Combining Shape Completion and Grasp Prediction for Fast and Versatile Grasping with a Multi-Fingered Hand

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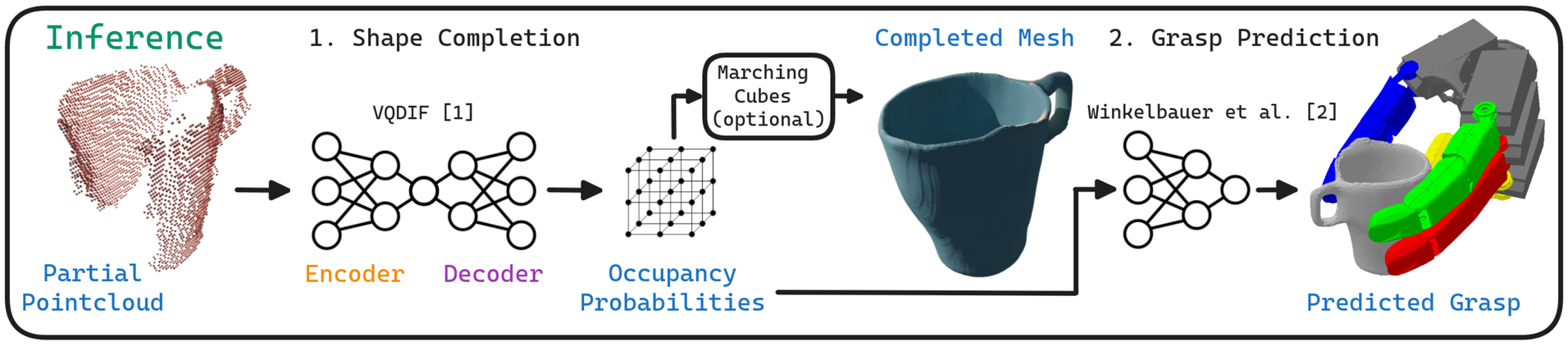
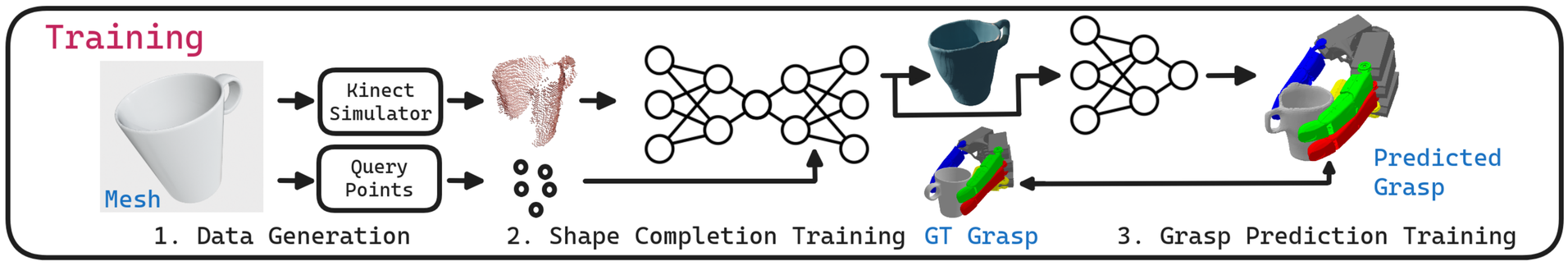
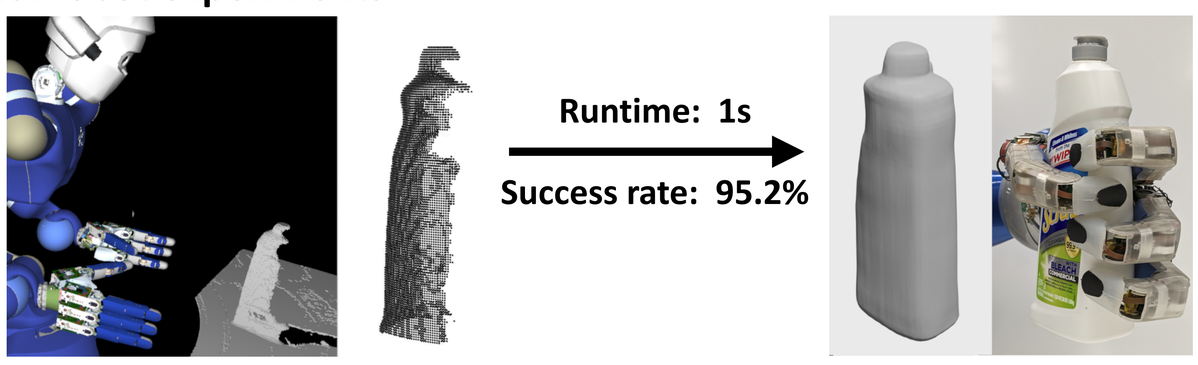




