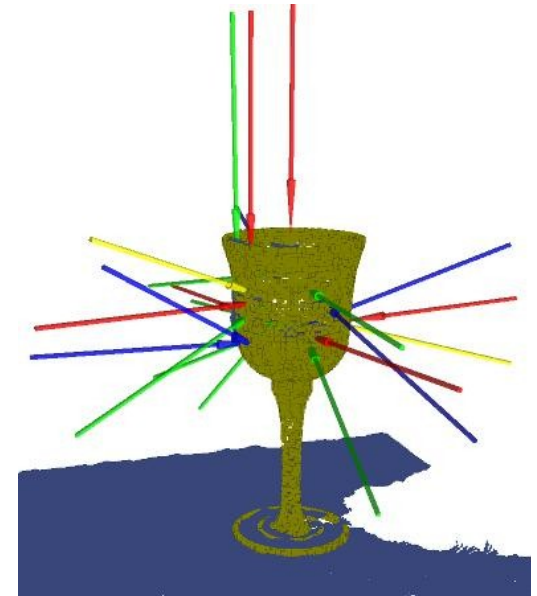
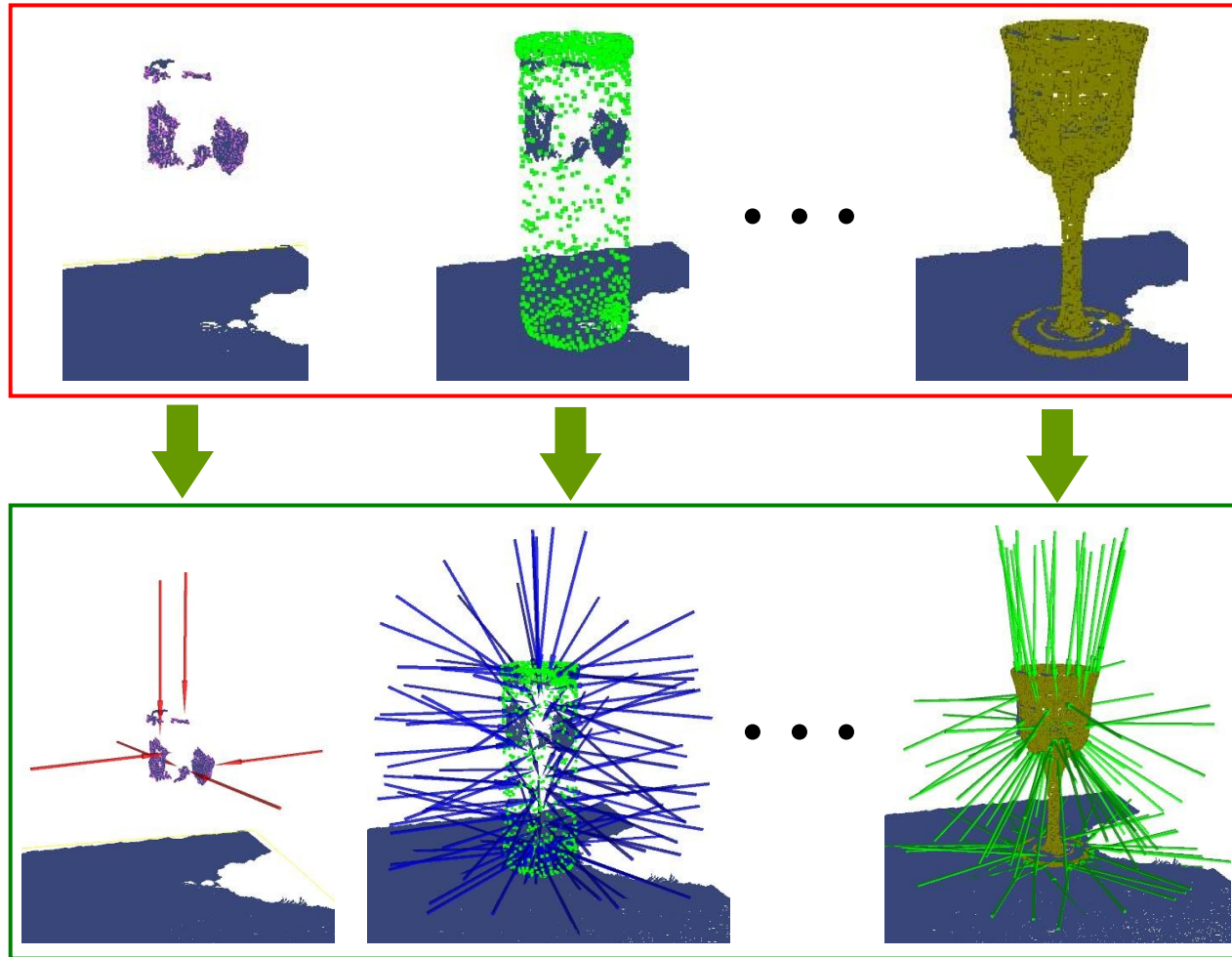


