Grasping Objects Big and Small: Human-informed Relationships between Grasp Type and Object Size

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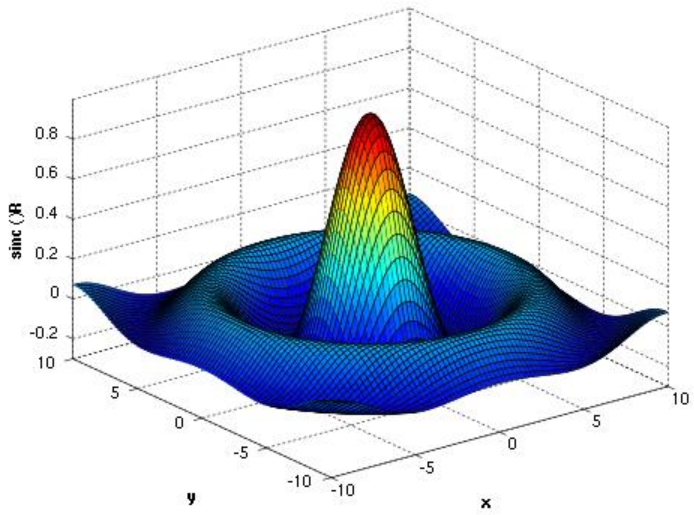
Grasping Lab
Dr. Cindy Grimm and Dr. Ravi Balasubramanian


0.8
0.6
0.4
0.2
0
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10
5
0
-5
-10
y
-10
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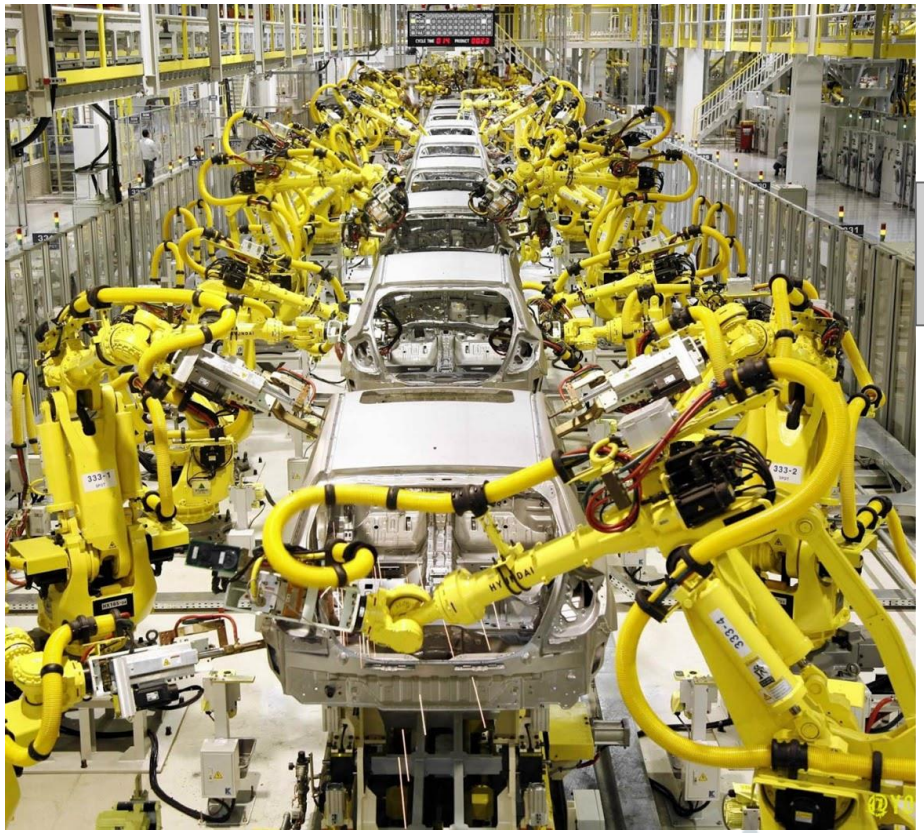
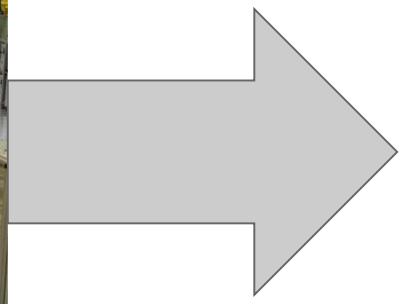
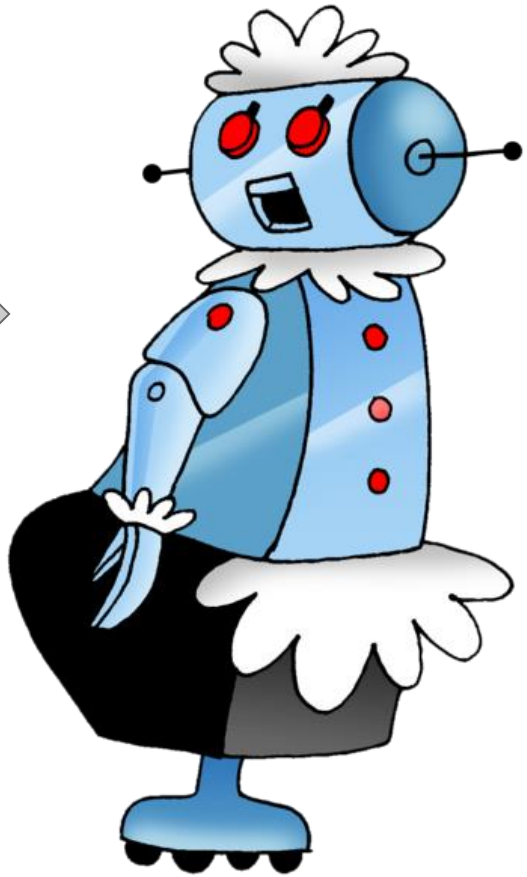
5
10
x