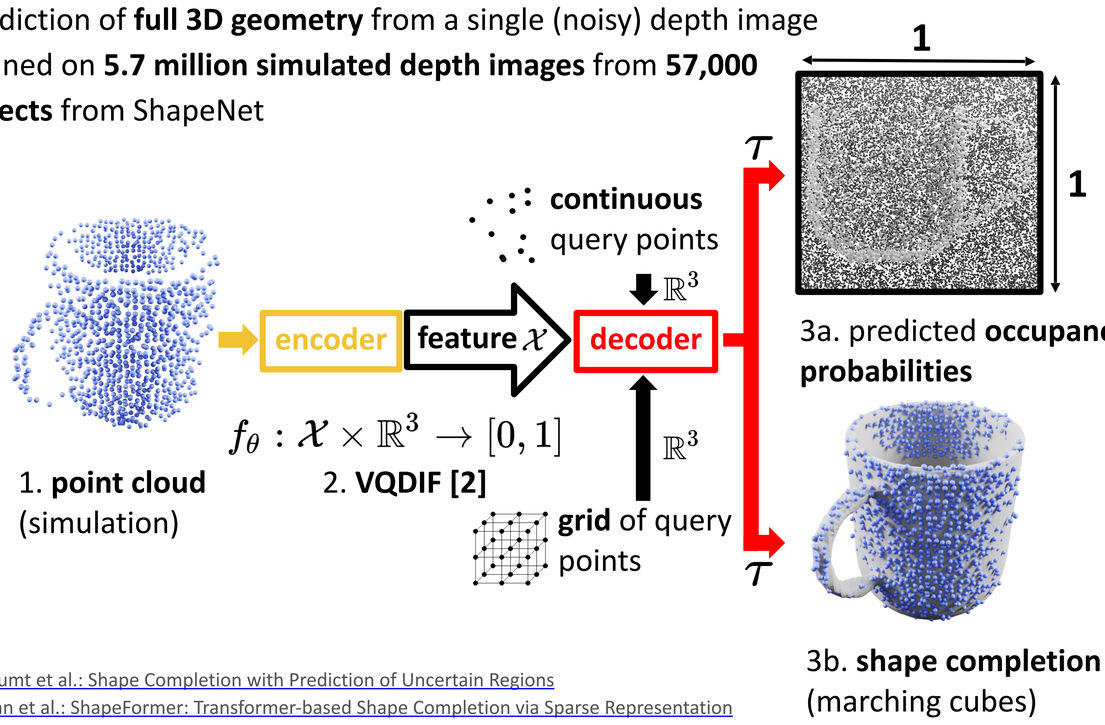
The first complete pipeline for robust grasping of unknown objects

Real robot experiments



Shape completion

- Prediction of **full 3D geometry** from a single (noisy) depth image
- Trained on **5.7 million simulated depth images** from **57,000 objects** from ShapeNet

