

Evaluating Human Cognition of Containing Relations with Physical Simulation

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***BEIJING INSTITUTE OF TECHNOLOGY**

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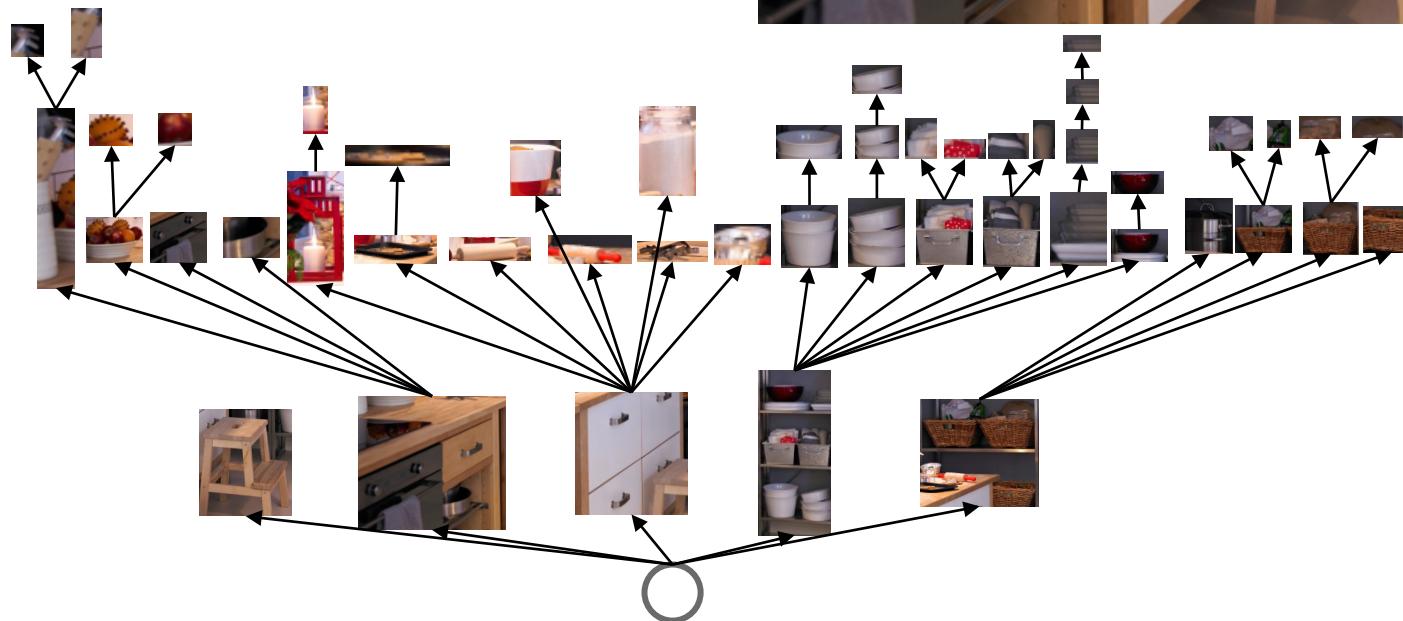
UNIVERSITY OF CALIFORNIA, LOS ANGELES

Motivation



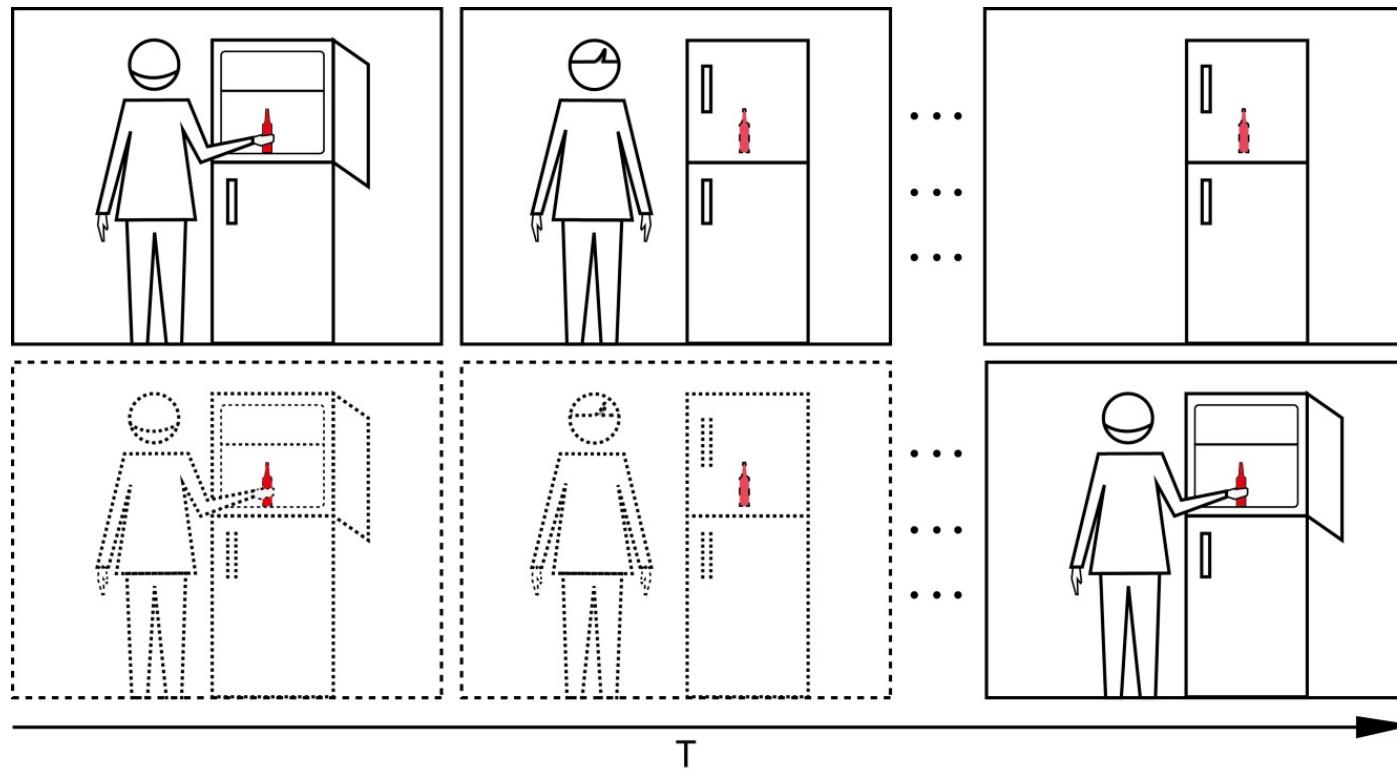
Containers are ubiquitous in our daily life