Why do we care?





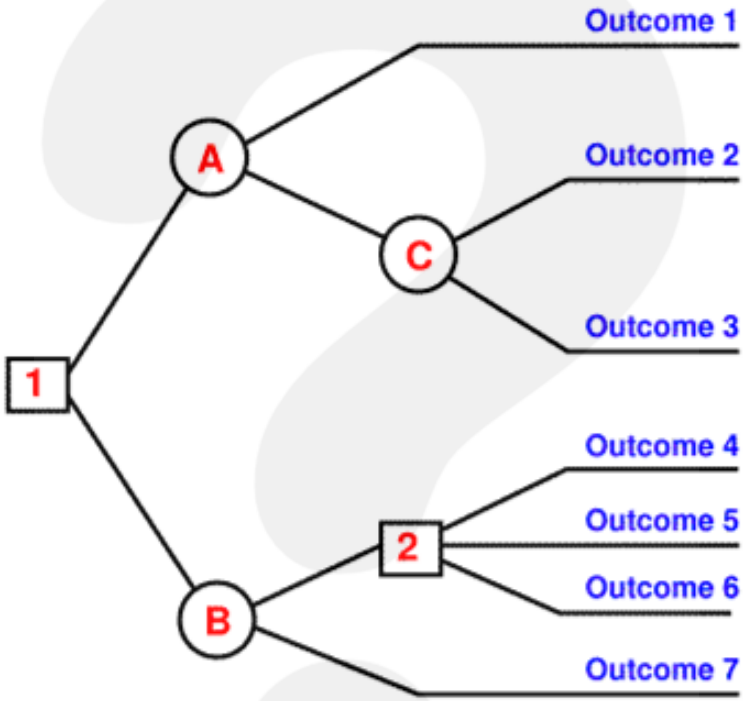


We can implement human techniques in robots

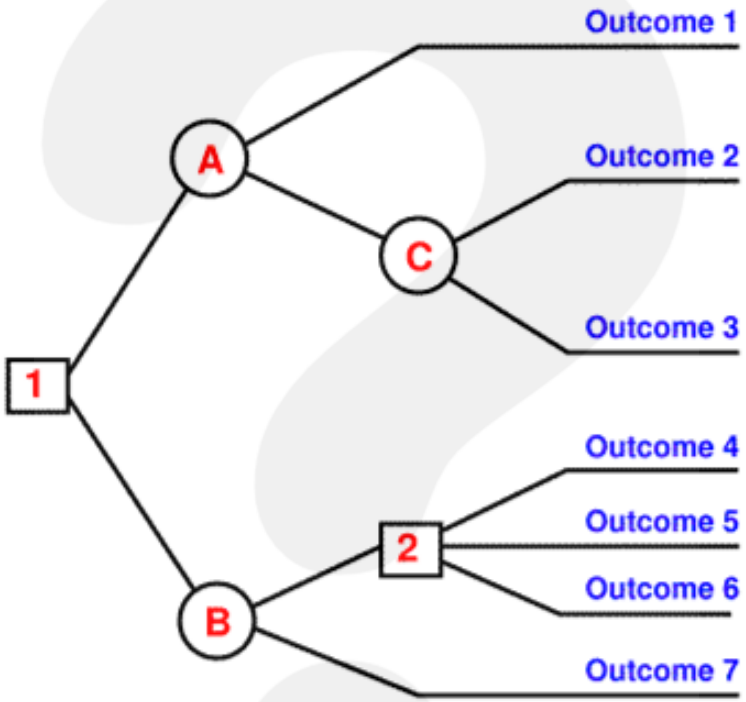
First we need to study humans

Human Grasping Decision Tree

- Shape
- Size
- Viewpoint
- Weight
- Compliance
- Texture
- Center of Mass
- ...



