



# Visual Tactile Grasping

David Watkins-Valls



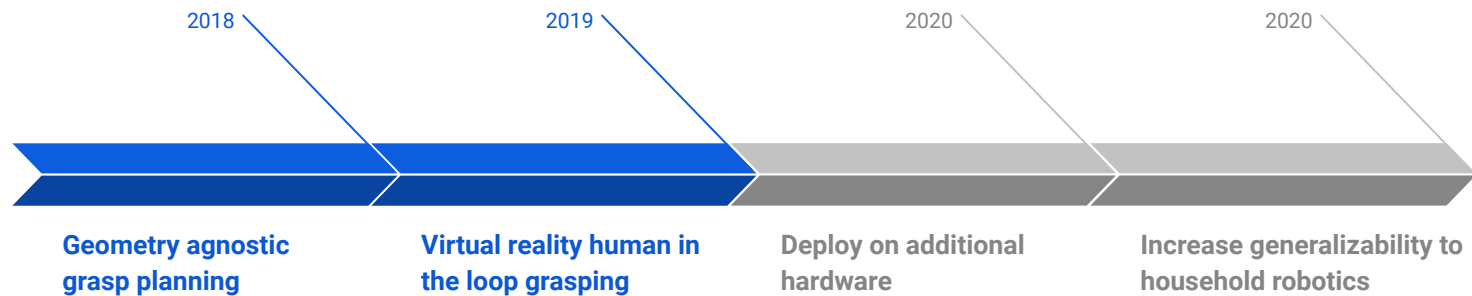
Source: <https://www.youtube.com/watch?v=rNLv7f2wmLQ>



# Overview

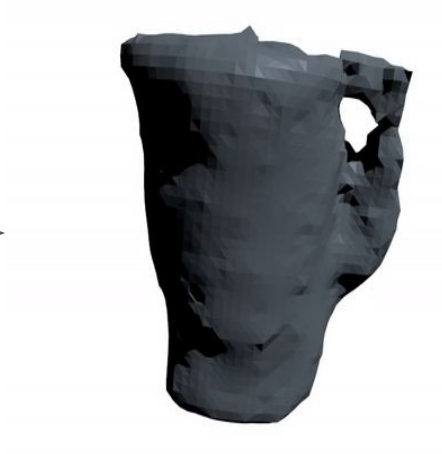
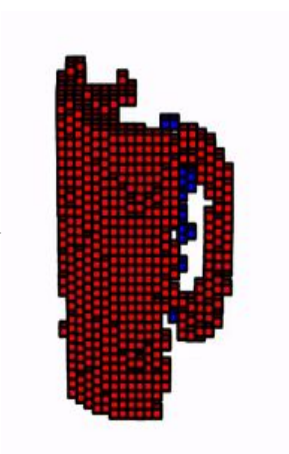
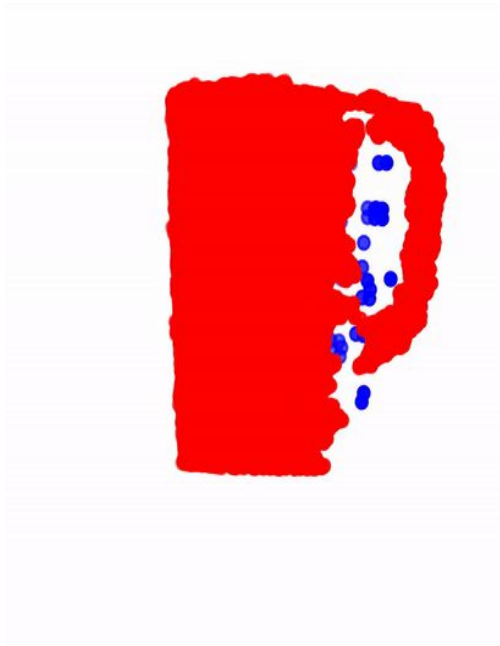
- Dataset generation
- Depth and tactile shape completion
- Grasping results
- VR to enable human in the loop grasping
- Future work