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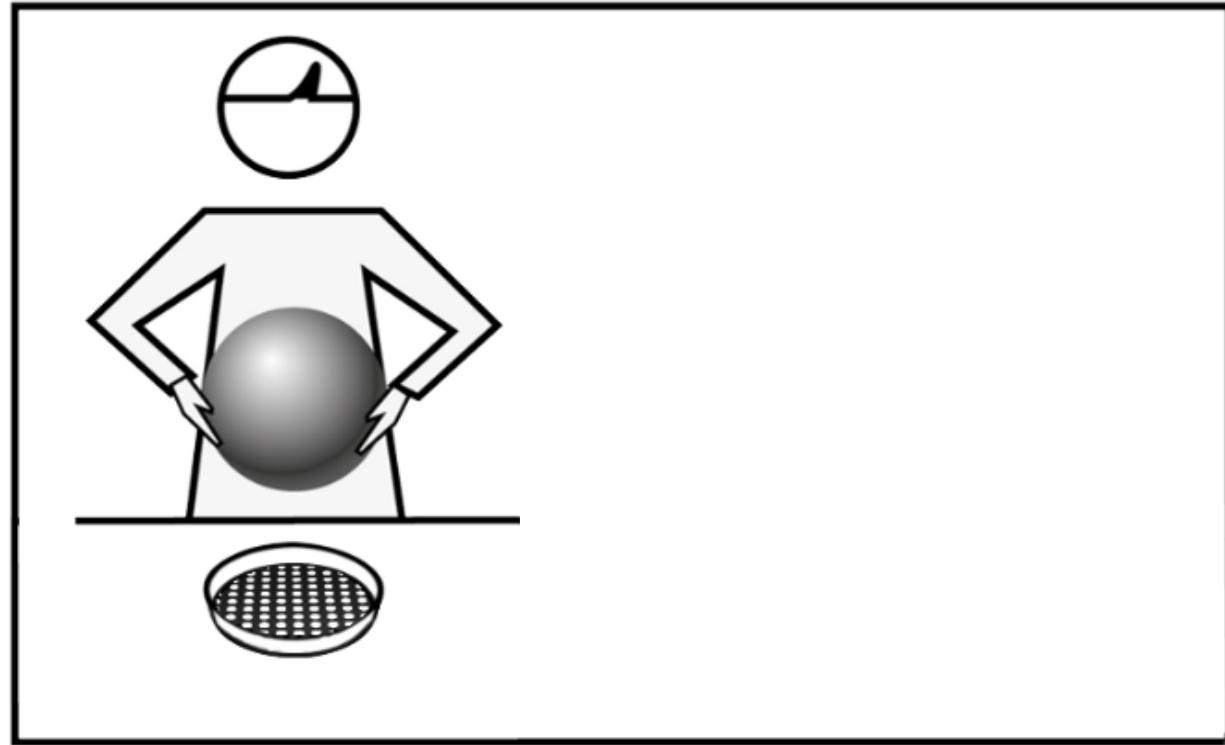
Motivation

