Multi-Modal Geometric Learning for Grasping and Manipulation

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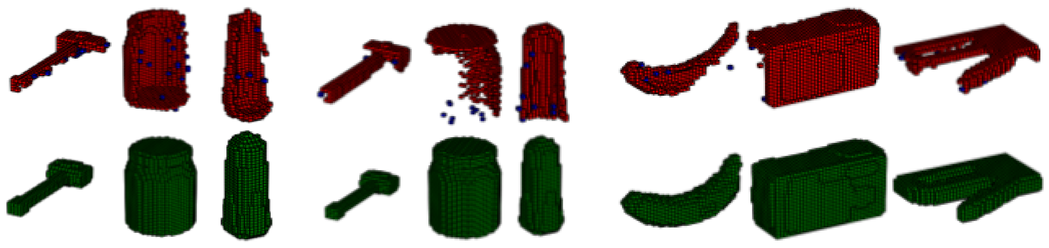
Abstract

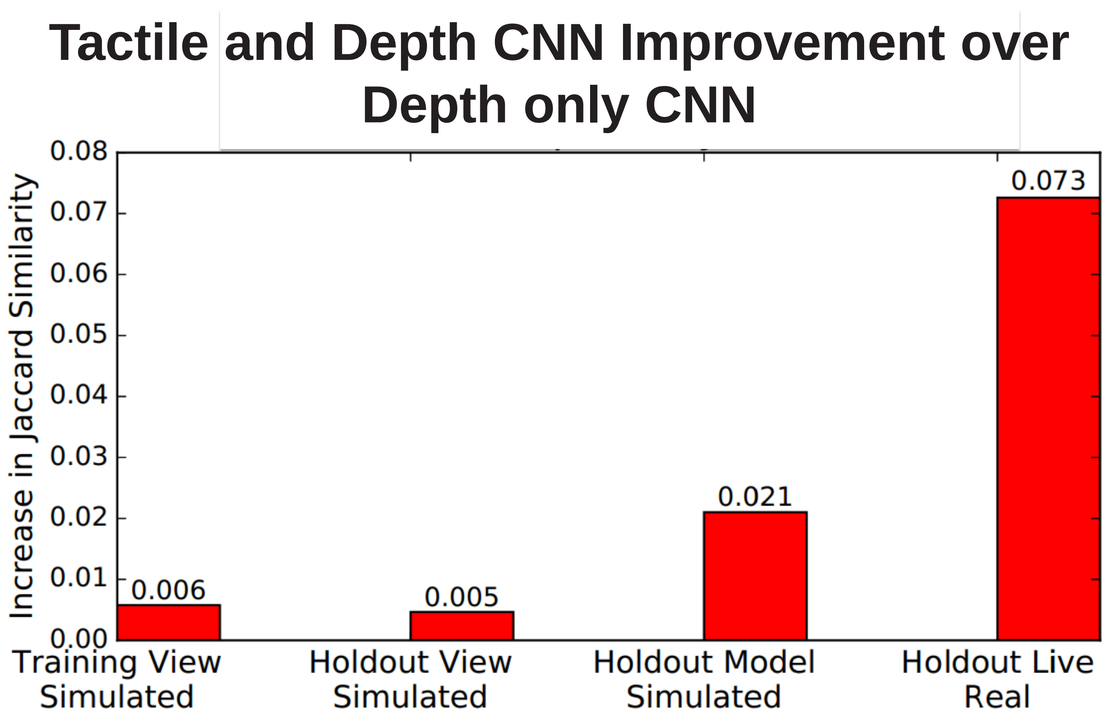
- Provides an architecture for 3D geometric approximation using a depth camera and tactile information
- We predict geometry more reliably and faster than other methods
- Our completions can use limited information to reason about occluded geometry



Input voxel dataset

Training

- We used 608 objects from YCB + Grasp datasets with 726 views per object
- Each object had 40 randomly generated tactile points simulated for training
- We implemented completion methods for GPIS, partial, convex hull to compare with our own method