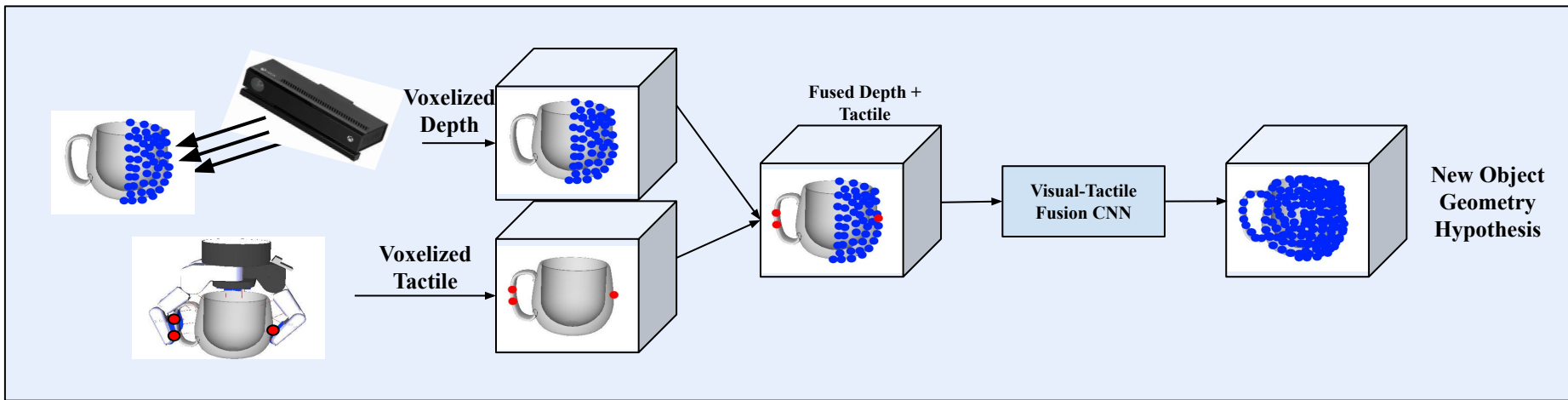
# Timeline



# Project summary

- Fellowship collaboration with Columbia Robotics lab
- Resources at Samsung
- Publications that are in the works



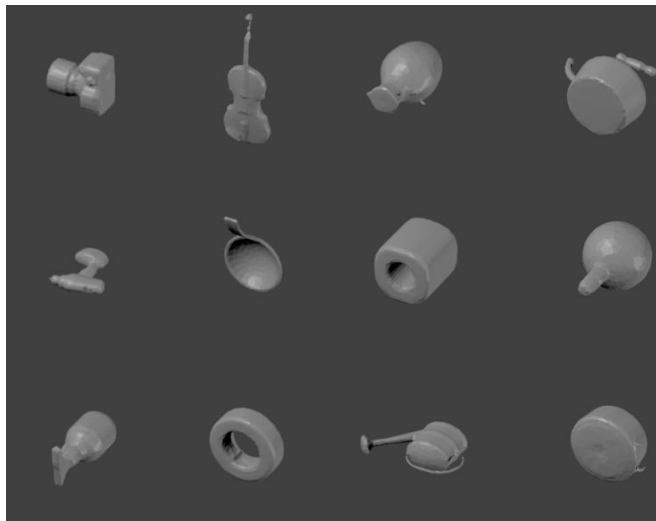




# Dataset generation

## A collection of various food items arranged on a white surface. The items include a red can of Pringles Original, a yellow bottle of French's 40% More Mustard, a blue can of Master Chef, a red box of Cheez-It Original, a yellow box of Domino Sugar, a red box of SPAM, a box of Jell-O chocolate, a box of Jell-O strawberry, a can of Campbell's tomato soup, a can of Starkist tuna, a banana, a green pear, a red apple, a yellow lemon, a purple grape, a strawberry, and a small orange.