# Grasping Under Uncertainty

- Objects are observed via noisy sensors
- Recognition methods are not 100% accurate



# Grasping Under Uncertainty



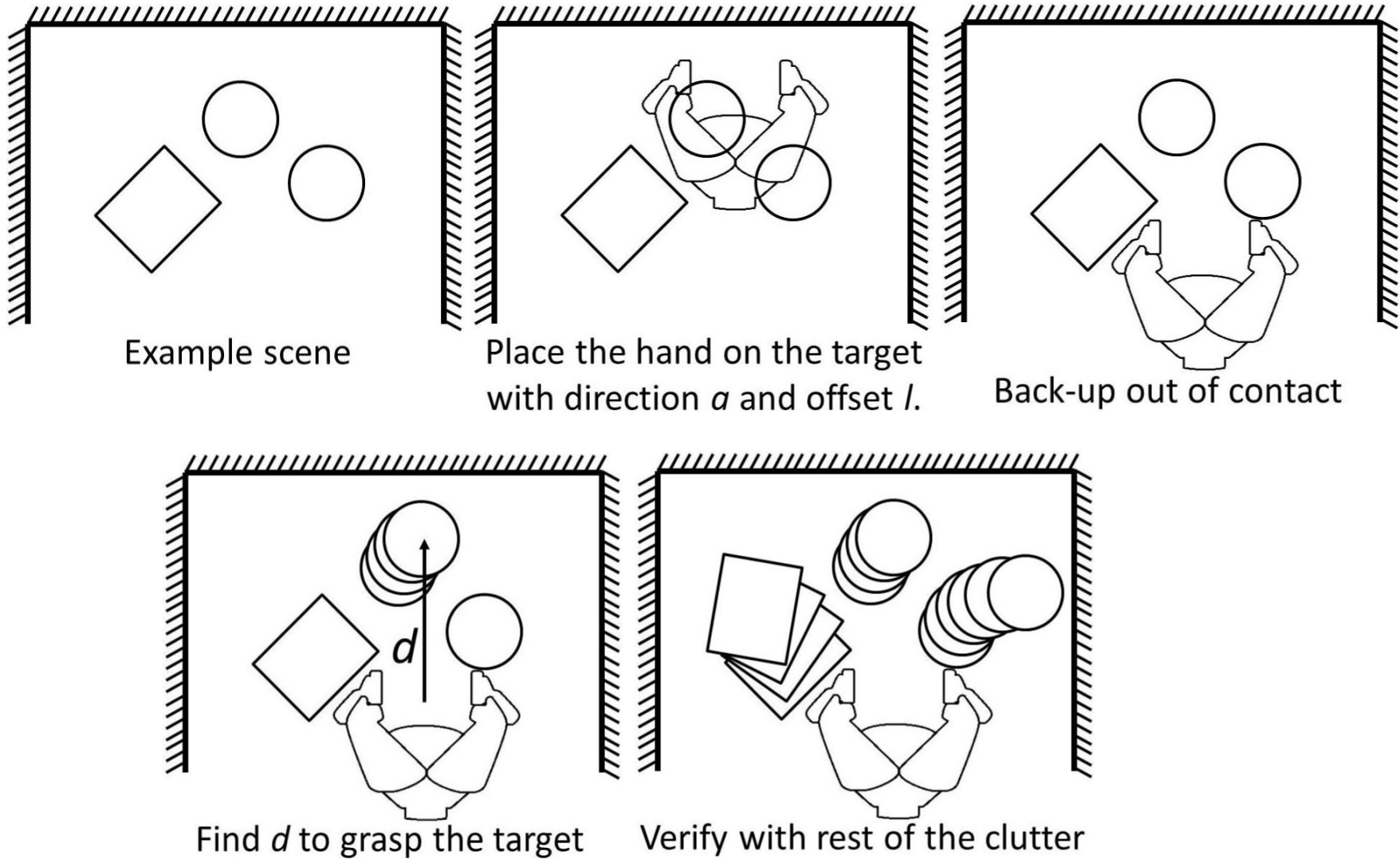
# Probabilistic Grasping - Results

	Collabo rative Planner	Naïve Planner
Novel objects	22/25	18/25
Database objects	22/25	21/25