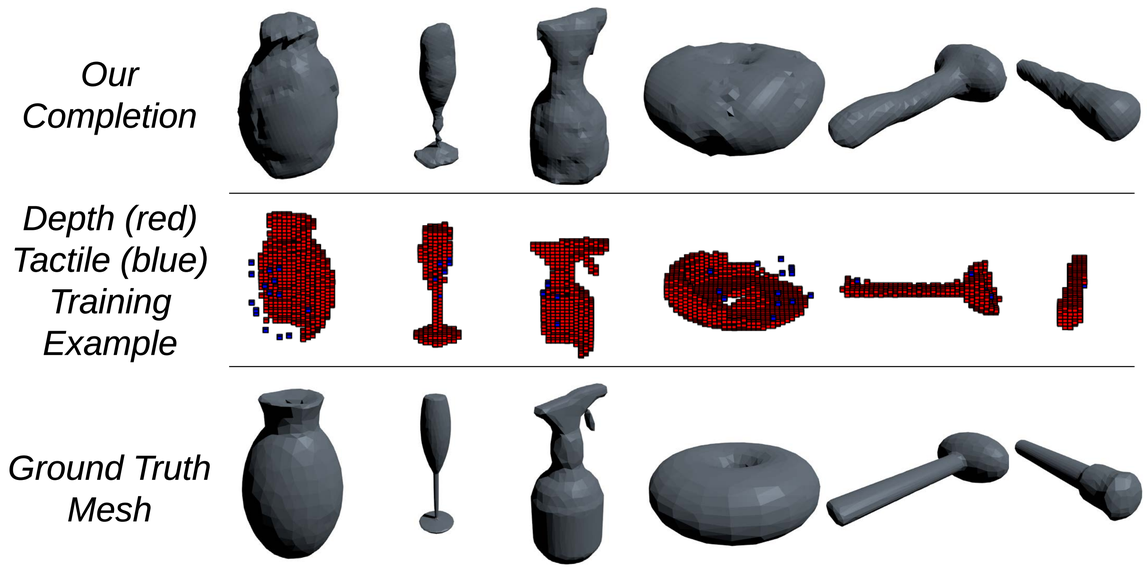


Tactile and Depth improvement over previous Depth Only CNN solution. The live data showed a significant improvement

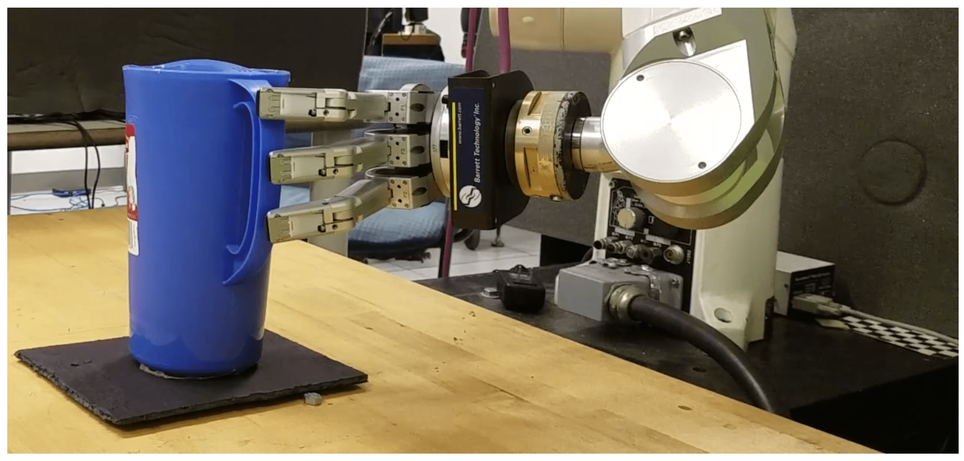
Performance Metrics for Completion Methods

Completion Method	Partial	Convex Hull	GPIS	Depth CNN	Ours
Lift Success (%)	62.5%	62.5%	87.5%	75.0%	**87.5%**
Joint Error (°)	6.37°	6.05°	10.61°	5.42°	**4.67°**
Time (s)	1.533s	**0.198s**	45.536s	3.308s	3.391s

Lift Success is the percentage of successful lift executions. Joint Error is the average error per joint in degrees between the planned and executed grasp joint values. While GPIS and our method have the same lift success, our method is 1340% faster and has 41% of the joint error, making the process more reliable. Average time to complete a mesh using each completion method. While the convex hull completion method is fastest, ours has a superior tradeoff between speed and quality. (Smaller is better)



