CADOps-Net: Jointly Learning CAD Operation Types and Steps from Boundary-Representations

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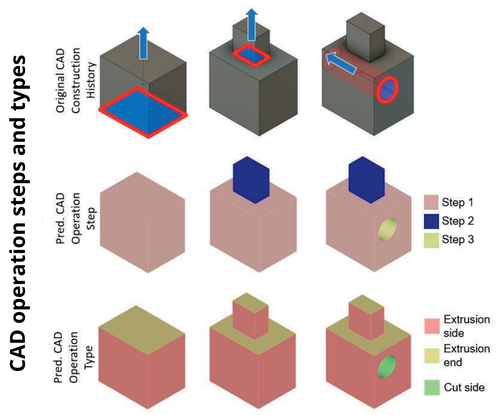
3DV 2022

Project Page Dataset

Introduction



- Computer Aided Design (CAD) modelling has become the standard for any industrial design.
- A long sought after goal is 3D reverse engineering: the automated recovery of a CAD model design history.
- One step towards bridging the gap between works [1,2,3,4] recovering the construction history of CAD model made of only the extrusion operation type and works [5,6,7] segmenting B-Rep faces according to their operation type.
- ***CADOps-Net***, a model that learns the segmentation of faces into both CAD **operation types and steps**.

Contributions

- A neural network, ***CADOps-Net***, that operates on B-Reps to learn the **segmentation** of faces into CAD operation **types** and **steps**. We introduce a **joint learning** method within an **end-to-end** model.
- A **novel dataset**, ***CC3D-Ops***, that builds on top of the existing CC3D dataset by extending it with B-Reps and their corresponding per-face CAD operation type and step annotations.
- Evaluation on two datasets and compared to recent state-of-the-art methods.
- A potential downstream application consisting of **CAD sketch recovery** from B-Reps.

References

[1] Wu, R., *et al.* (2021). Deepcad: A deep generative network for computer-aided design models. CVPR.

[2] Willis, K., *et al.* (2020). Fusion 360 gallery: A dataset and environment for programmatic cad reconstruction. ACM Transactions on Graphics.

[3] Xu, X., *et al.* (2021). Inferring cad modeling sequences using zone graphs. CVPR.

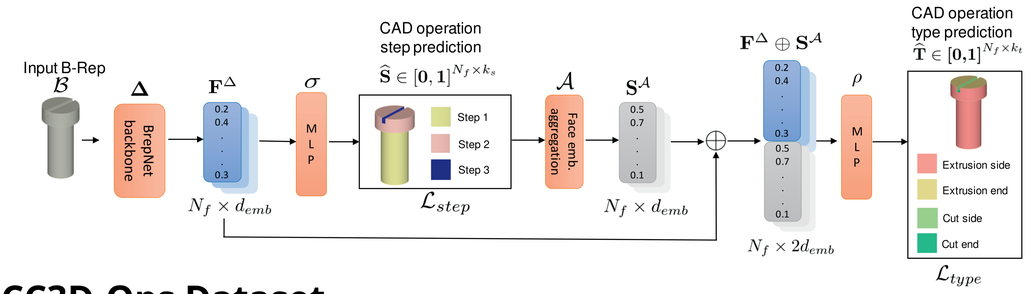
[4] Uy, M. A., *et al.* (2022). Point2Cyl: Reverse Engineering 3D Objects From Point Clouds to Extrusion Cylinders. CVPR.

[5] Colligan, A. R., *et al.* (2022). Hierarchical CADNet: Learning from B-Reps for Machining Feature Recognition. Computer-Aided Design.

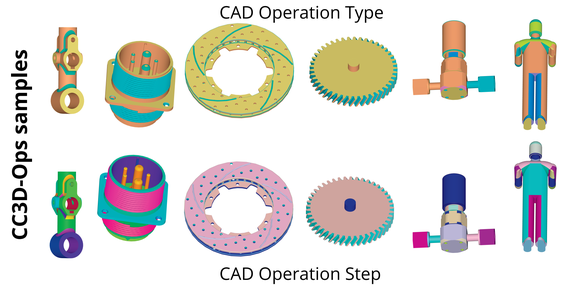
[6] Jayaraman, *et al.* (2021). Uv-net: Learning from boundary representations. CVPR.

[7] Lambourne, J. G., *et al.* (2021). Brepnet: A topological message passing system for solid models. CVPR.