Human Grasping Decision Tree

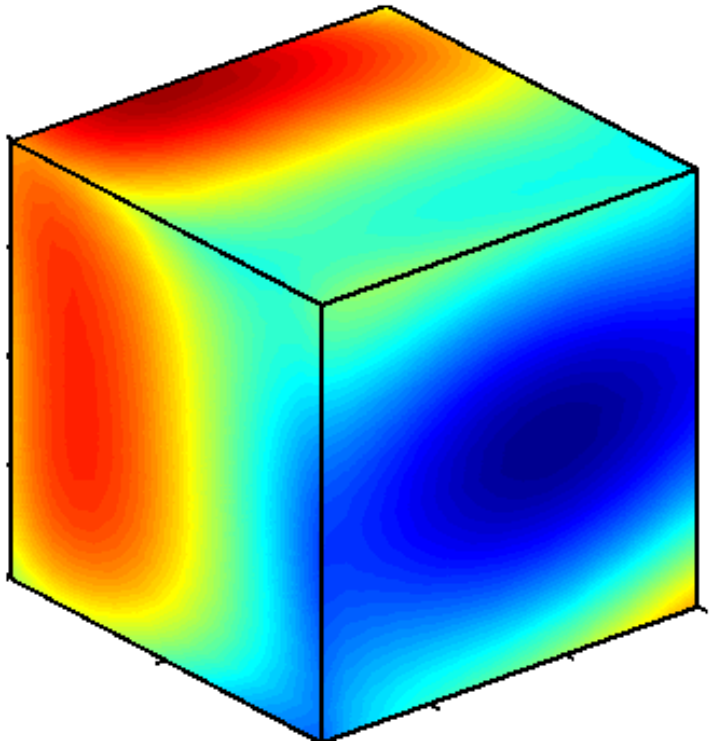


- Grasp Types
  - Wrist Rotation
  - Finger Spread
  - Hand Translation
- Metrics
  - Finger Closure
  - Distance of Palm from Object
  - Position of Palm to Center of Object
  - Surface Contact
- Control Strategies
  - Caging

Big Picture End Result:

Partition the Space