- Single object on table
- Success = lift and move to side without dropping

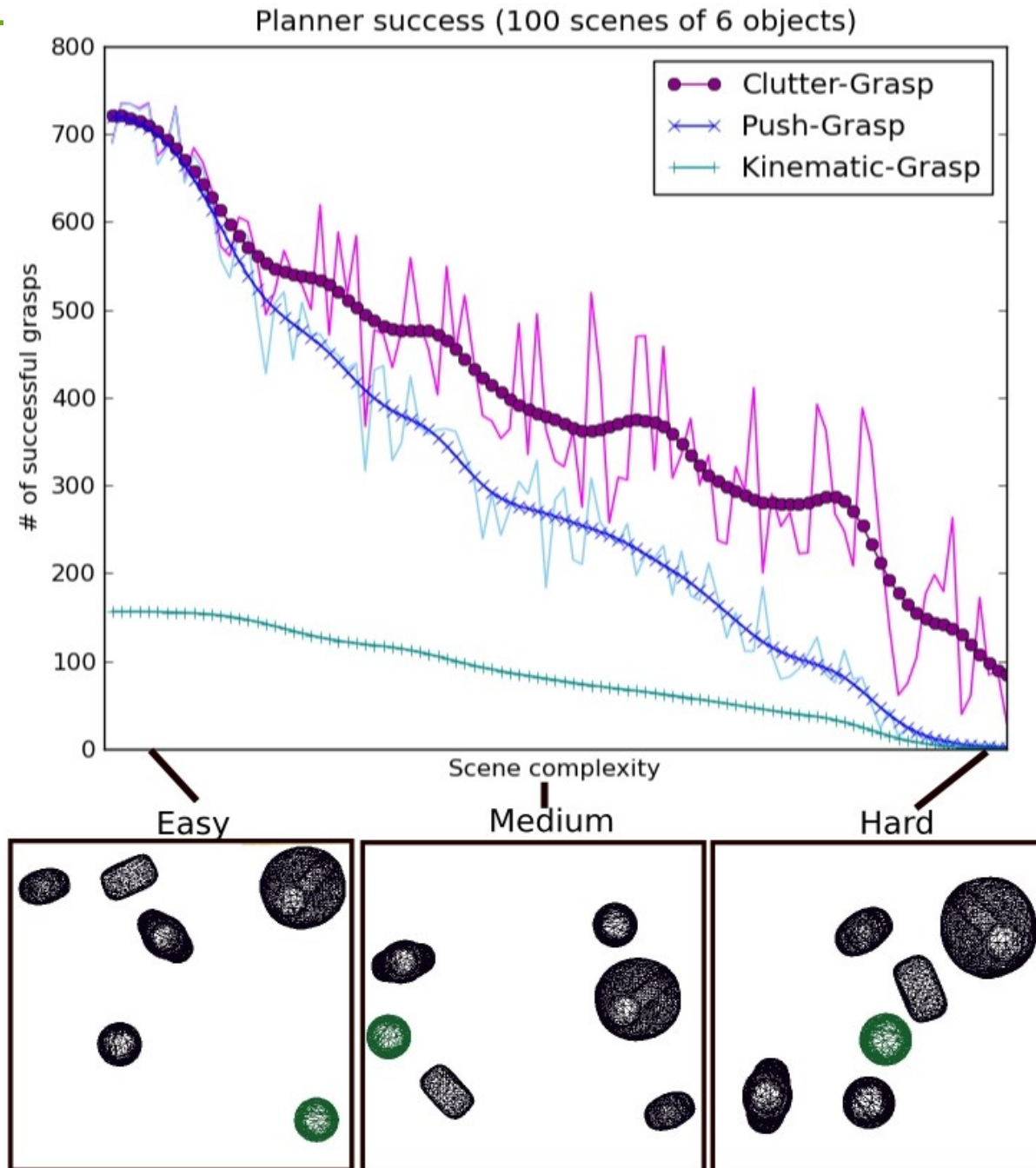


# Grasping in Clutter





# Grasping in Clutter

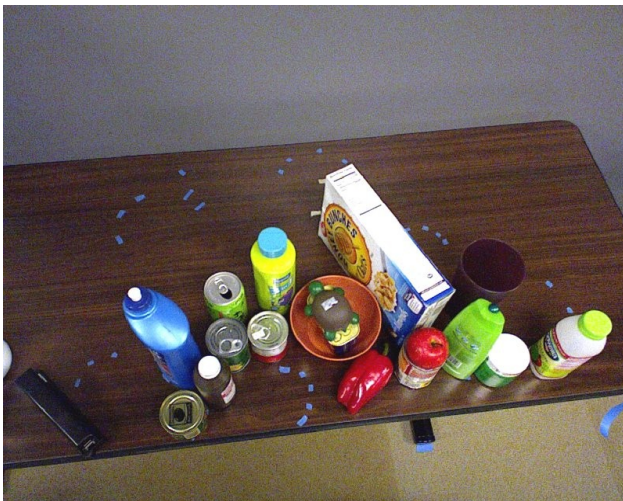




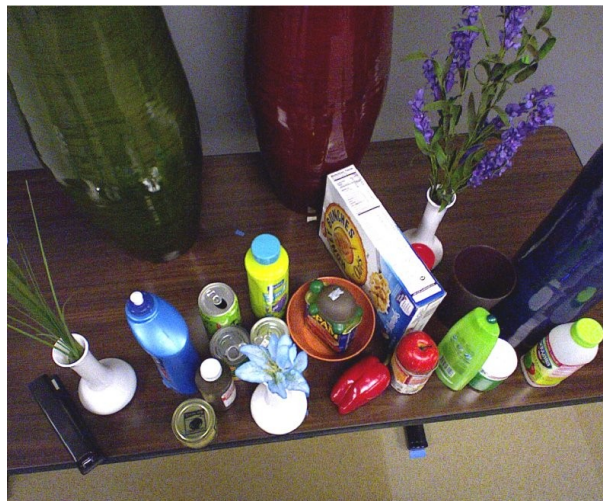
# Tiered Human-in-the-Loop Grasping

- 4 grasping strategies, different levels of autonomy
- 3 environments: from moderate to extreme clutter