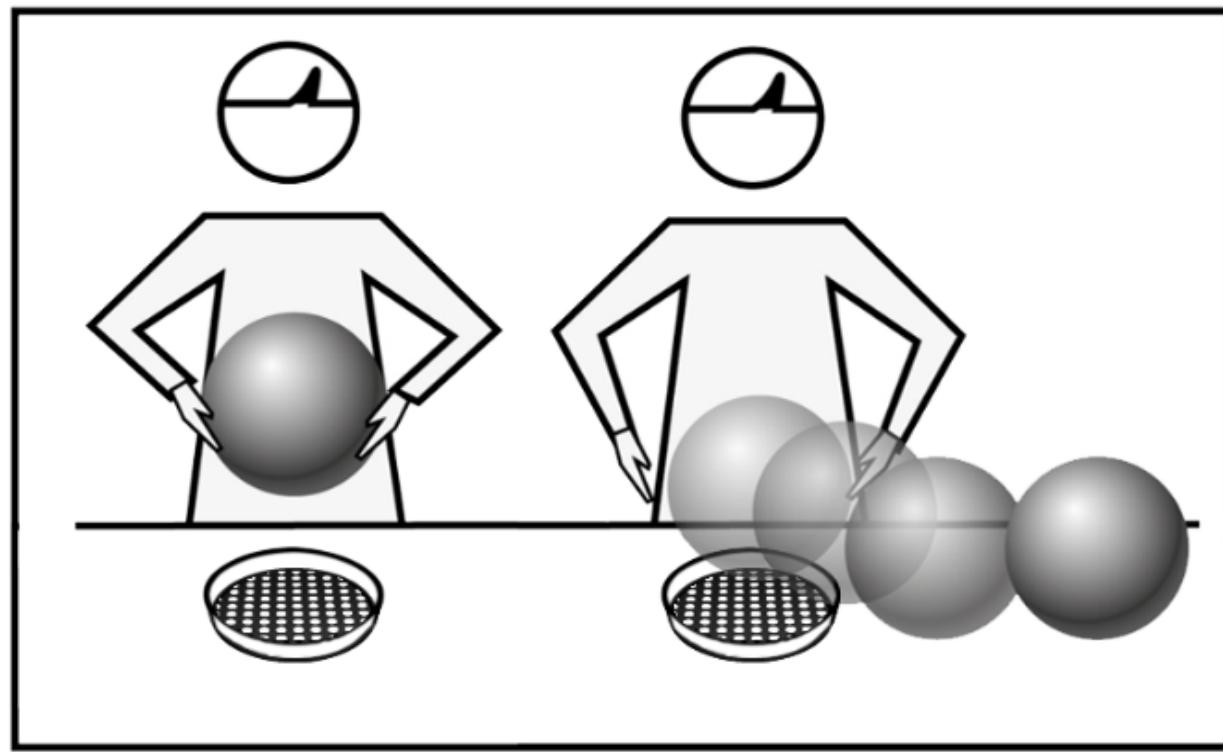


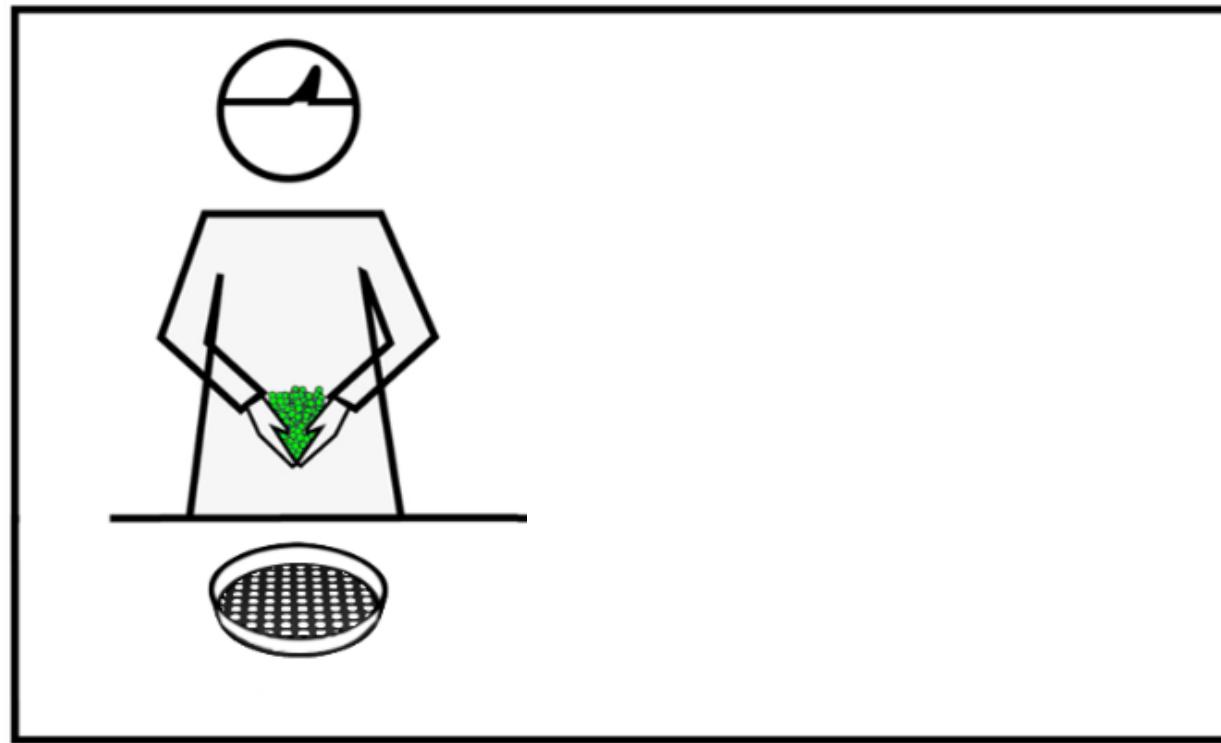
Containers qualitatively quantize our perceptual space of the 3D physical scene.