- so robots can make better choices about how to grasp different objects
- so robots can make more predictable grasps



Human Grasping Decision Tree

- ◎ Shape
- ◎ Size
- ◎ Viewpoint
- ◎ Weight
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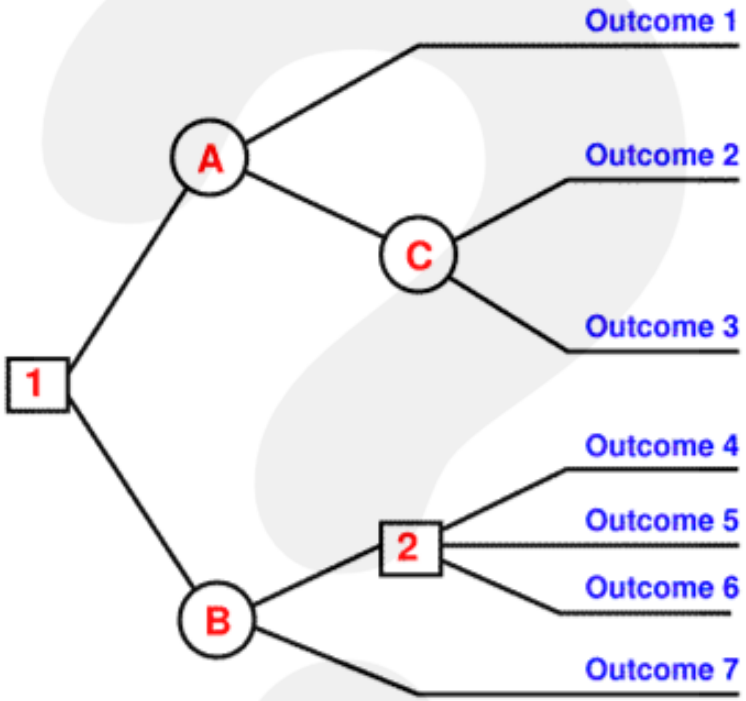
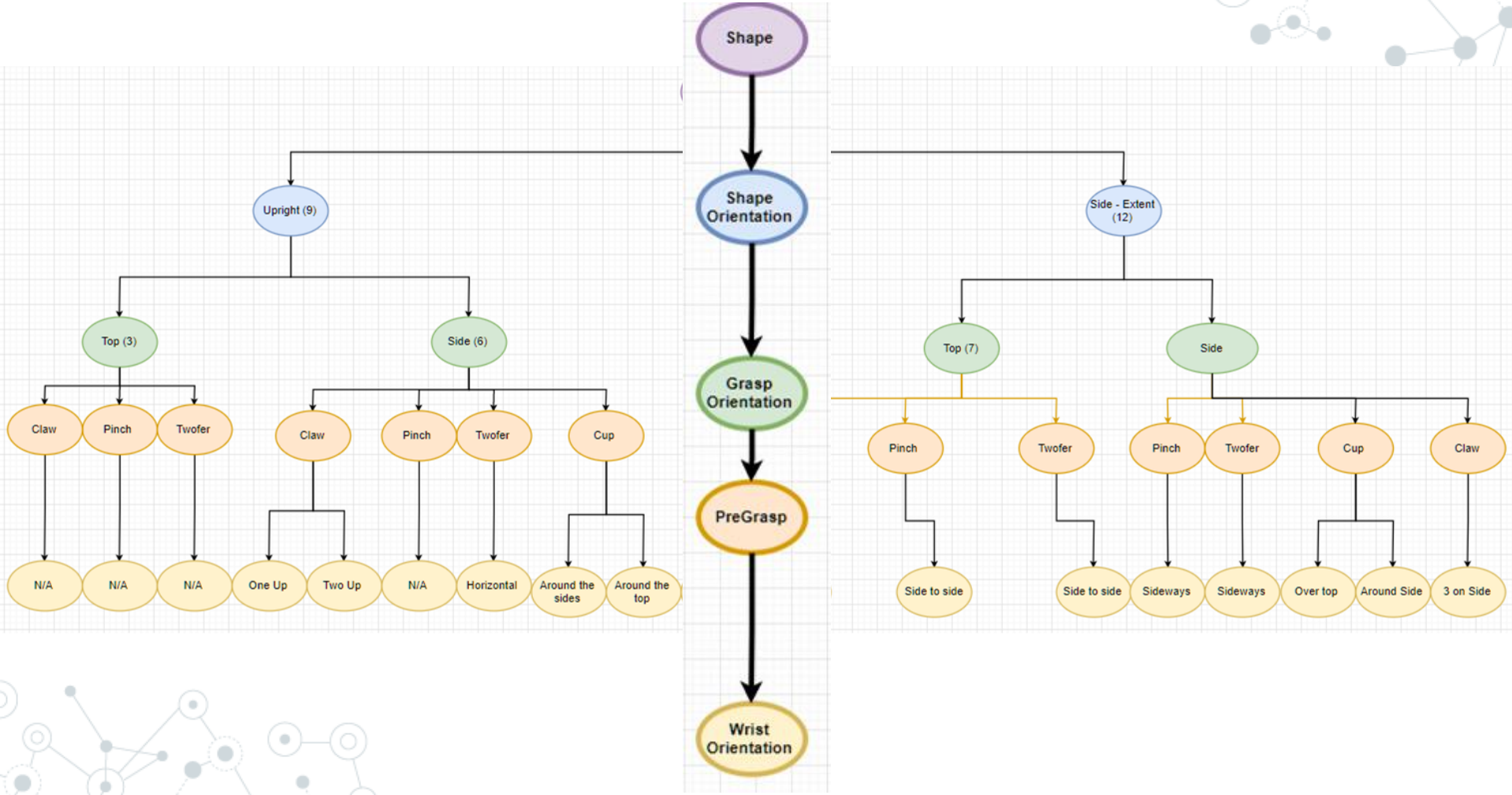
- ◎ Texture
- ◎ Center of Mass
- ◎ ...