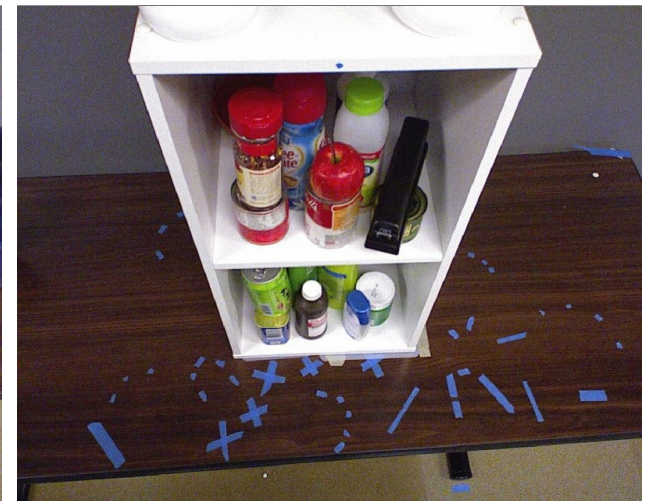
Environment 1



Environment 2



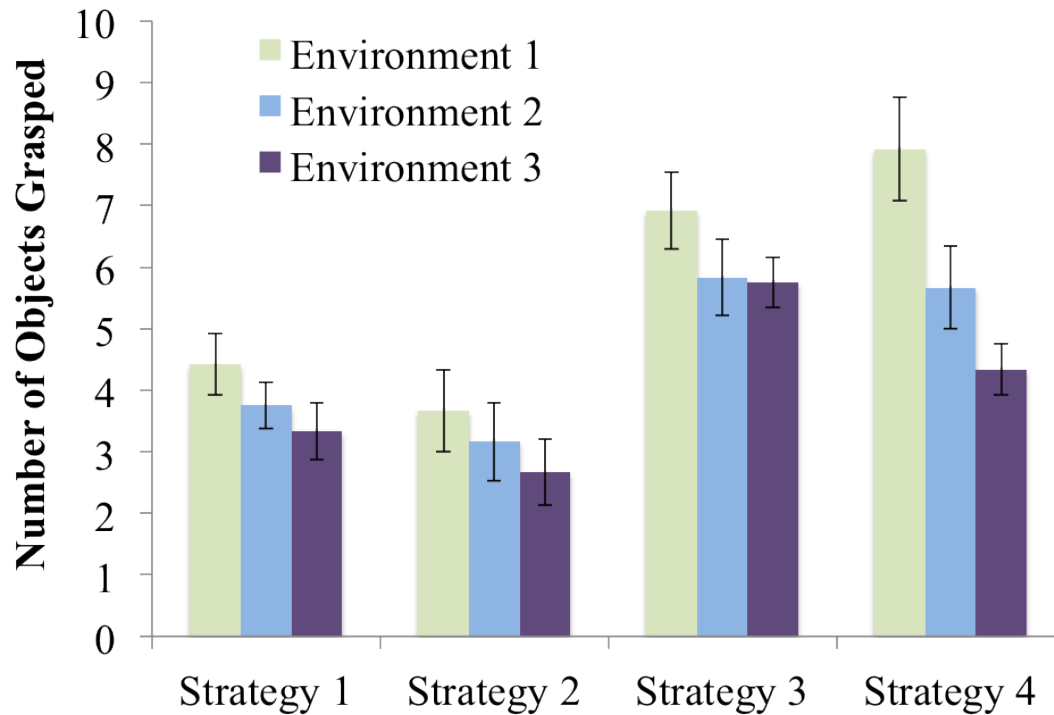
Environment 3



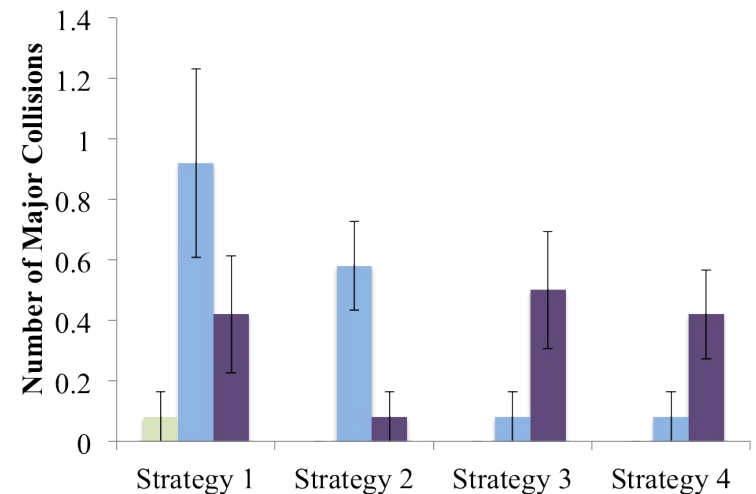
[Leeper, Hsiao, Ciocarlie, Takayama, Gossow – HRI 2012]

