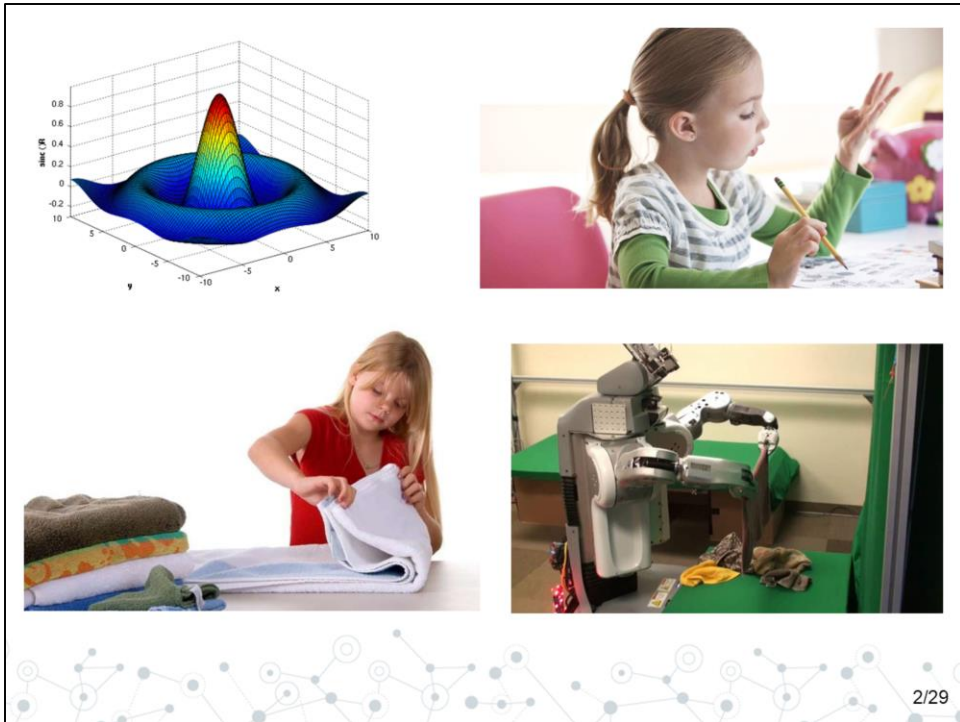




Grasping Objects Big and Small: Human-informed Relationships between Grasp Type and Object Size

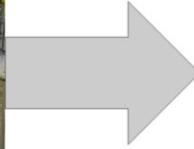
Vicky Thrasher
thrasher@oregonstate.edu

Grasping Lab
Dr. Cindy Grimm and Dr. Ravi Balasubramanian



We often consider computers to be much better at a lot of tasks than humans
Computers are much better than math than humans
But some things, often the most intrinsic things for humans, can be really hard for robots
Grasping is one of those examples

Why do we care?



Because a lot of our robot are good at one job- putting one piece on a car
But we have been dreaming of robot servants to do our chores for us
These robots need to be more flexible than just doing one simple job

We can implement human techniques in robots

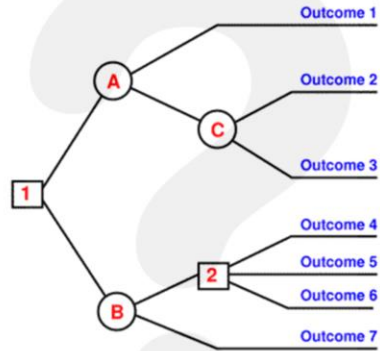
First we need to study humans

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But because humans are really good at it, we can try to implement human techniques in robots
But first we need to study the humans

Human Grasping Decision Tree

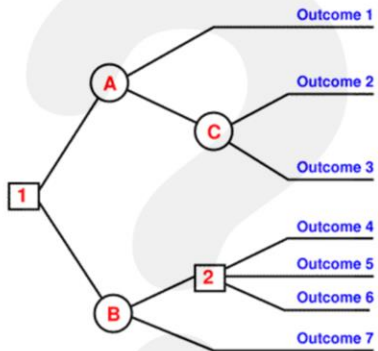
- Shape
- Size
- Viewpoint
- Weight
- Compliance
- Texture
- Center of Mass
- ...