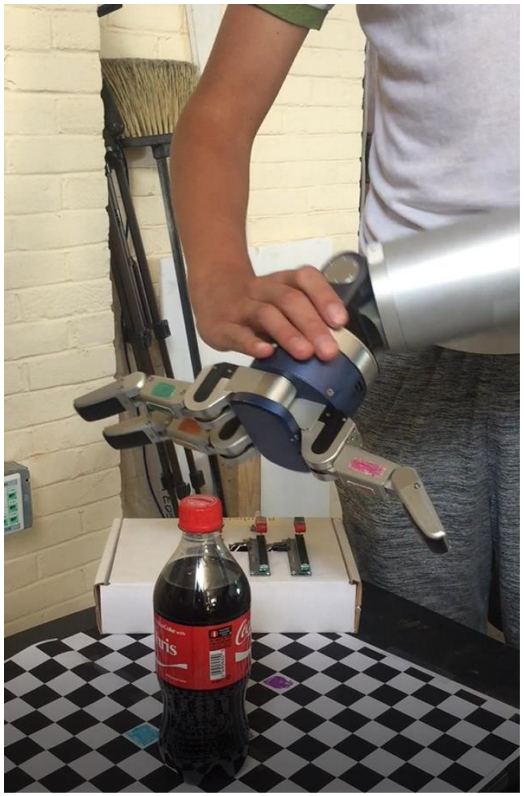
The Grasping Tree



Mechanical Turk Survey and User Study

amazon mechanical turk

Data



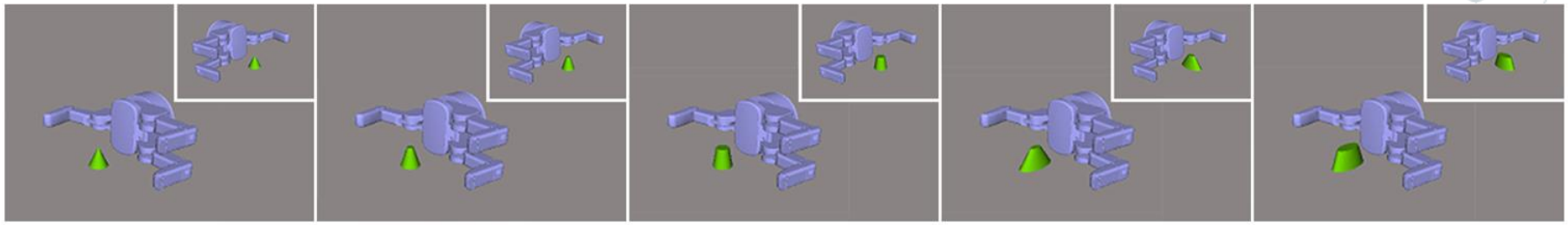
Mechanical Turk Survey

- Questions
- Images for the Questions
- Training Video
- Interface

Mechanical Turk Survey

- ◎ Questions
- ◎ Images for the Questions
- ◎ Training Video
- ◎ Interface

Mechanical Turk Survey: Questions



Smallest Graspable Object

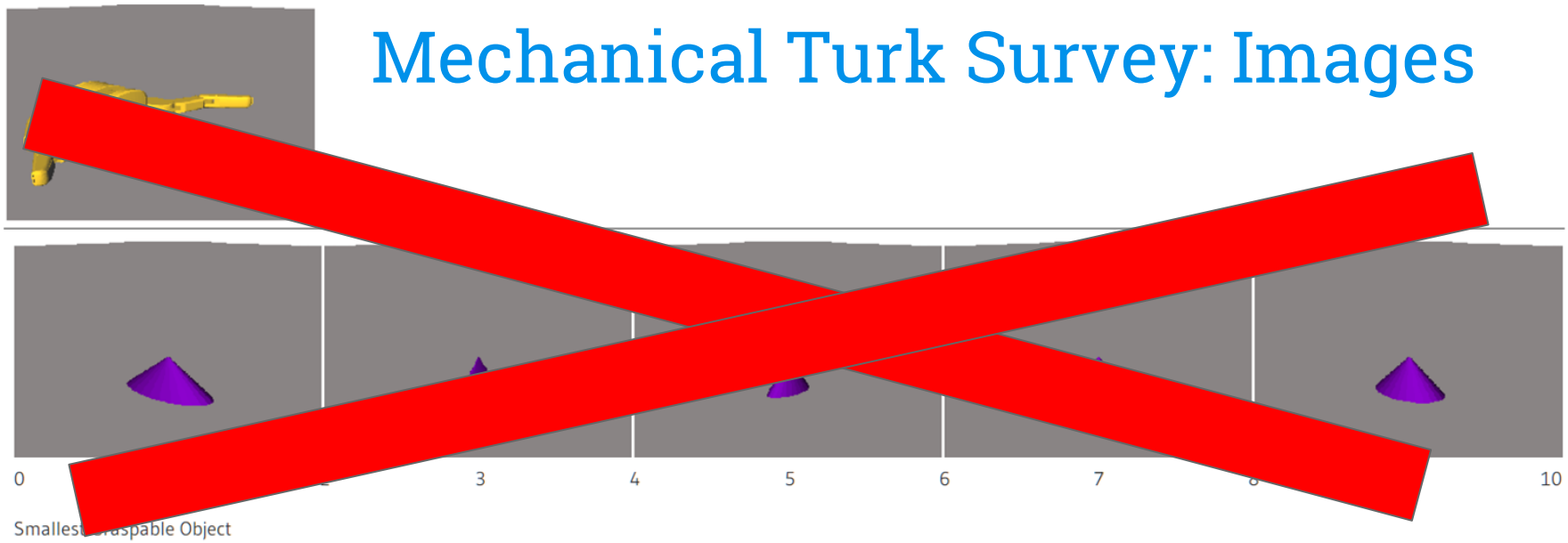
Largest Graspable Object

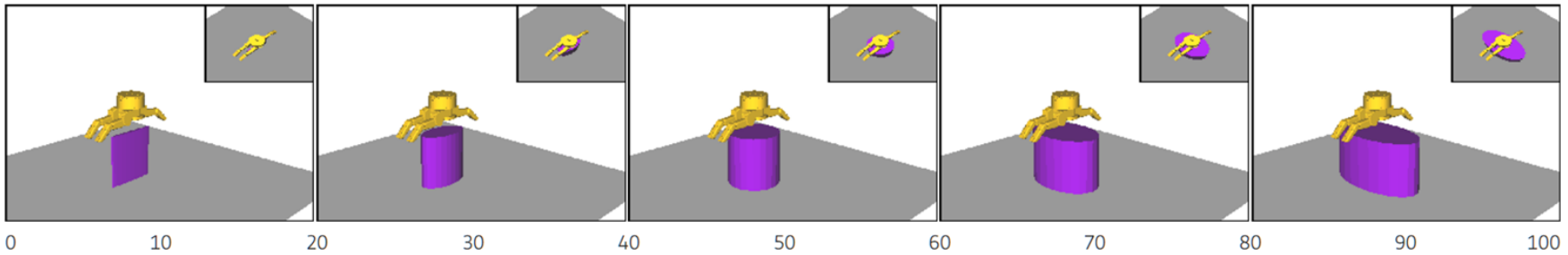
Best Size for this Grasp

Mechanical Turk Survey

- ◎ Questions
- ◎ Images for the Questions
- ◎ Training Video
- ◎ Interface

Mechanical Turk Survey: Images





Mechanical Turk Survey

- ◎ Questions
- ◎ Images for the Questions
- ◎ Training Video
- ◎ Interface

Mechanical Turk Survey: Tutorial Video

Mechanical Turk Survey

- ◎ Questions
- ◎ Images for the Questions
- ◎ Training Video
- ◎ Interface

Mechanical Turk Survey: Interface

Survey Challenges

- Making sure the survey is value adequate
- Making sure the training video is informative enough without being confusing
- Generating images

Data

```
Shortest: hook_side: around the sides: cylinder_e_: W:          Std Dv: 7.19444229944, Center: 0.68cm
Shortest: hook_side: around the sides: cylinder_e_: E:          Std Dv: 12.7769323392, Center: 0.8cm
Shortest: hook_side: around the sides: cylinder_e_: H:          Std Dv: 16.3095064303, Center: 7.0cm
Longest: hook_side: around the sides: cylinder_e_: H:           Std Dv: 16.3571255285, Center: 28.6cm
Longest: hook_side: around the sides: cylinder_e_: E:           Std Dv: 15.3586747113, Center: 34.0cm
Longest: hook_side: around the sides: cylinder_e_: W:           Std Dv: 13.4014924542, Center: 20.6cm
Shortest: 2fingerpinch_side: end to end: cone_e_: W:            Std Dv: 0.471404520791, Center: 0.0333333333333cm
Shortest: 2fingerpinch_side: end to end: cone_e_: H:            Std Dv: 3.68178700573, Center: 12.7333333333cm
Shortest: 2fingerpinch_side: end to end: cone_e_: E:            Std Dv: 8.00683301937, Center: 4.55cm
Longest: 2fingerpinch_side: end to end: cone_e_: H:             Std Dv: 4.49691252108, Center: 26.7333333333cm