## GRASP Dataset



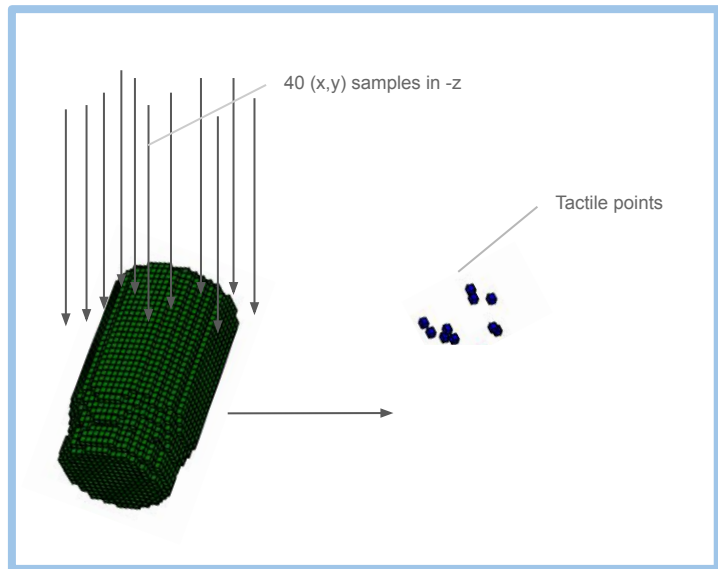
590 unique 3D models

618 objects

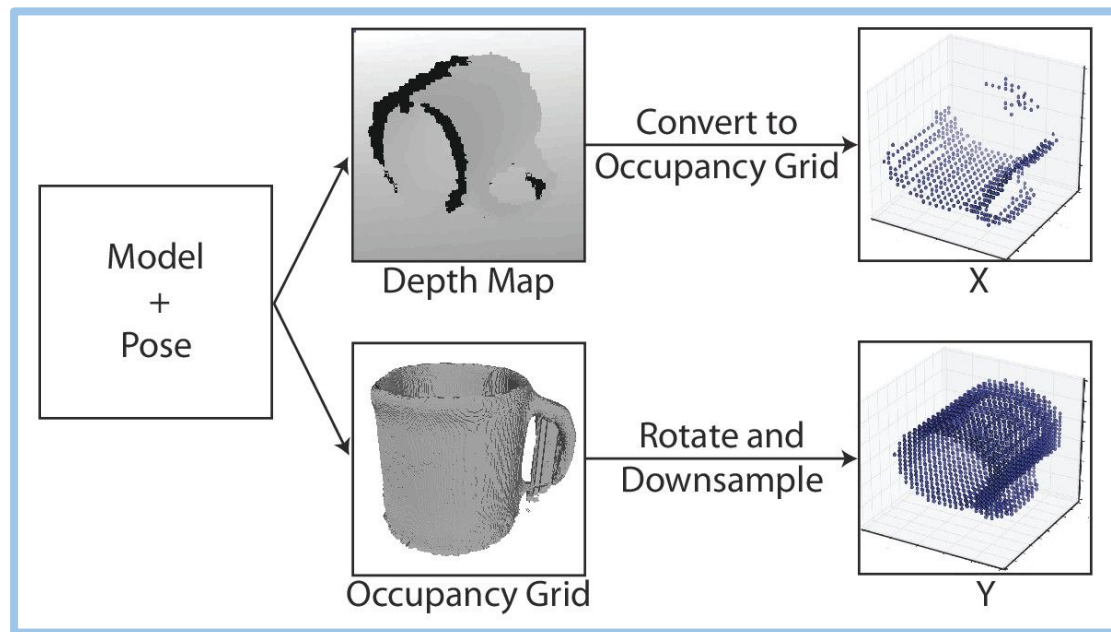
726 views per object

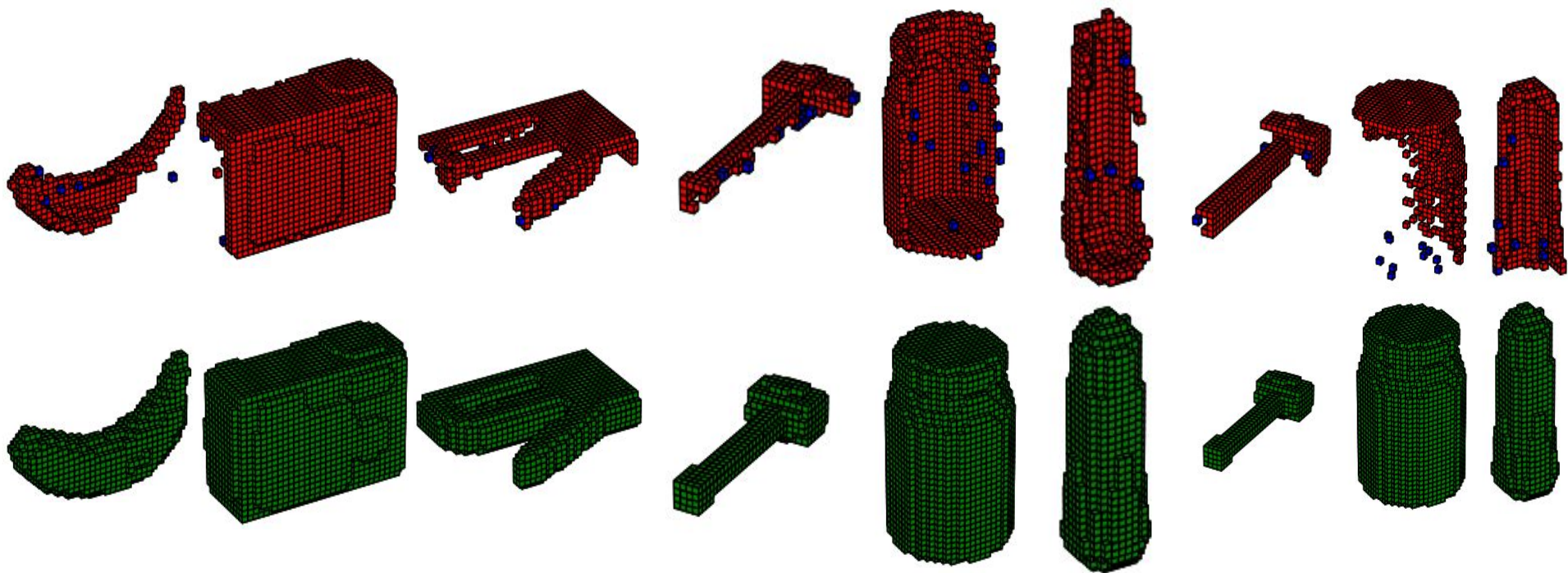
448,668 depth images

## Capturing tactile samples

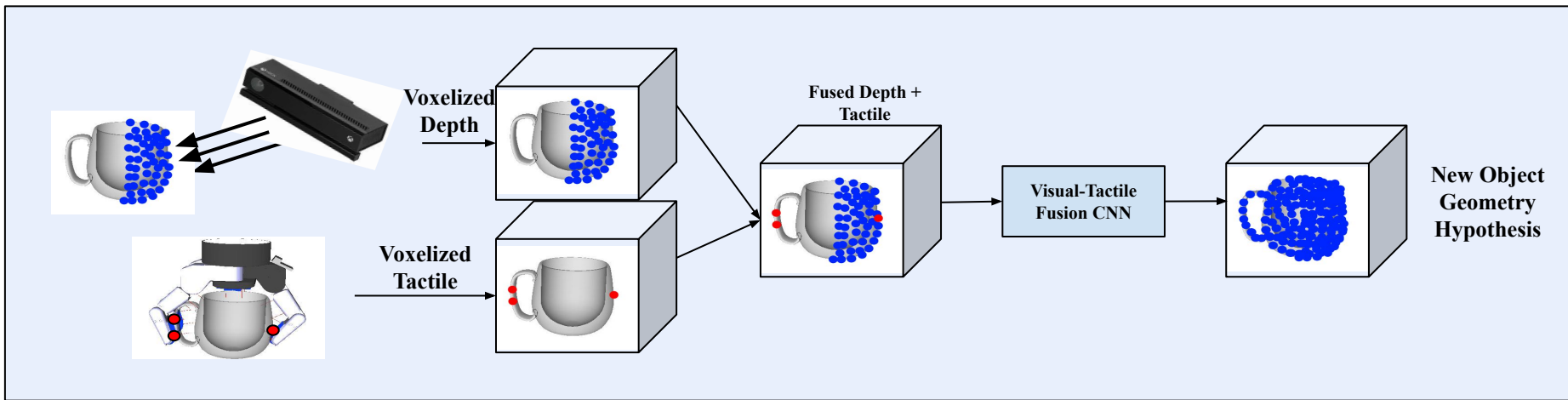