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Size: height, width, extent, angle, curvature

Human Grasping Decision Tree

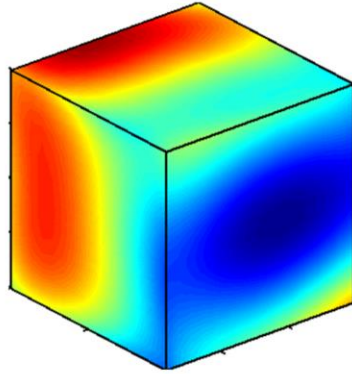


- ⊙ Grasp Types
 - Wrist Rotation
 - Finger Spread
 - Hand Translation
- ⊙ Metrics
 - Finger Closure
 - Distance of Palm from Object
 - Position of Palm to Center of Object
 - Surface Contact
- ⊙ Control Strategies
 - Caging

Big Picture End Result:

Partition the Space

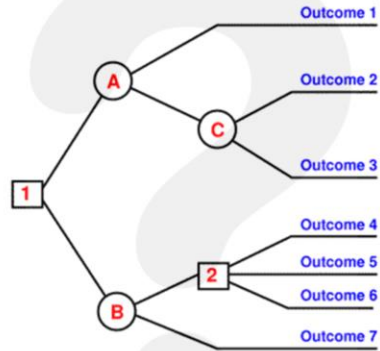
- ⦿ so robots can make better choices about how to grasp different objects
- ⦿ so robots can make more predictable grasps



Ideally with

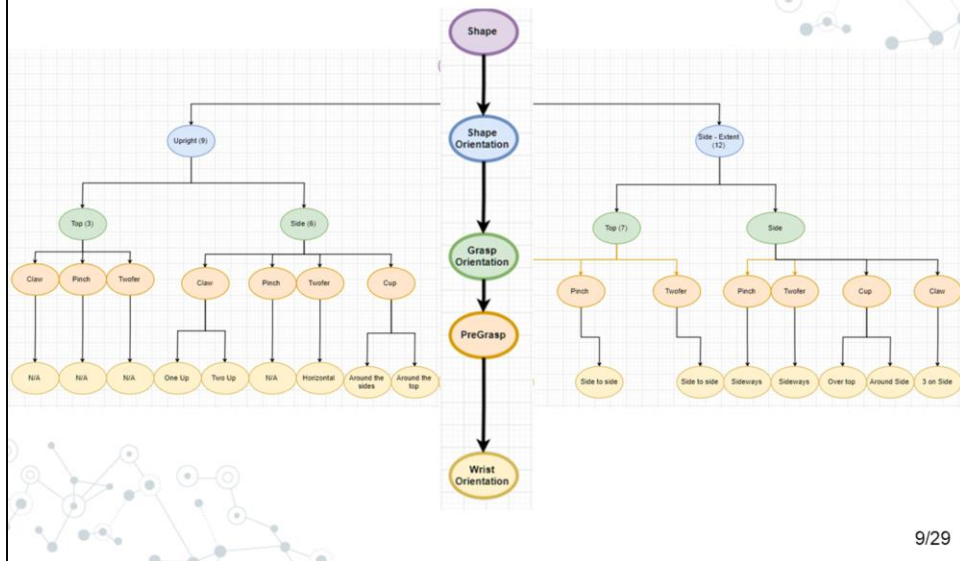
Human Grasping Decision Tree

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



Size: height, width, extent, angle, curvature

The Grasping Tree



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- 80% of objects can be simplified to very few geometric object: cylinder, cone, cube, ellipse
- These objects can also be rotated
- For each shape and shape rotation, we looked at which grasps would even be possible to do
 - Then we wanted to know which sizes of these shapes and grasps would be possible

Mechanical Turk Survey and User Study



Data



10/29

- Use the MT to find the fuzzy boundaries
- Use the fuzzy boundaries to create physical shapes
- Use the new physical shapes to ask users about more variations in the object (Decisions) and to record their metrics