Longest: 2fingerpinch_side: end to end: cone_e_: E:             Std Dv: 17.1277370076, Center: 33.1cm
Longest: 2fingerpinch_side: end to end: cone_e_: W:             Std Dv: 11.0453610172, Center: 23.4cm
Shortest: 3fingerpinch_side: around the sides: ellipse_h_: W:           Std Dv: 9.9679486355, Center: 0.62cm
Shortest: 3fingerpinch_side: around the sides: ellipse_h_: E:           Std Dv: 0.37267799625, Center: 0.0166666666667cm
Shortest: 3fingerpinch_side: around the sides: ellipse_h_: H:           Std Dv: 12.9807549857, Center: 11.4cm
Longest: 3fingerpinch_side: around the sides: ellipse_h_: W:            Std Dv: 10.2097992145, Center: 21.4cm
Longest: 3fingerpinch_side: around the sides: ellipse_h_: E:            Std Dv: 18.6874883872, Center: 27.0cm
Longest: 3fingerpinch_side: around the sides: ellipse_h_: H:            Std Dv: 3.76662979333, Center: 33.625cm
Shortest: 3fingerpinch_top: opposite sides: cylinder_h_: W:             Std Dv: 12.3288280059, Center: 0.3cm
Shortest: 3fingerpinch_top: opposite sides: cylinder_h_: H:             Std Dv: 19.0962474499, Center: 13.0cm
Shortest: 3fingerpinch_top: opposite sides: cylinder_h_: E:             Std Dv: 10.677078252, Center: 5.4cm
Longest: 3fingerpinch_top: opposite sides: cylinder_h_: W:              Std Dv: 7.38647412505, Center: 11.48cm
Longest: 3fingerpinch_top: opposite sides: cylinder_h_: E:              Std Dv: 17.3269218912, Center: 12.6cm
Longest: 3fingerpinch_top: opposite sides: cylinder_h_: H:              Std Dv: 11.0855260989, Center: 18.6cm
Longest: equidistant_side: 3 around the sides, palm on flat: cylinder_e_: W:            Std Dv: 19.0591185525, Center: 24.0cm
Longest: equidistant_side: 3 around the sides, palm on flat: cylinder_e_: E:            Std Dv: 13.1600721883, Center: 33.65cm
Shortest: equidistant_side: 3 around the sides, palm on flat: cylinder_e_: W:           Std Dv: 3.41869858279, Center: 0.325cm
Shortest: equidistant_side: 3 around the sides, palm on flat: cylinder_e_: E:           Std Dv: 10.9401782435, Center: 2.0cm
Shortest: equidistant_side: 3 around the sides, palm on flat: cylinder_e_: H:           Std Dv: 11.1208574034, Center: 8.6cm
Longest: equidistant_side: 3 around the sides, palm on flat: cylinder_e_: H:            Std Dv: 19.6468827044, Center: 19.8cm
```