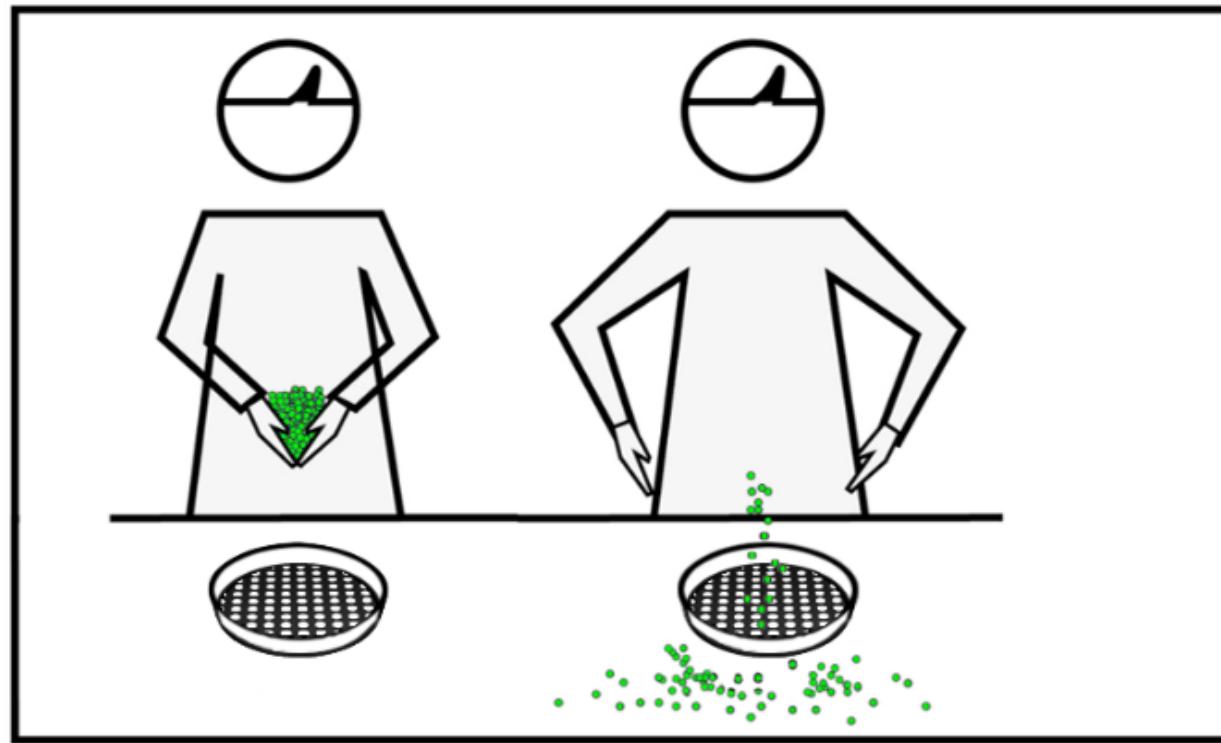
Research questions

1. What is a container?
2. Given two objects, can one object contain another object?
3. How many objects can a container hold?







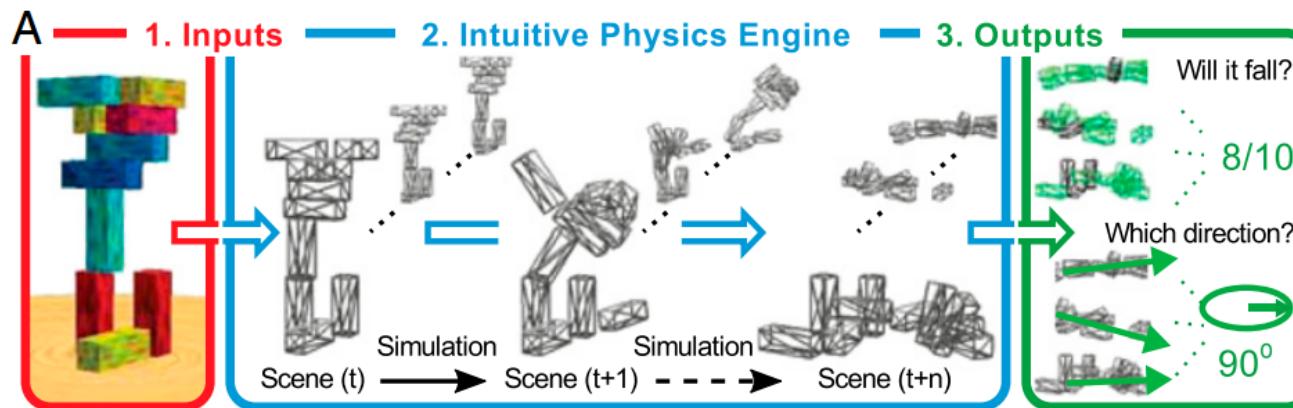


The challenge of container recognition



The recognition of containers can not be performed solely based on their visual appearances.

Intuitive Physics Engine



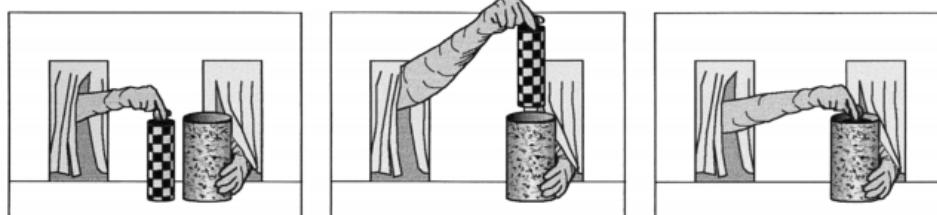
(Battaglia, Hamrick, & Tenenbaum. PNAS 2013)

The physical model of the 3D scene quantitatively encodes a large number of static and dynamic variables needed to capture the interactions among objects.

These variables include scene configurations, object geometries, masses, material properties, rigidity, fragileness, frictions, collisions, etc.

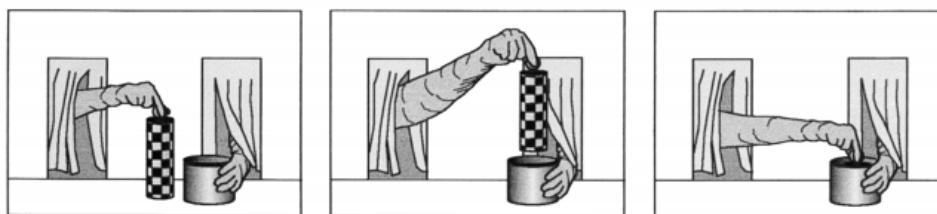
Related work

Tall Event



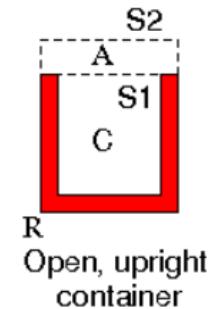
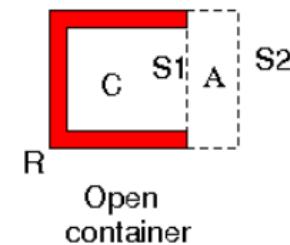
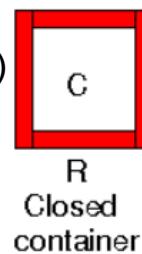
- Developmental psychology

Short Event



- Qualitative reasoning

(Hespos & Baillargeon, 2001; Hespos & Spelke, 2007)



(Collins & Forbus, 1987, Davis, Marcus & Chen, 2013)