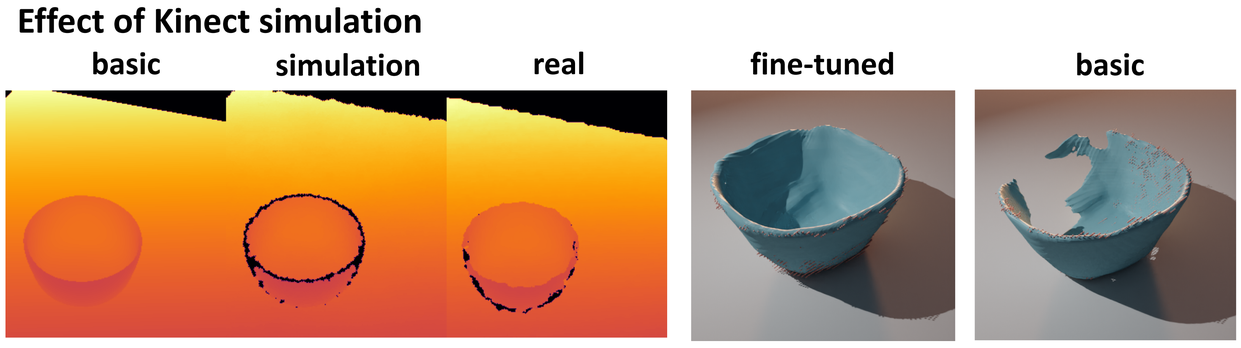


[1] Humt et al.: Shape Completion with Prediction of Uncertain Regions

[2] Yan et al.: ShapeFormer: Transformer-based Shape Completion via Sparse Representation

Results on real world data

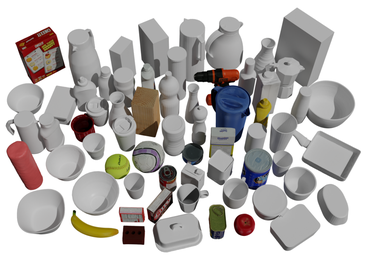
Effect of Kinect simulation



Results on realistic synthetic data

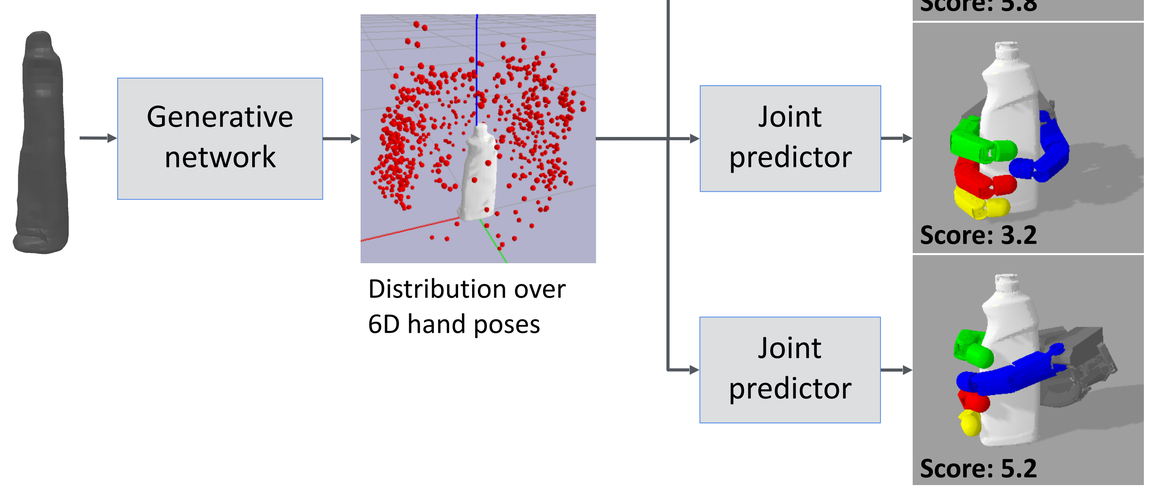
- Evaluated on **57,000** simulated depth images from **57 novel objects**
- High-quality meshes from **laser scanned** household objects

Model	IoU↑	F1↑	Precision↑	Recall↑
KINECT FINETUNE	66.7	75.7	73.5	83.3
KINECT SCALE	60.4	71	75.5	73.6
KINECT	58	68.9	75.7	70.6
BASIC	49.5	61.1	74	59.5