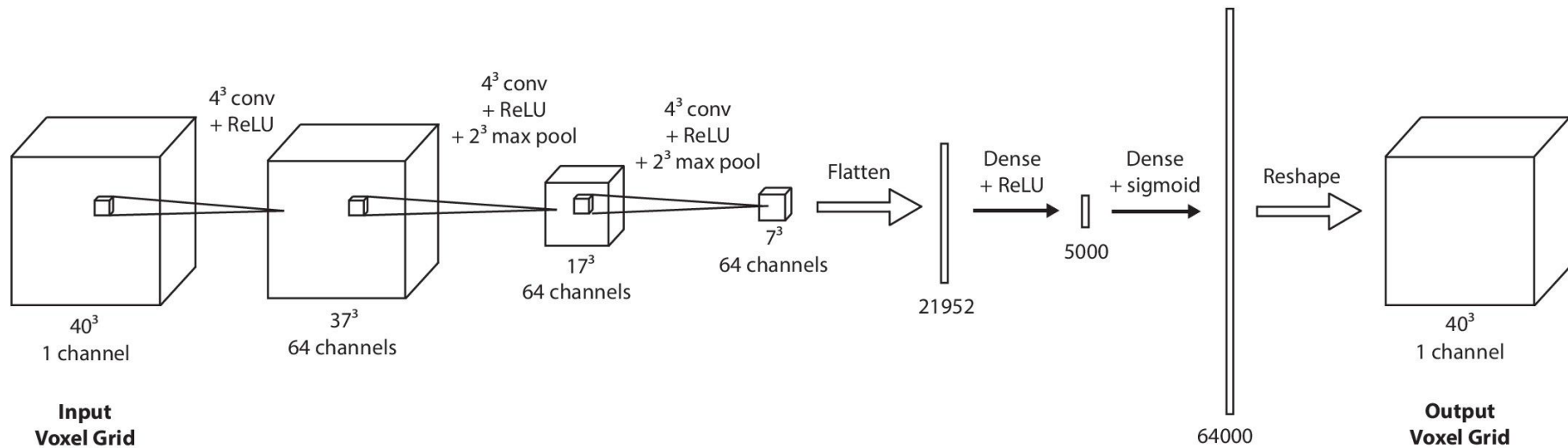
## Capturing depth samples



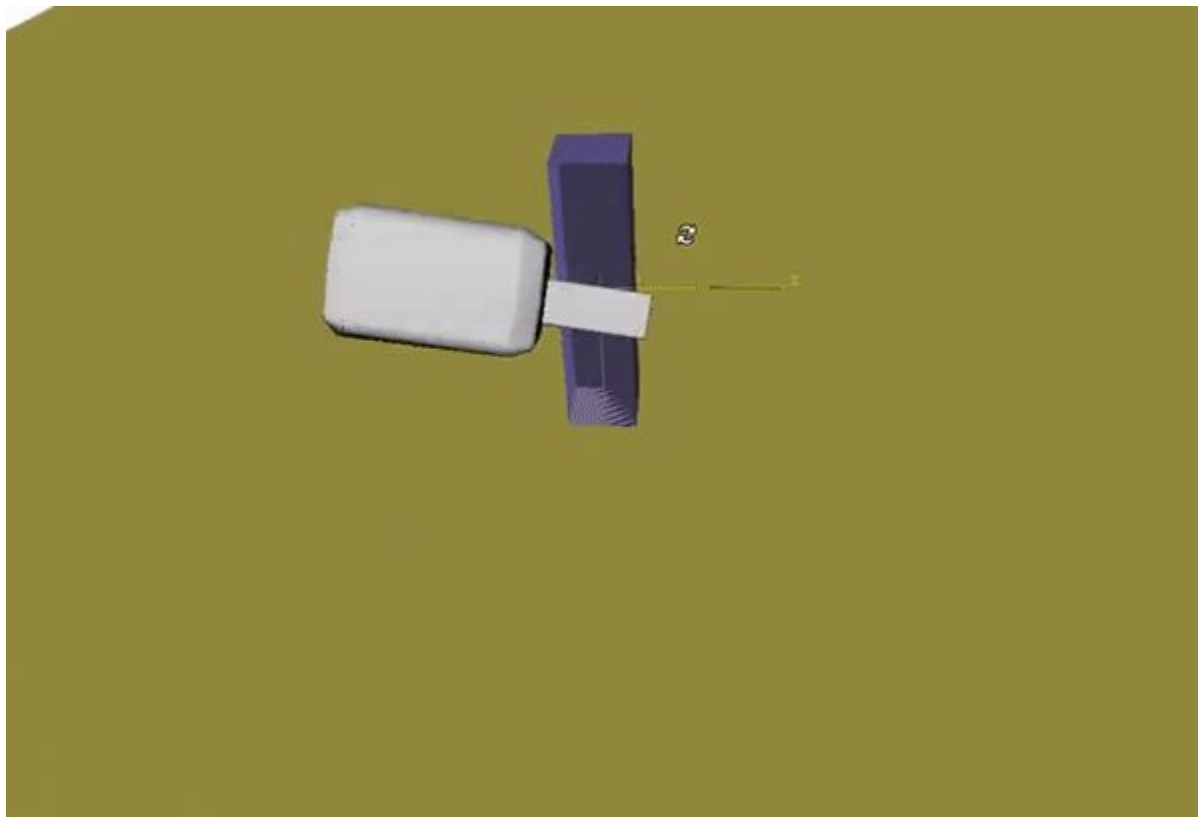


# Depth and tactile completion



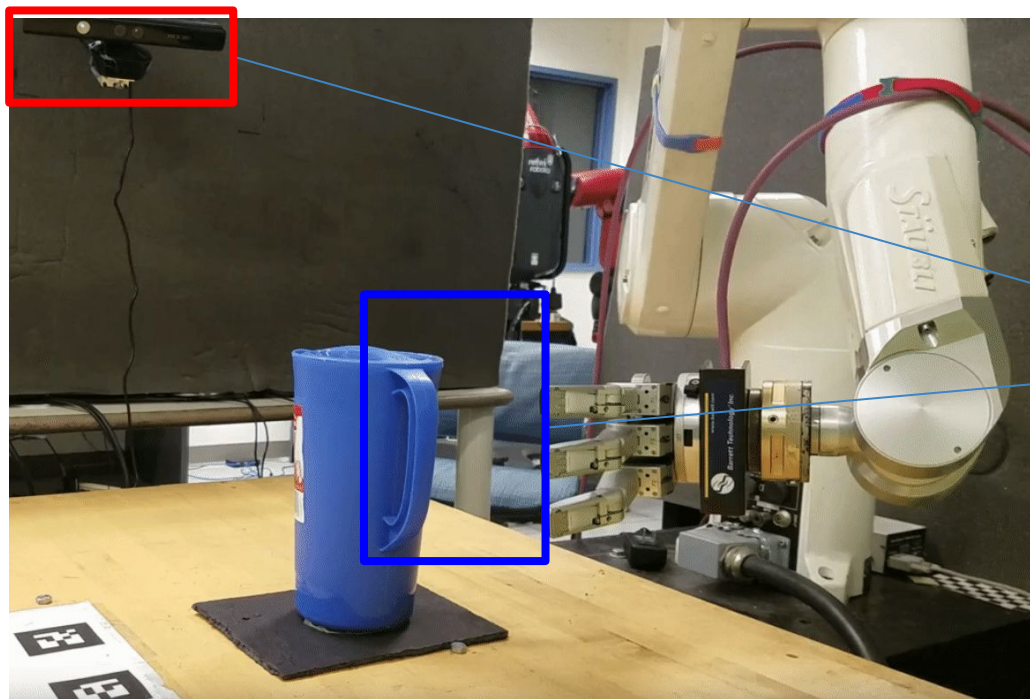


# Grasp-It!



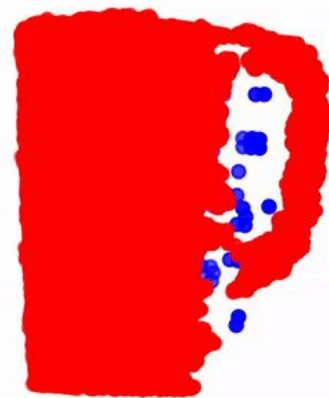


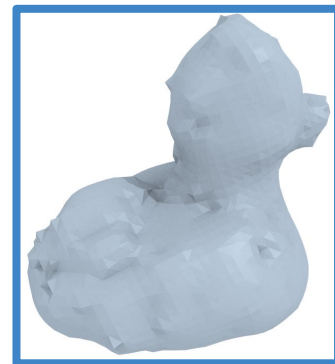