# Tiered Human-in-the-Loop Grasping

**Number of Objects Grasped  
with Each Strategy in Each Environment**



**Number of Major Collisions  
with Each Strategy in Each Environment**



# Strategies for HitL Grasping

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- Autonomy helps (yay!)
  - motion planning for non-anthropomorphic kinematics
  - motion planning for collision avoidance
- Autonomy does not have to be perfect
- Trust and communication are key
  - autonomous component must communicate what it **can** or **can not** do

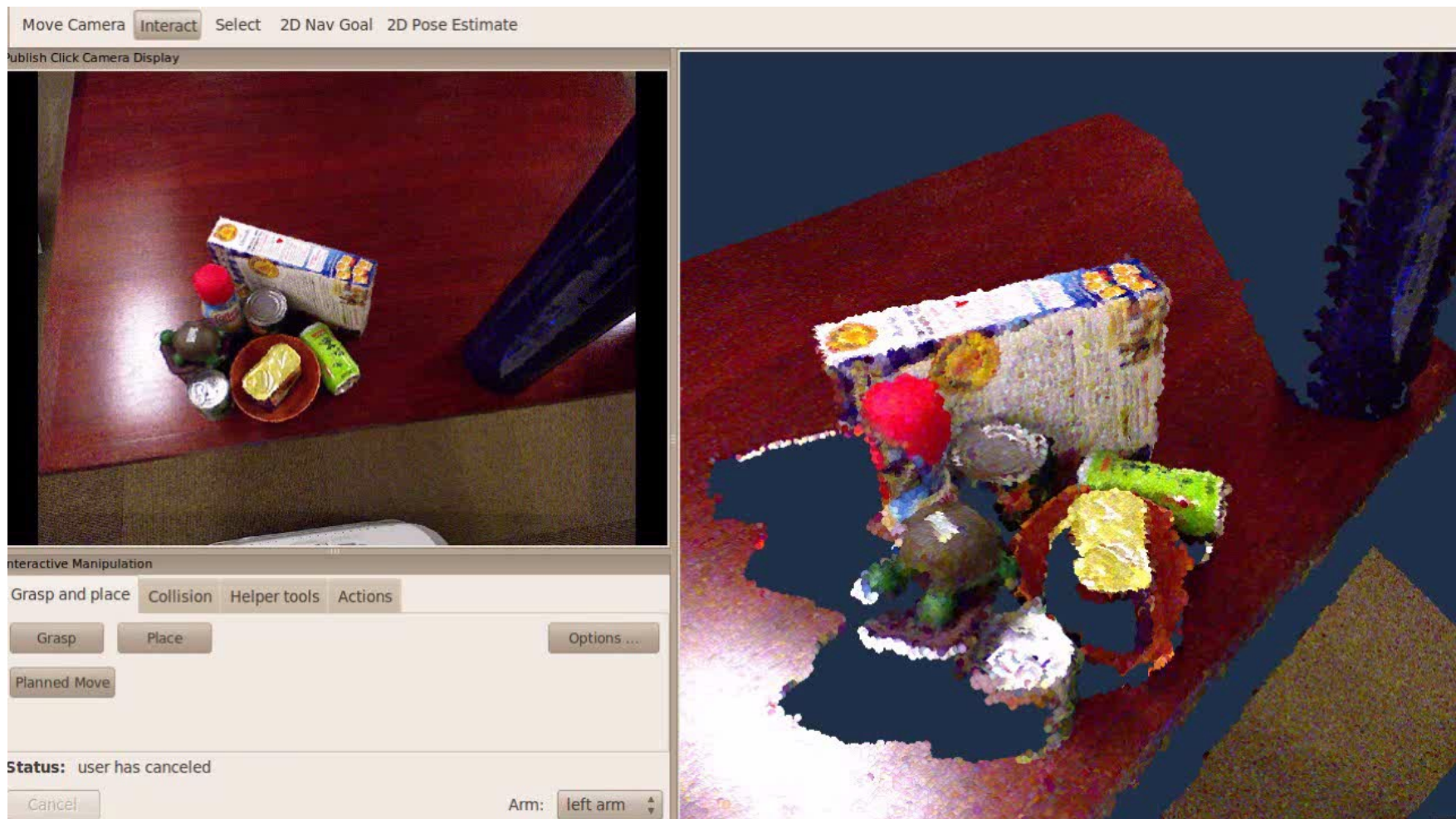
# Human-in-the-Loop Robotics

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- Accelerate deployment of robots in homes or offices
- Learn about what is hard in the context of complete tasks
  - progress towards full autonomy
- Enable applications in the near-term
  - remote operation
  - call center for robots
  - help people with disabilities: “**Robots for Humanity**”



