

# SCARP: 3D Shape Completion in ARbitrary Poses for Improved Grasping

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#### What:

- Improves shape completion in arbitrary poses by 45%.
- Reduces grasping errors by **71%** on tabletop objects. How:
- Learns a disentangled representation of rotationally equivariant pose features & geometric shape features



# Shape completed using SCARP

Grasp poses collide with the object Grasp poses on completed object don't collide

> Codes and pre-trained models at https://github.com/vanhalen42/SCARP

### Multi-task objective: Disentangling shape and pose



SCARP learns a disentangled representation of pose and shape. A multi-task objective to perform (1) canonicalization, (2) shape completion, and (3) 6D pose estimation in a single end-to-end network

#### **Qualitative and Quantitative Results**

Partial Input ConDor+Sinv ConDor+Pointr SCARP (Ours) Ground Truth Partial Input ConDor+SInv ConDor+Pointr SCARP (Ours) Ground Truth



		Tabletop					Off-Table				
		Bowl	Bottle	Can	Mug	Basket	Plane	Car	Chair	Watercraft	Average
CD↓	ConDor+SInv.	82.7	27.4	45.4	41.5	85.3	34.2	14.7	59.4	39.9	47.8
	ConDor+Pointr	30.8	20.9	29.9	14.2	40.9	22.1	6.4	19.8	8.5	21.5
	SCARP (Ours)	21.8	7.9	11.8	12.1	34.2	6.9	5.6	19.1	7.1	14.0
		Bowl	Bottle	Can	Mug	Basket	Plane	Car	Chair	Watercraft	Average
MMD-EMD↓	ConDor+SInv.	27.3	17.2	20.1	19.9	29.2	19.6	11.3	22.2	18.9	20.6
	ConDor+Pointr	21.6	13.6	14.8	12.6	18.8	14.4	8.1	13.5	9.1	14.1
	SCARP (Ours)	9.6	6.3	8.8	8.4	10.6	5.0	5.6	8.4	6.0	7.6

Quantitative comparison of shape completion for tabletop and off-tabletop objects on Chamfer's Distance (CD) and Earth Movers Distance-Maximum Mean Discrepancy (EMD-MMD)

#### **Results on Real-world Scans**



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#### Scan taken using Intel<sup>®</sup> RealSense<sup>™</sup> Depth Camera D455

## **Applications to Grasping**



Grasping errors on partial observations (shown in red)

Grasp proposals on objects completed using SCARP reduce collisions drastically (shown in green).