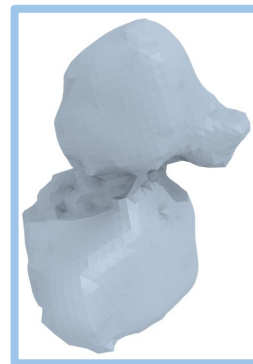
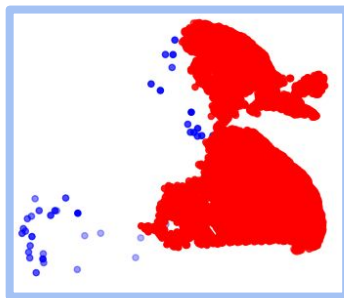
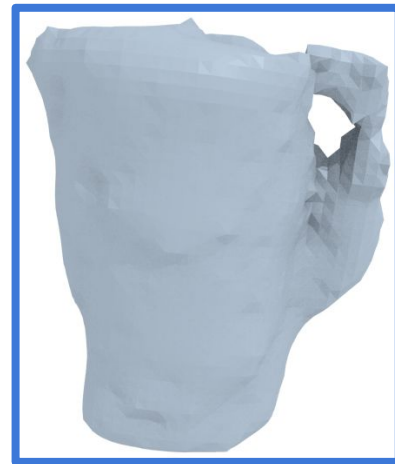
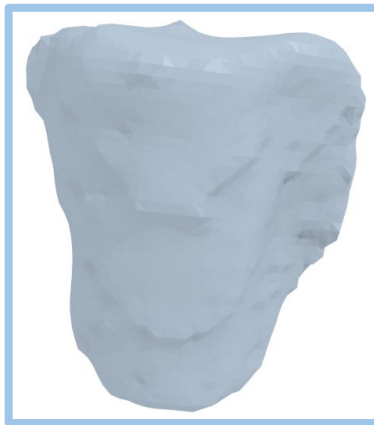
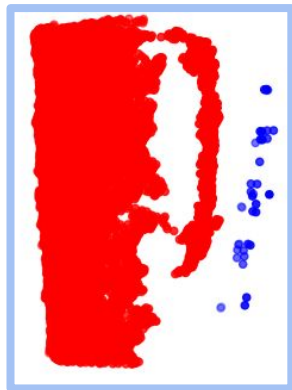
# Results



Depth (Red)

Tactile (Blue)





Ground Truth

Depth and  
Tactile Clouds

Depth Only  
Completion

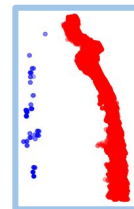
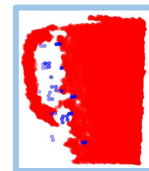
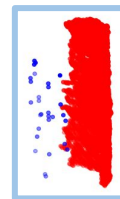
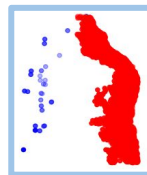
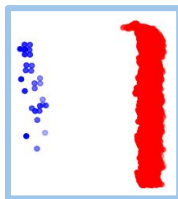
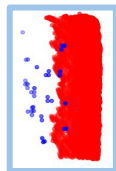
Tactile and Depth  
Completion (ours)