Mechanical Turk Survey

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



amazon mechanicalturk



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Training Video

Mechanical Turk Survey

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



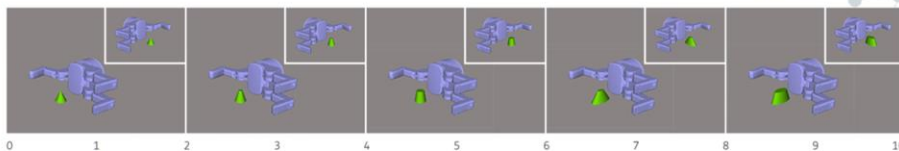
amazon mechanicalturk



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Training Video

Mechanical Turk Survey: Questions



Smallest Grasable Object



Largest Grasable Object



Best Size for this Grasp



Training Video

Mechanical Turk Survey

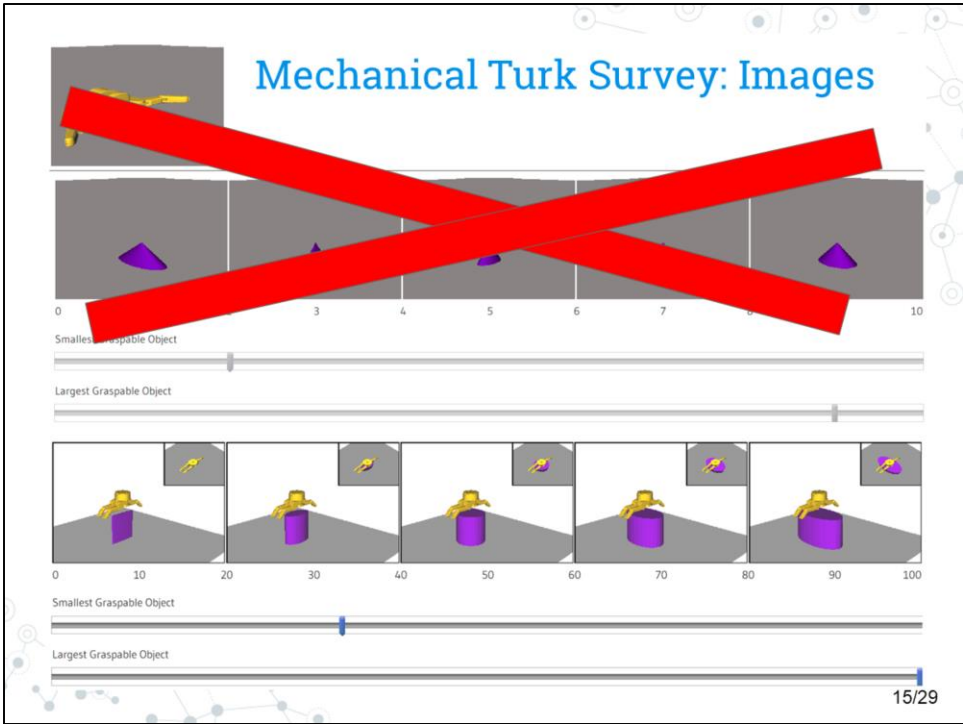
- © Questions
- © Images for the Questions
- © Training Video
- © Interface



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Training Video



Training Video

Mechanical Turk Survey

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



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Training Video

Mechanical Turk Survey: Tutorial Video

The robot is allowed to close it's fingers simultaneously...



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Training Video

Mechanical Turk Survey

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



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Training Video

Mechanical Turk Survey: Interface

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Training Video

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
```

Unfortunately, the data we've collected cannot realistically be put into pretty figures and graphs but I will give you an example

Data