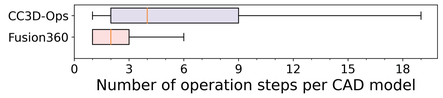
Proposed Approach



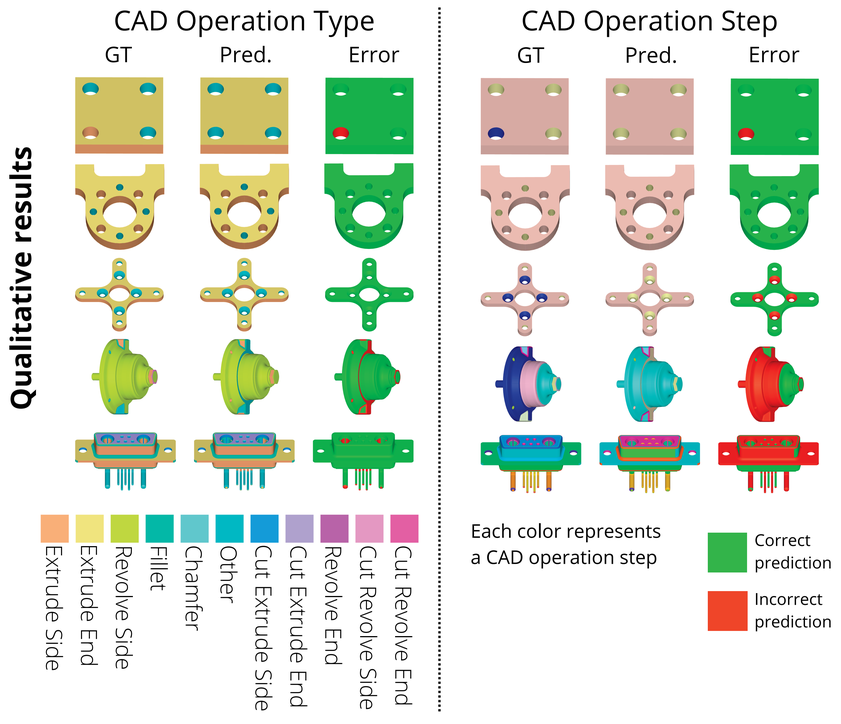
CC3D-Ops Dataset



- 37k+ B-Reps with the corresponding per-face CAD operation type and step annotations.
- The proposed *CC3D-Ops* dataset comes with more complex models that are closer to real-world industrial challenges than other existing datasets.

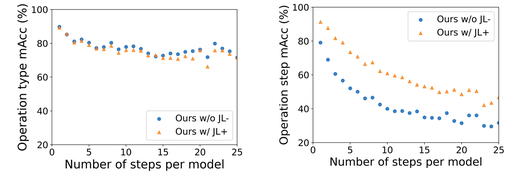


Experimental Results



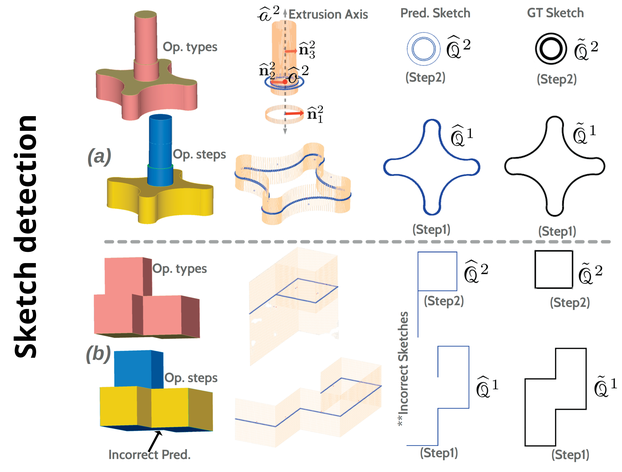
Quantitative results

	Model	*op.type* mAcc	*op.type* mIoU	*op.step* mAcc	*Consistency* R_C	*Consistency* mS_C
Fusion360	*CADNet*	88.9	67.9	-	-	-
	UV-Net	92.3	72.4	-	-	-
	BRepNet	94.3	81.4	-	-	-
	Ours w/o JL⁻	95.5	83.2	80.2	87.1	97.4
	Ours w/ JL⁺	**95.9**	**84.2**	**82.5**	**93.3**	**98.7**
CC3D-Ops	*CADNet*	57.5	26.9	-	-	-
	BRepNet	71.4	35.9	-	-	-
	Ours w/o JL⁻	**76.0**	43.0	48.4	40.7	82.7
	Ours w/ JL⁺	75.0	**44.3**	**62.7**	**82.4**	**96.7**



- CAD operation step segmentation task is much more challenging for complex models made of many construction steps.

Downstream Application



Conclusion

- CADOps-Net jointly learning CAD operation types and steps of B-Rep faces.
- Joint learning leads to more consistent CAD operation type and step predictions.
- Combining these two segmentations allows for recovery of further information of the construction history such as sketches.
- As future work, an investigation of the ordering of the construction steps while maintaining various types of CAD operations.

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