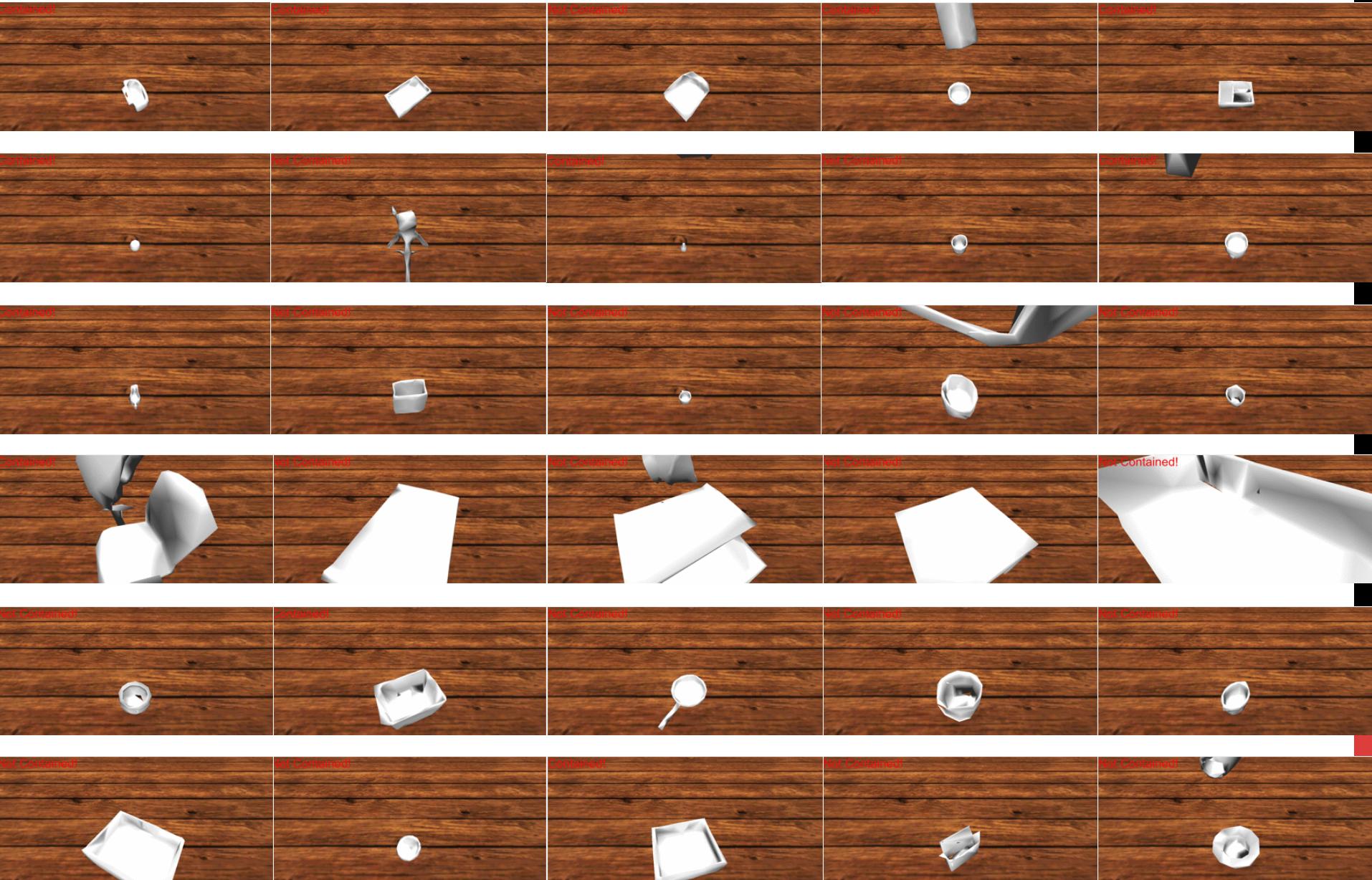
We collected a dataset of 315 real-world 3D models including containers and other daily objects.

We built a physical simulation system using Unity physics engine to infer the “affordance” of containers and containing relations between objects.

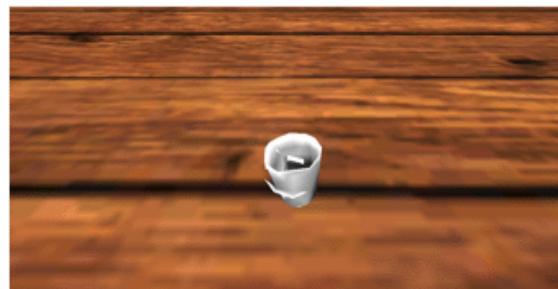
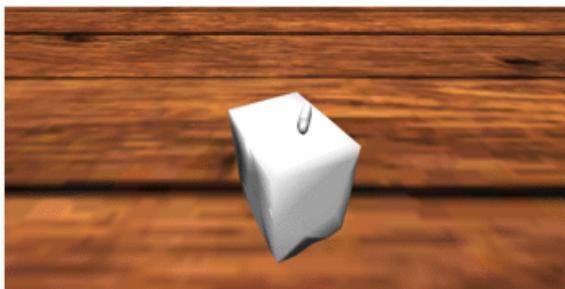
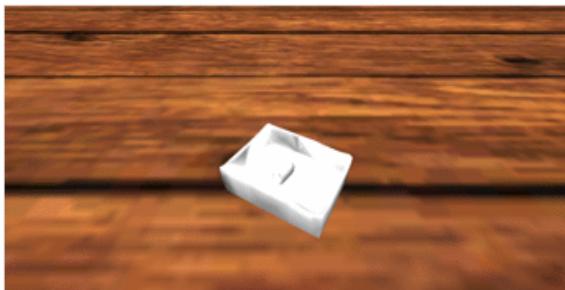