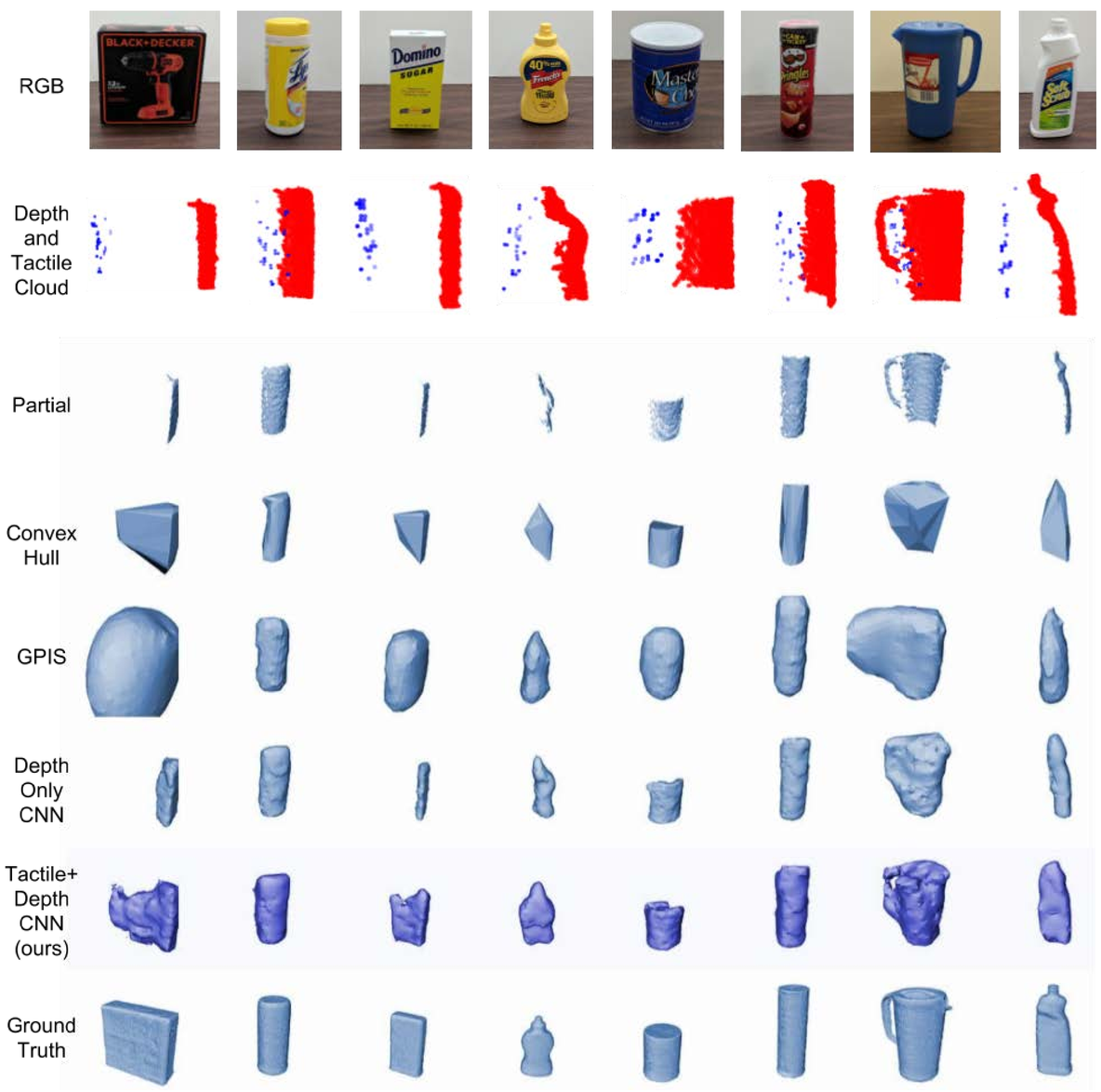
Example completions and training examples



Tactile data collection using Staubli-Barrett arm

Results

- We saw significant improvements over all other completion methods for Jaccard and Hausdorff metrics
- Our completion method performs best in terms of quality and time to completion
- Grasp probability and success is higher for our method than alternative options



Completions for the holdout live dataset. These consisted of partial clouds and tactile data collected from real world, YCB objects.

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