```
cylinder_e_
5.0 ( 4.96655480858)          16.8 ( 26.53718565)
0.9 ( 5.35412613474)          34.0 ( 30.6412938514)
3.6 ( 9.60468635615)          32.2 ( 28.5788383249)
7.0 ( 16.3095064303)          28.6 ( 16.3571255285)
8.6 ( 11.1208574034)          19.8 ( 19.6468827044)
6.76 ( 9.74884608556)         20.6 ( 14.2688471854)
8.2 ( 37.1954298268)          20.0 ( 35.8495118516)
-----
Boundaries: 5.8(17.9343148304) - 20.8(26.3574993775)
-----
5.2 ( 10.8943792848)          20.8 ( 9.23309265631)
0.15 ( 25.7644242232)         15.4 ( 31.2691541299)
0.68 ( 7.19444229944)         20.6 ( 13.4014924542)
1.0 ( 10.0)                    15.2 ( 15.5)
0.325 ( 3.41869858279)        24.0 ( 19.0591185525)
0.0 ( 0.0)                      21.8 ( 5.0)
0.0333333333333 ( 0.471404520791)  7.8 ( 27.0)
-----
Boundaries: 0.2(15.2777054568) - 19.4(22.929087543)
-----
0.0 ( 10.1666120217)          20.0 ( 30.5509410657)
2.36 ( 9.02441133814)          19.4 ( 15.7098695093)
0.8 ( 12.7769323392)          34.0 ( 15.3586747113)
8.6 ( 13.2453765518)          34.0 ( 16.8)
2.0 ( 10.9401782435)           33.65 ( 13.1600721883)
1.1333333333333 ( 8.17856276426)  21.0 ( 16.996731712)
1.2 ( 10.5)                      25.0 ( 30.0)
-----
Boundaries: 1.2(12.3873142995) - 27.6(25.905469178)
-----
```

```
equidistant_top: 3 around the sides: cylinder_e_ : H
hook_side: over the top: cylinder_e_ : H
equidistant_top: 2 around the sides, 1 on the base: cylinder_e_ : H
hook_side: around the sides: cylinder_e_ : H
equidistant_side: 3 around the sides, palm on flat: cylinder_e_ : H
2fingerpinch_top: 2 around the sides: cylinder_e_ : H
3fingerpinch_top: around the sides: cylinder_e_ : H
```

```
equidistant_top: 3 around the sides: cylinder_e_ : W
equidistant_top: 2 around the sides, 1 on the base: cylinder_e_ : W
hook_side: around the sides: cylinder_e_ : W
hook_side: over the top: cylinder_e_ : W
equidistant_side: 3 around the sides, palm on flat: cylinder_e_ : W
2fingerpinch_top: 2 around the sides: cylinder_e_ : W
3fingerpinch_top: around the sides: cylinder_e_ : W
```

```
equidistant_top: 3 around the sides: cylinder_e_ : E
equidistant_top: 2 around the sides, 1 on the base: cylinder_e_ : E
hook_side: around the sides: cylinder_e_ : E
hook_side: over the top: cylinder_e_ : E
equidistant_side: 3 around the sides, palm on flat: cylinder_e_ : E
2fingerpinch_top: 2 around the sides: cylinder_e_ : E
3fingerpinch_top: around the sides: cylinder_e_ : E
```

Unfortunately, the data we've collected cannot realistically be put into pretty figures and graphs but I will give you an example

Data



23/29

Unfortunately, the data we've collected cannot realistically be put into pretty figures and graphs but I will give you an example

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



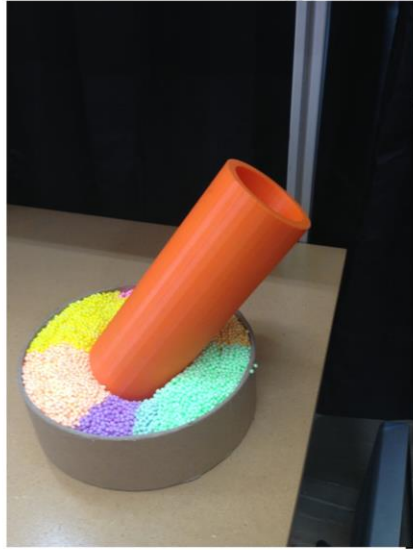
User Study

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



Both eye tracking and motion capture data are used for analysis

User Study

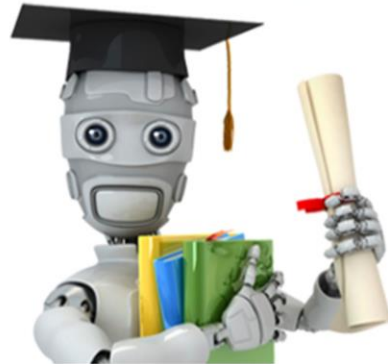


Data?

© 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?

Vicky Thrasher:
thrashev@oregonstate.edu