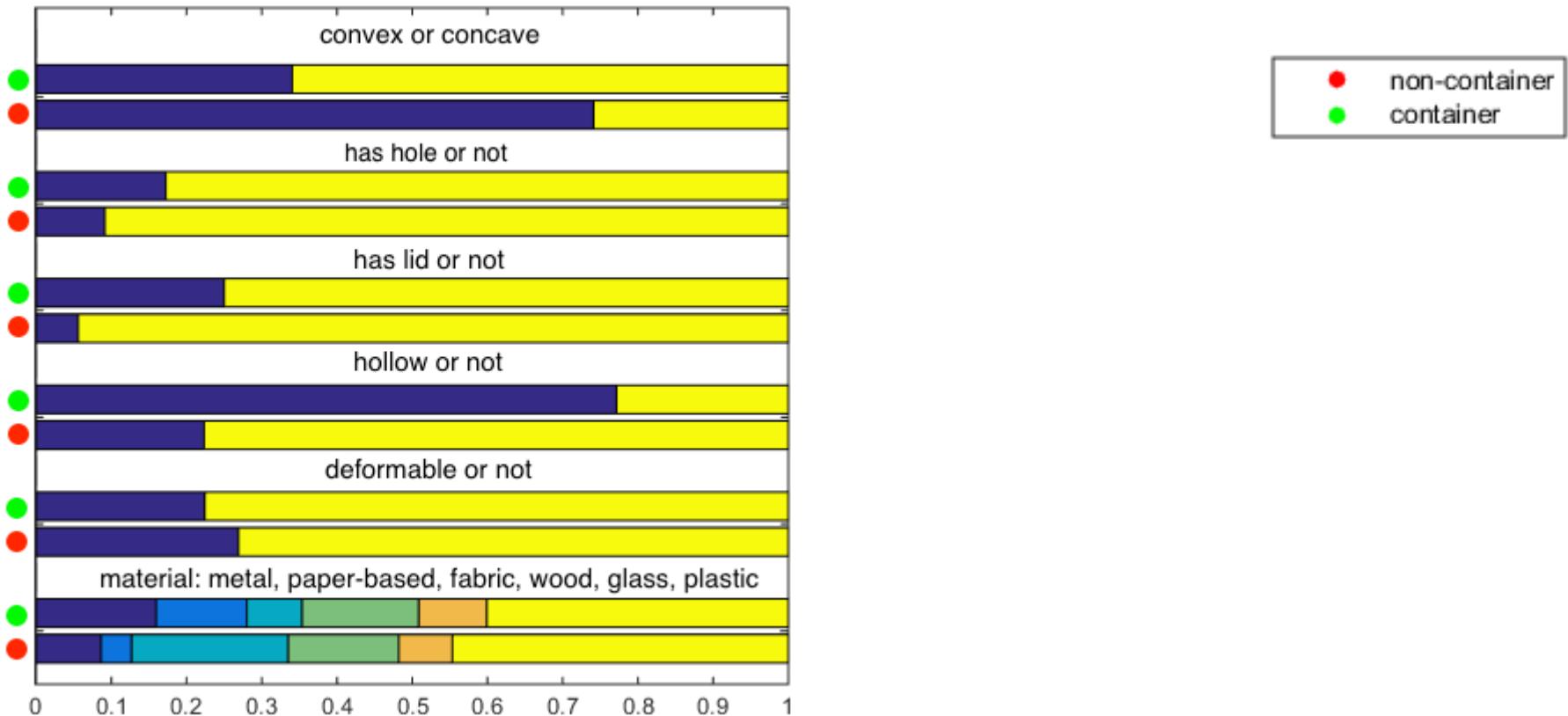
Will an object contain another?