Data

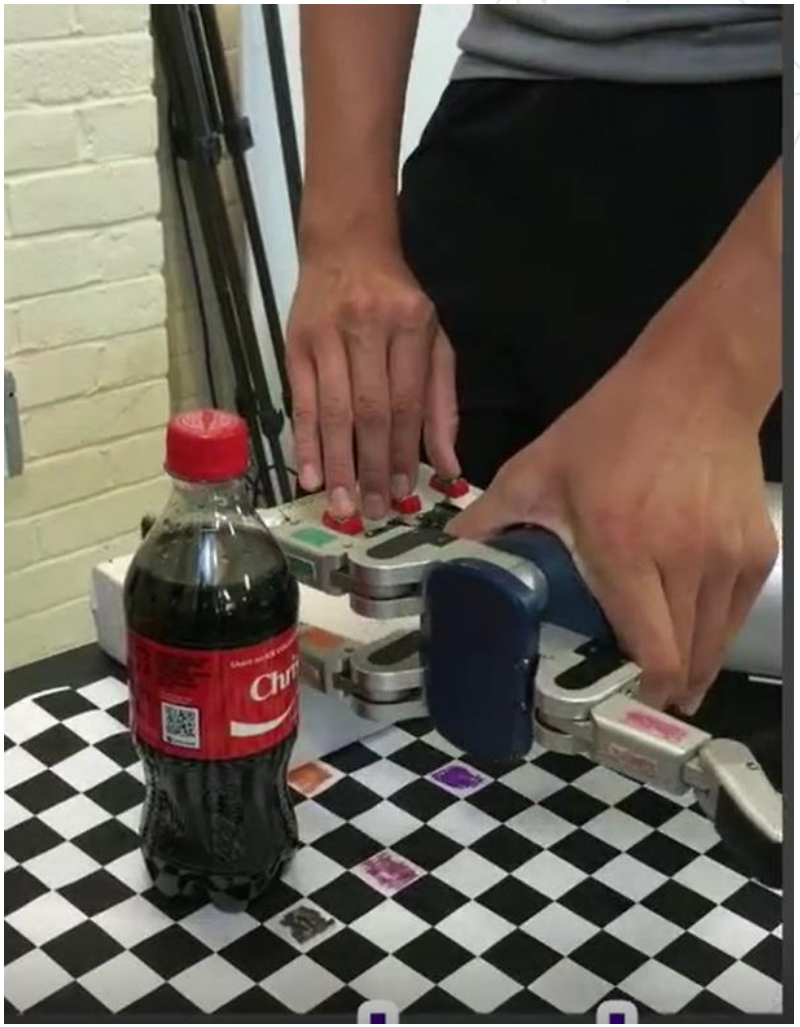
```
cylinder_e_
            5.0 (  4.96655480858)                 16.8 (    26.53718565)        equidistant_top: 3 around the sides: cylinder_e_: H
            0.9 (  5.35412613474)                 34.0 (  30.6412938514)        hook_side: over the top: cylinder_e_: H
            3.6 (  9.60468635615)                 32.2 (  28.5788383249)        equidistant_top: 2 around the sides, 1 on the base: cylinder_e_: H
            7.0 (  16.3095064303)                 28.6 (  16.3571255285)        hook_side: around the sides: cylinder_e_: H
            8.6 (  11.1208574034)                 19.8 (  19.6468827044)        equidistant_side: 3 around the sides, palm on flat: cylinder_e_: H
           6.76 (  9.74884608556)                 20.6 (  14.2688471854)        2fingerpinch_top: 2 around the sides: cylinder_e_: H
            8.2 (  37.1954298268)                 20.0 (  35.8495118516)        3fingerpinch_top: around the sides: cylinder_e_: H
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Boundaries: 5.8(17.9343148304) - 20.8(26.3574993775)
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
            5.2 (  10.8943792848)                 20.8 (  9.23309265631)        equidistant_top: 3 around the sides: cylinder_e_: W
           0.15 (  25.7644242232)                 15.4 (  31.2691541299)        equidistant_top: 2 around the sides, 1 on the base: cylinder_e_: W
           0.68 (  7.19444229944)                 20.6 (  13.4014924542)        hook_side: around the sides: cylinder_e_: W
            1.0 (           10.0)                 15.2 (           15.5)        hook_side: over the top: cylinder_e_: W
          0.325 (  3.41869858279)                 24.0 (  19.0591185525)        equidistant_side: 3 around the sides, palm on flat: cylinder_e_: W
            0.0 (            0.0)                 21.8 (            5.0)        2fingerpinch_top: 2 around the sides: cylinder_e_: W
0.0333333333333 ( 0.471404520791)                  7.8 (           27.0)        3fingerpinch_top: around the sides: cylinder_e_: W