# Live results

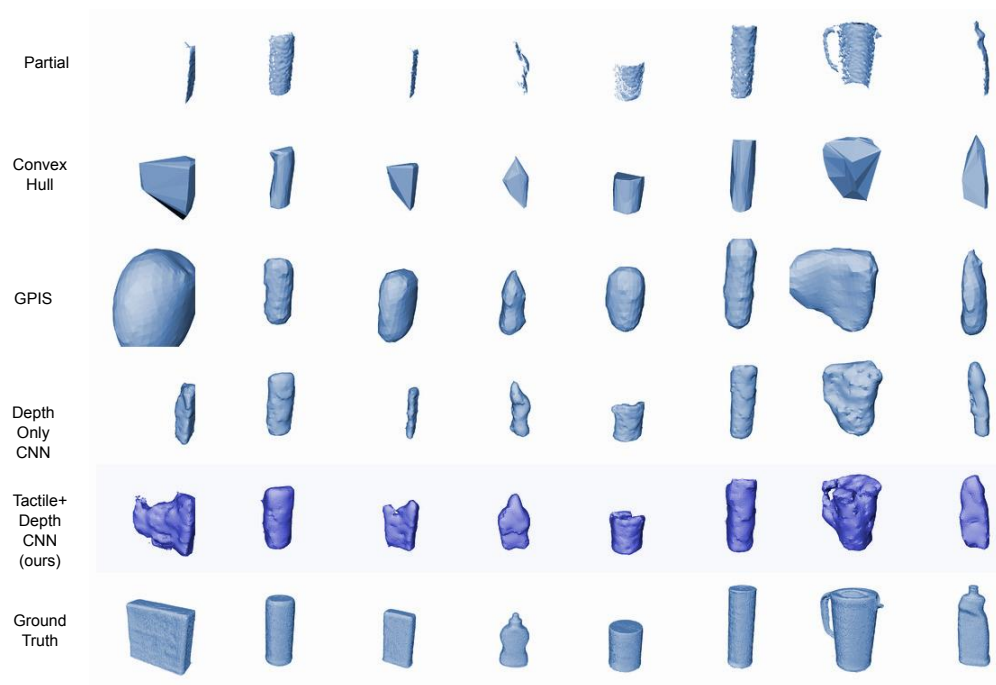
RGB



Depth  
and  
Tactile  
Cloud



# Completion comparisons

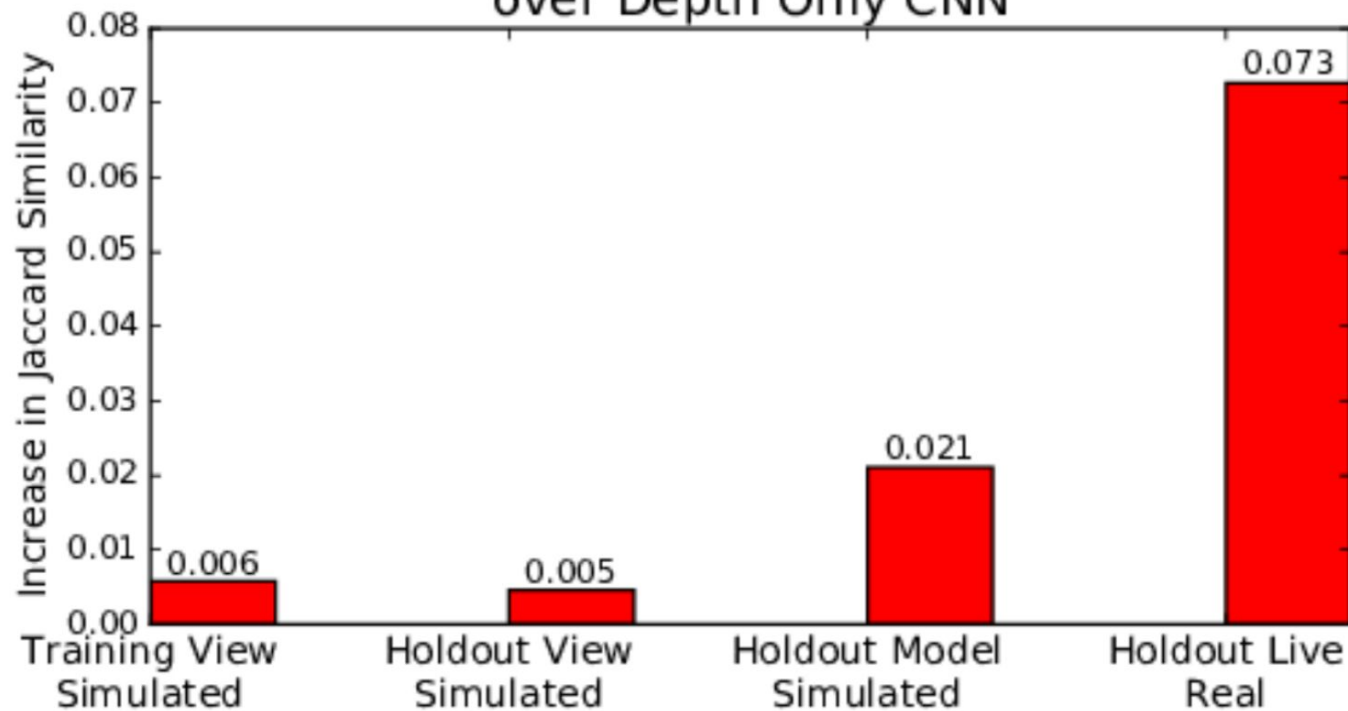


# Completion results

<b>Completion Method</b>	<b>Train View(Sim)</b>	<b>Holdout View(Sim)</b>	<b>Holdout Model(Sim)</b>	<b>Holdout (Live)</b>
Partial	7.8	7.0	7.6	11.9
Convex Hull	32.7	45.1	49.1	11.6
GPIS	59.9	79.2	118.0	17.9
Depth CNN	6.5	6.9	6.5	16.5
Ours	<b>5.8</b>	<b>5.8</b>	<b>6.2</b>	<b>7.4</b>

Hausdorff distance measuring the mean distance in millimeters from points on one mesh to points on another mesh

## Tactile and Depth CNN Improvement over Depth Only CNN



# Grasping Results

Completion Method	Train View(Sim)	Holdout View(Sim)	Holdout Model(Sim)	Holdout (Live)
Partial	19.9mm	21.1mm	16.6mm	18.6mm
Convex Hull	13.9mm	16.1mm	14.1mm	10.5mm
GPIS	17.1mm	16.0mm	21.3mm	20.8mm
Depth CNN	12.1mm	13.7mm	12.4mm	22.9mm
Ours	<b>7.7mm</b>	<b>13.9mm</b>	<b>13.6mm</b>	<b>6.2mm</b>

L2 difference between planned and realized grasp pose  
averaged over the 3 finger tips and the palm of the hand





# Multi-Modal Geometric Learning for Grasping and Manipulation

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Live Split  
Black And Decker Lithium Drill Driver  
Clorox Disinfecting Wipes 35  
Domino Sugar 1LB  
Frenchs Classic Yellow Mustard 140z  
Master Chef Ground Coffee 297G  
Pingles Original  
Rubbermaid Ice Guard Pitcher Blue  
Soft Scrub 21L 40z  
Hobbit Models Hobbit Views  
Banana Poisson 004  
Block Of Wood 6in  
Book Poisson 002  
Book Poisson 003  
Book Poisson 008  
Book Poisson 015  
Book Poisson 006  
Book Poisson 015  
Box Poisson 019  
Box Poisson 023  
Camera Poisson 034  
Can Poisson 001  
Can Poisson 014  
Cellphone Poisson 009  
Dental Poisson 005  
Egg Poisson 011  
Flashlight Poisson 001  
Hammer Poisson 001  
Hammer Poisson 001  
Hammer Poisson 006  
Hammer Poisson 031  
Hammershoe Poisson 000  
Knife Poisson 004  
Knife Poisson 011  
Knife Poisson 032  
Melissa Doug Farm Fresh Fruit Banana  
Mushroom Poisson 007  
Mushroom Poisson 007  
Mushroom Poisson 013  
Mushroom Poisson 013  
Pitcher Poisson 003  
Pliers Poisson 000  
Remote Poisson 012  
Remote Poisson 012  
Remote Poisson 012  
Remote Poisson 013  
Remote Poisson 016  
Soccer Ball Poisson 003  
Soccer Ball Poisson 007  
Stapler Poisson 007  
Stapler Poisson 023  
Tetra Pak Poisson 020  
Toaster Poisson 009  
Toilet Paper Poisson 000  
Toy Poisson 001  
Toy Poisson 019  
Trash Can Poisson 011