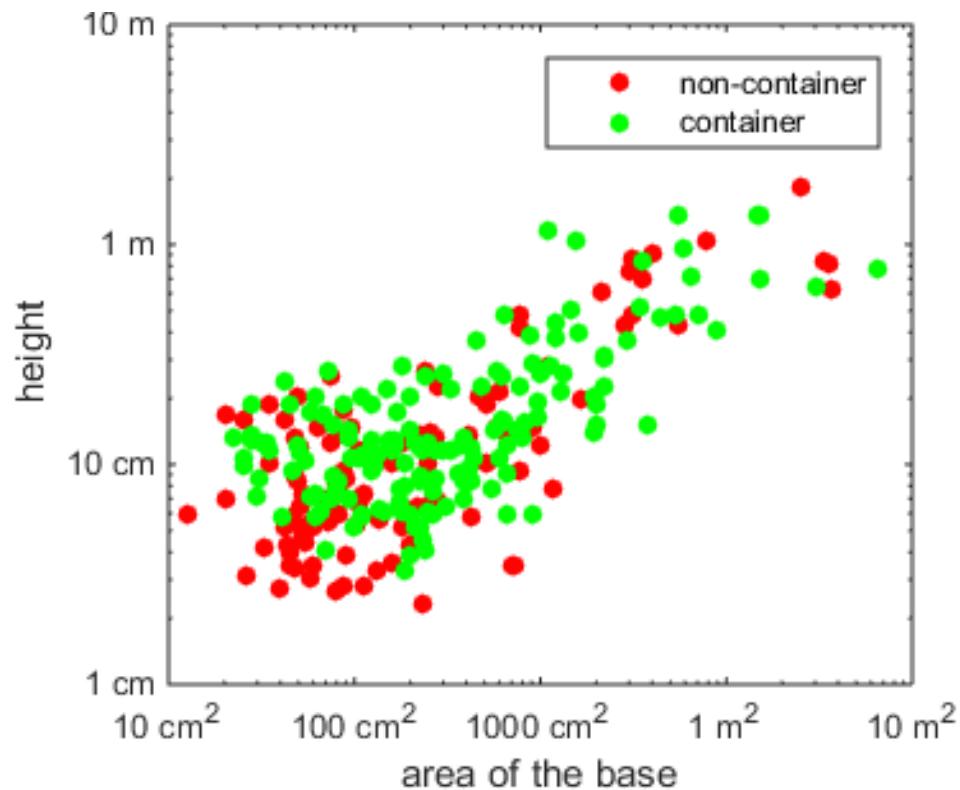
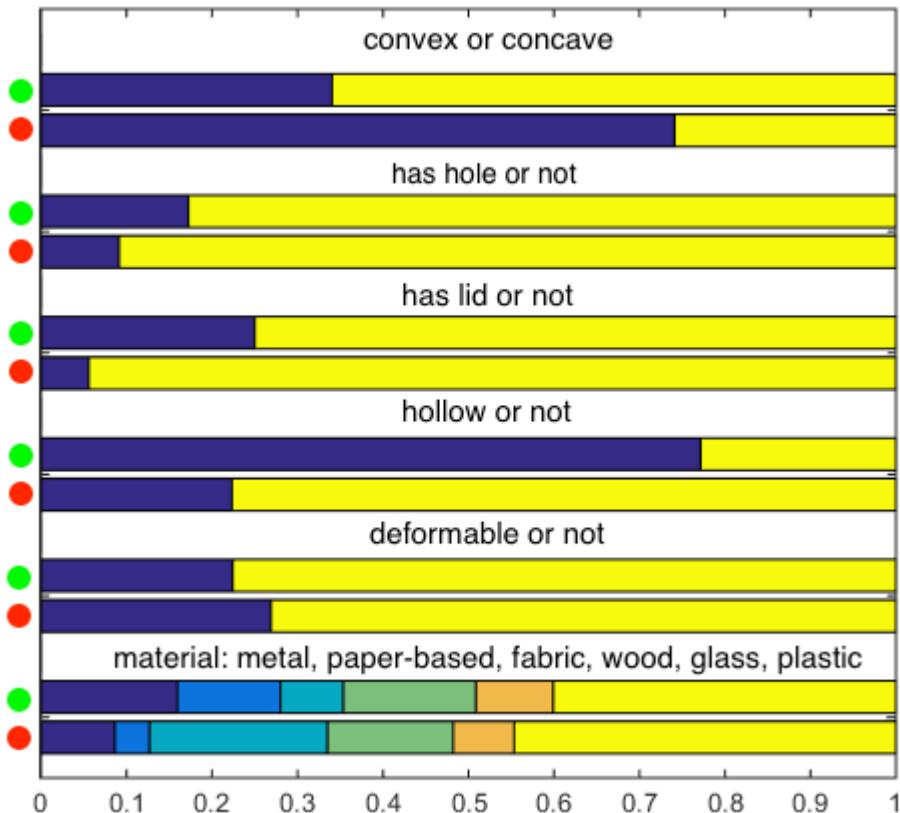
How many objects will a container hold?



Exp. 1: What is a container?



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Table 1: Analysis of logistic regression coefficients.

	Estimate	Std. Err	tStat	pValue
(Intercept)	-3.1168	1.1114	-2.8043	0.005043
convex	-1.8572	0.2692	-6.8999	5.204e-12
has hole	0.1248	0.3814	0.3274	0.7434
has lid	1.4893	0.4086	3.6449	0.0002675
hollow	2.2661	0.2736	8.2818	1.2132e-16
deformable	-0.7816	0.3067	-2.5485	0.01082
material	0.1712	0.0754	2.2714	0.02312
height	-0.8198	0.5969	-1.3733	0.1697
base area	0.4308	0.2580	1.6702	0.09489

Exp. 1: What is a container?