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Boundaries: 0.2(15.2777054568) - 19.4(22.929087543)
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
            0.0 (  10.1666120217)                 29.0 (  30.5509410657)        equidistant_top: 3 around the sides: cylinder_e_: E
           2.36 (  9.02441133814)                 19.4 (  15.7098695093)        equidistant_top: 2 around the sides, 1 on the base: cylinder_e_: E
            0.8 (  12.7769323392)                 34.0 (  15.3586747113)        hook_side: around the sides: cylinder_e_: E
            8.6 (  13.2453765518)                 34.0 (           16.8)        hook_side: over the top: cylinder_e_: E
            2.0 (  10.9401782435)                33.65 (  13.1600721883)        equidistant_side: 3 around the sides, palm on flat: cylinder_e_: E
  1.13333333333 (  8.17856276426)                 21.0 (   16.996731712)        2fingerpinch_top: 2 around the sides: cylinder_e_: E
            1.2 (           10.5)                 25.0 (           30.0)        3fingerpinch_top: around the sides: cylinder_e_: E
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Boundaries: 1.2(12.3873142995) - 27.6(25.905469178)
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Data

User Study Data

- We are looking in particular at metrics and survey inaccuracies

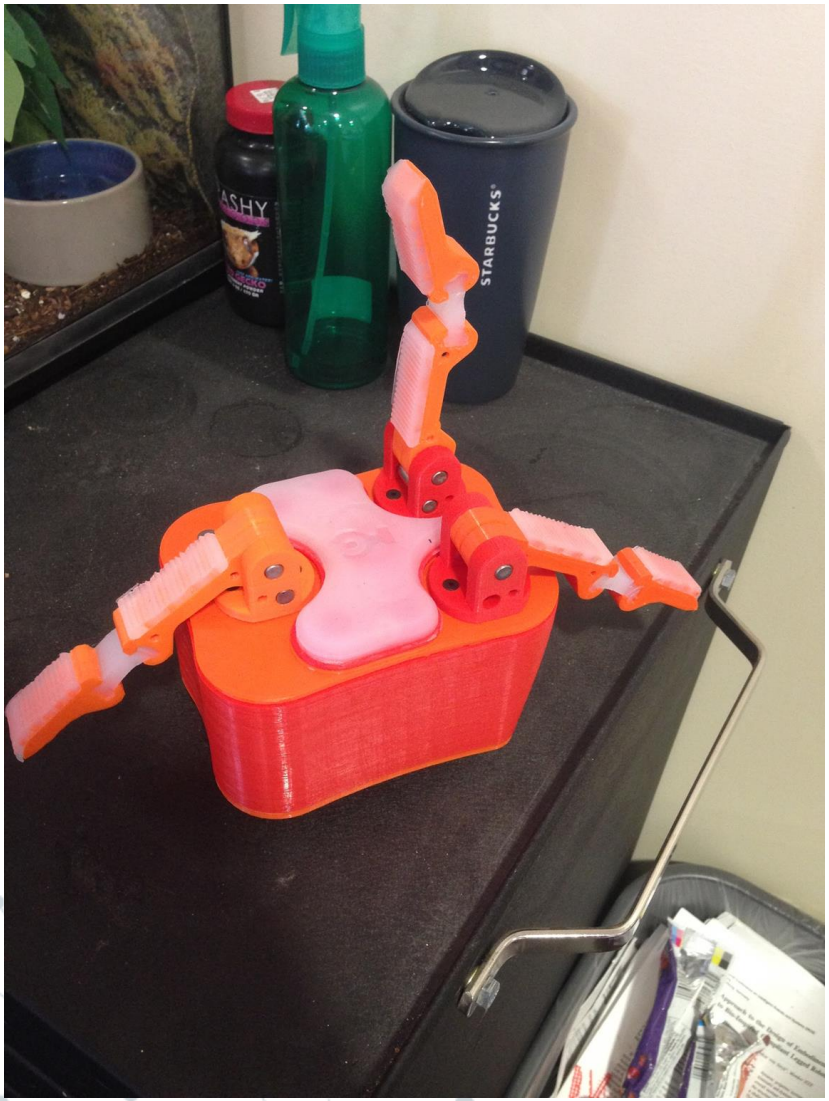
- Problems with the Barrett hand:
  - Grips are not very grippy
  - Finger pads are not compliant
  - Fingers are hard to control
  - No finger squeeze muscles
  - No grips on inside of fingers



User Study

- ◎ Create a preliminary protocol
- ◎ Iterate Through
  - ○ Subjects manipulate the Barrett Arm
  - ○ Constraints on viewpoint, finger position, and object orientation
  - ○ Think Aloud Protocol
- ◎ Motion Capture

User Study



Data?

◎ Not yet

Next Steps

- ◎ Finish gathering data from user study
- ◎ Analyze user study data
- ◎ Begin partitioning the space
- ◎ Continue to study other decisions involved in grasping

Questions?

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