## Rubbermaid Ice Guard Pitcher Blue

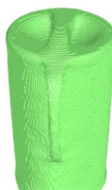
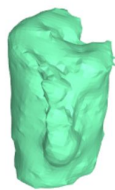
Point Cloud (Depth cloud in red, Tactile cloud in blue)

Partial View



Completion

Ground Truth



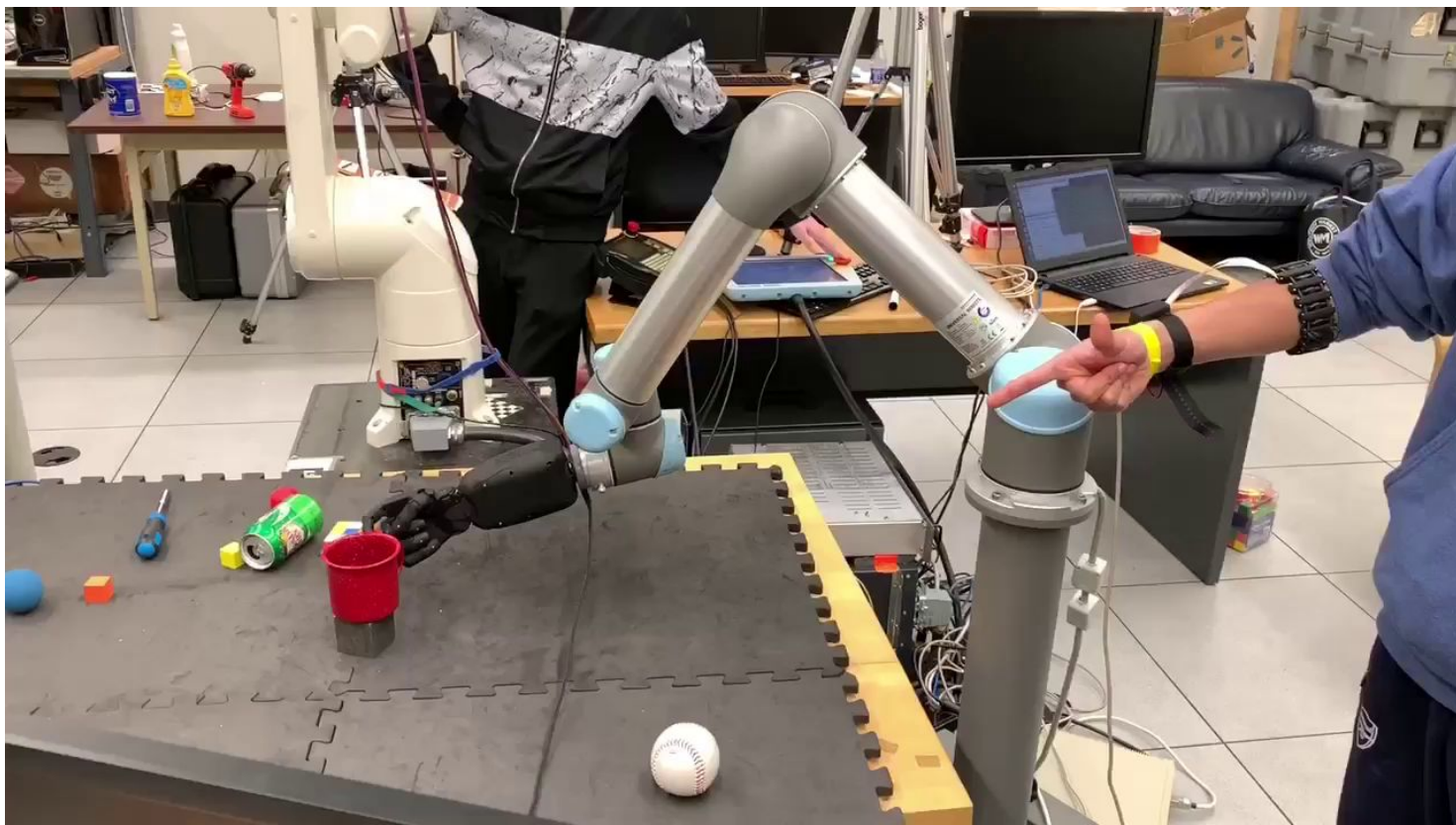
# Virtual reality



# Remote teleoperation







# Next Steps

- RGB voxel grid
  - Affordance labeling of output voxels
  - Segmentation of resultant voxel grids
  - Next best touch
- 
- Higher resolution grasping
  - Scene segmentation

# Multi-Modal Geometric Learning for Grasping and Manipulation

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