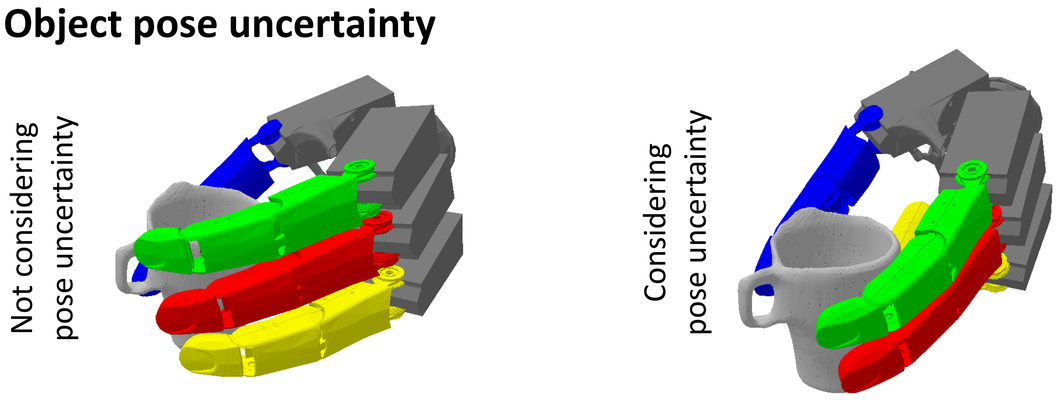


Grasp prediction

- **Two-stage architecture** [Winkelbauer et al.]
- Trained on shape completion of simulated depth images of **12,000 objects** from ShapeNet
- Trained with **300,000 ground truth grasps**

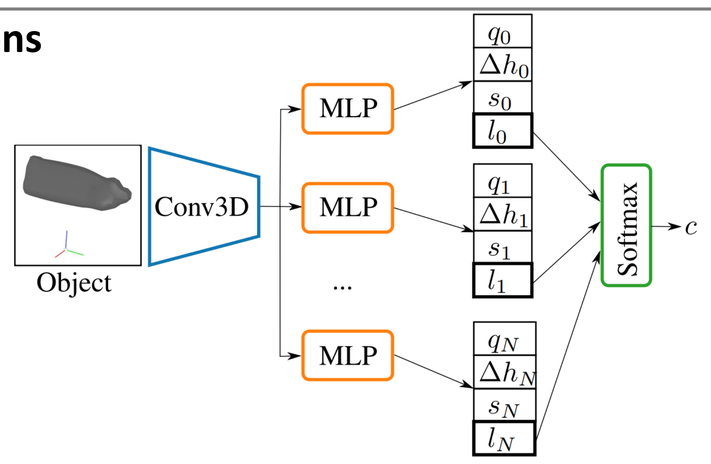


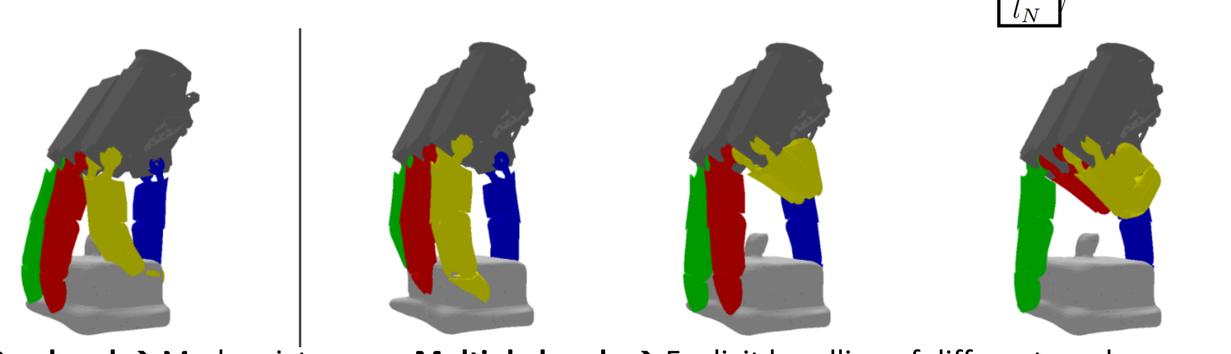
Object pose uncertainty



Ambiguous joint configurations

- Usually: **Multiple labels** per training sample necessary
- Novel **multi-head approach** to handle ambiguities with one label per sample





Conclusion and future work

- Pipeline for **grasping of unknown objects**
- Complete, versatile, **fast**: 1s from perception to grasp
- **Single depth image** as input
- Trained entirely in simulation: Strong **sim-to-real generalization**
- **Future**: Further improvements to sensor simulation, network architectures, and training procedures

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