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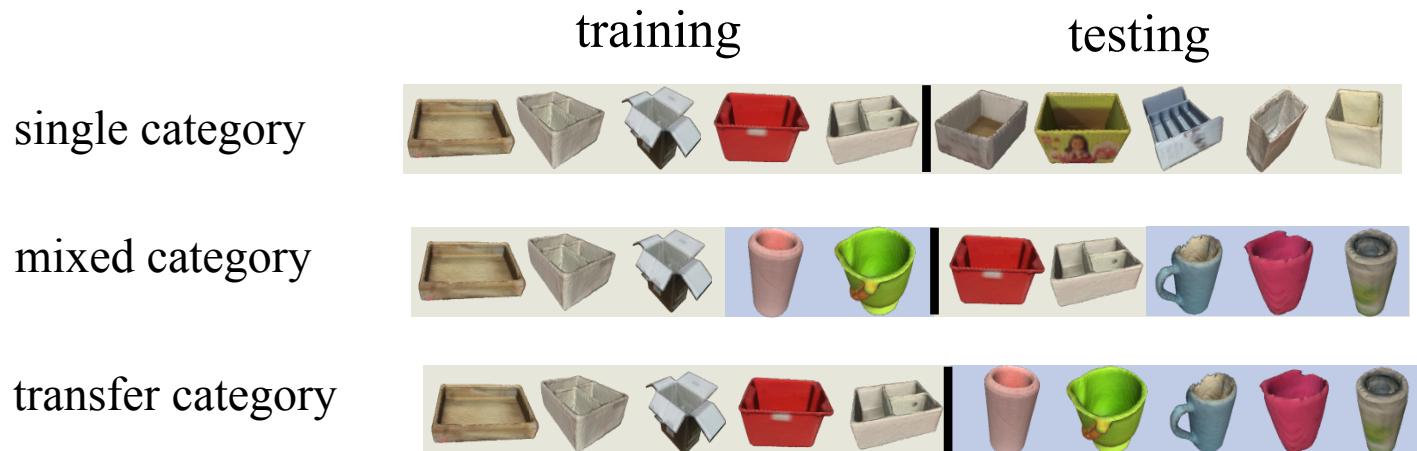
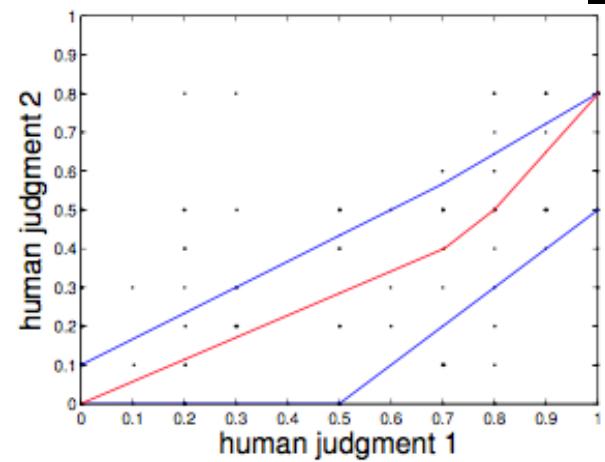
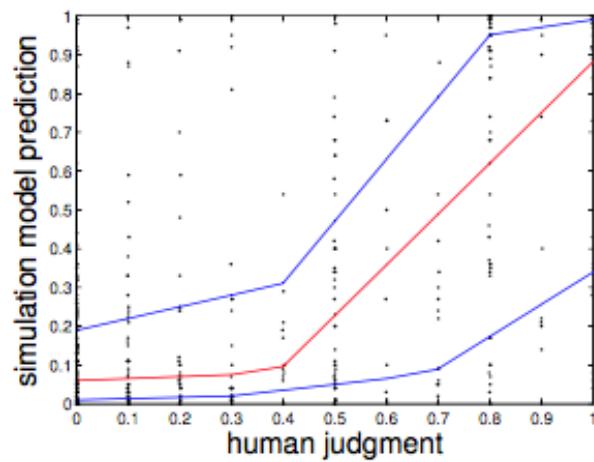
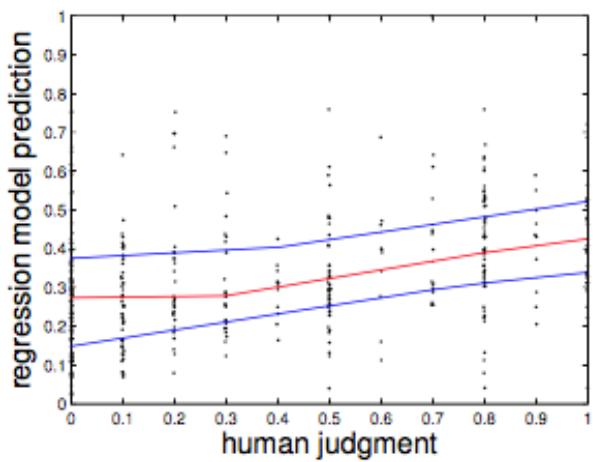


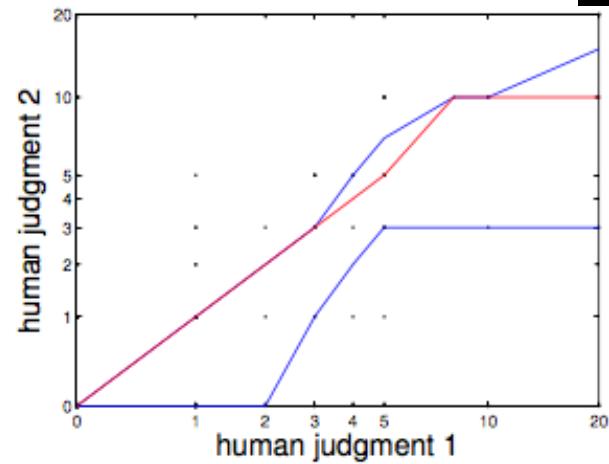
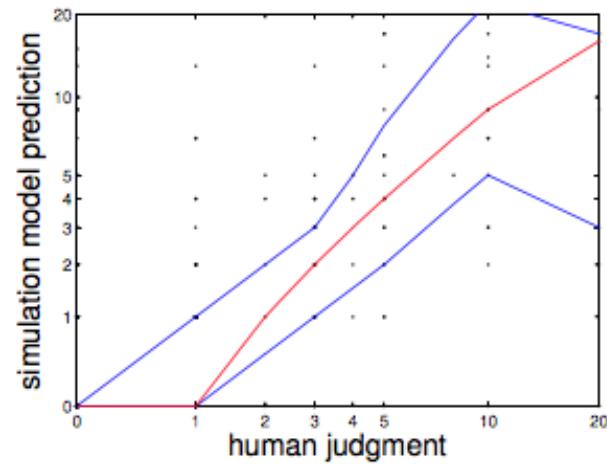
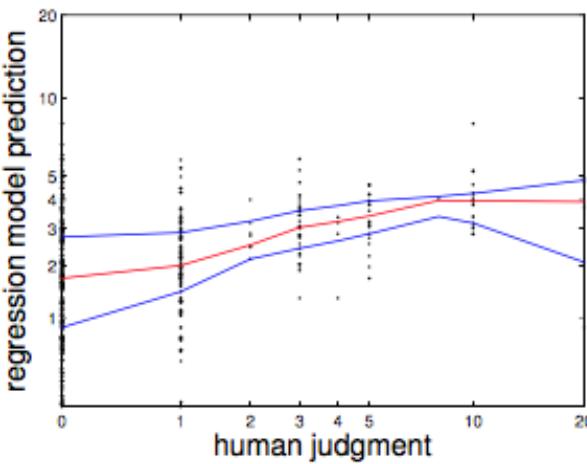
Table 2: Accuracy of container recognition

	RGB	RGB-Depth	Simulation
single category	0.89	0.94	0.93
mixed categories	0.70	0.78	0.93
transfer category	0.35	0.59	0.93

Exp. 2: How likely one object contain another?



Exp. 3 How many objects can a container hold?



Conclusions

Physical simulation results have stronger correlations with human judgments than the regression model of geometric features

We take advantages of the state-of-the-art 3D scanning technique, which enables us to analyze complex real-world 3D objects in a physical realistic environment.

Thank you for your attention!