# Interactive Manipulation



`pr2_interactive_manipulation`

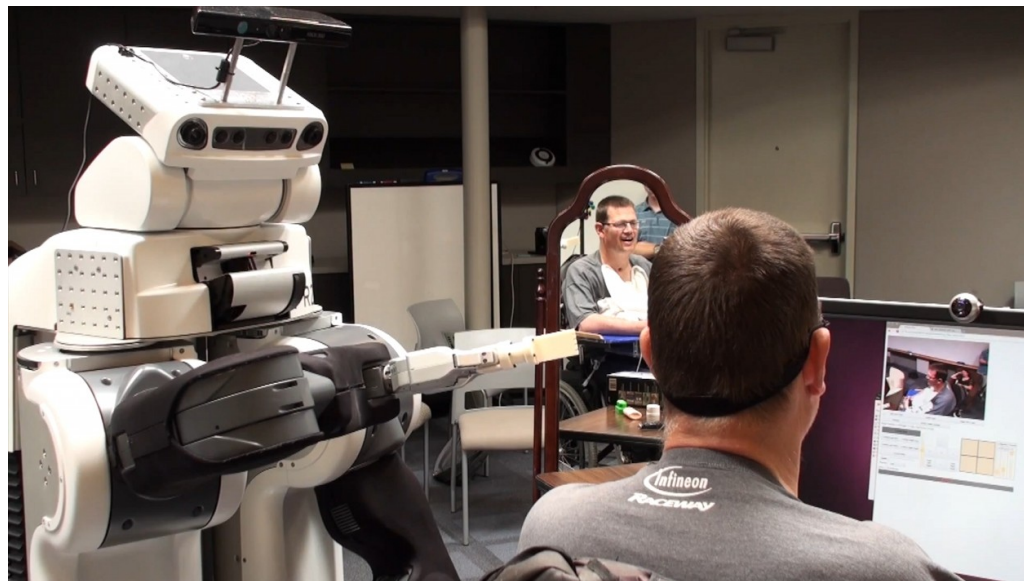
VIDEOS!



# “Robots for Humanity”

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- Collaborative project:
  - Willow Garage
  - Georgia Tech (Prof. Charlie Kemp)
  - Oregon State University (Prof. William Smart)
  - Henry and Jane Evans
- Goal: enable people with motor impairments to interact with their environment through mobile manipulators



# Interactive Manipulation for Assistive Robotics



VIDEO!



[Chen et al. – IROS 2012] – WeGVT4.4

[Ciocarlie, Hsiao, Leeper, Gossow – IROS 2012] – WeGT7.2

Keynote at Assistance and Service Robotics Workshop - Friday

# Grasping in ROS - Foundation

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- Semantic Perception
  - simple scenes: **tabletop\_object\_detector**
  - **object\_recognition**
- Grasp Planning
  - known objects: **household\_objects\_database**
  - new: **pr2\_gripper\_grasp\_planner\_cluster**
- Grasping Pipeline and Execution
  - Integration with sensing and Motion Planning
  - Pickup and Place actions: **object\_manipulator**

# Grasping in ROS - Research

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- Grasping in Uncertainty and Clutter
  - **probabilistic\_grasp\_planner**
  - **push\_grasp\_planner**
- Interactive Manipulation
  - **pr2\_interactive\_manipulation**

# Grasping and Manipulation in ROS

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- Check out our Internship Program:
  - [www.willowgarage.com](http://www.willowgarage.com)
    - \* **Jobs → Internship Opportunities → Grasping & Manipulation**
  - Resume / code samples / recommendations