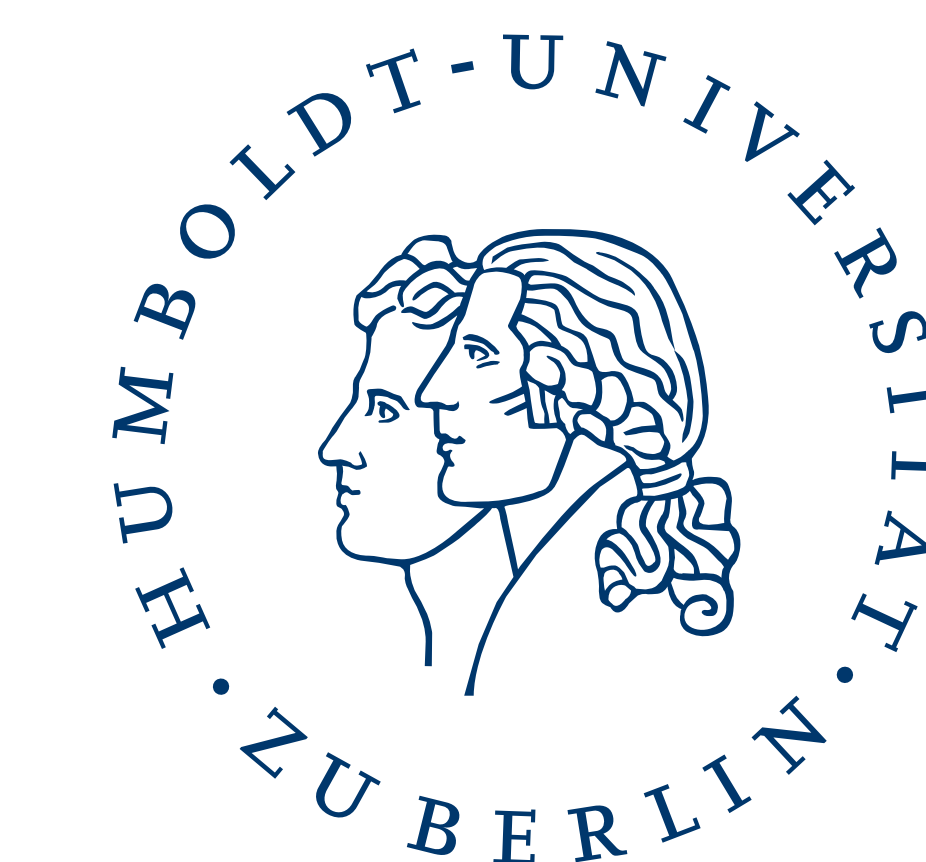




# Don't Mesh with Me: Generating Constructive Solid Geometry Instead of Meshes by Fine-Tuning a Code-Generation LLM

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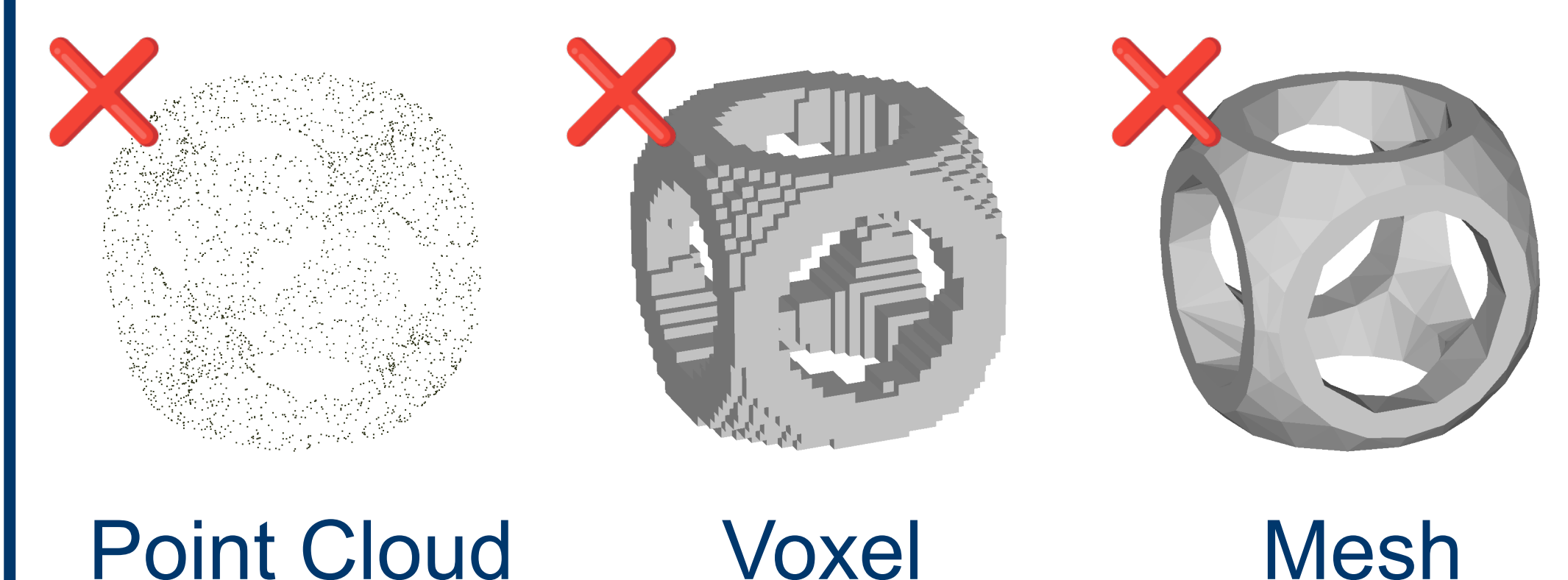
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## Motivation

“Software developers use AI tools like ChatGPT to write code. Mechanical engineers don’t have similar AI tools to design parts.”

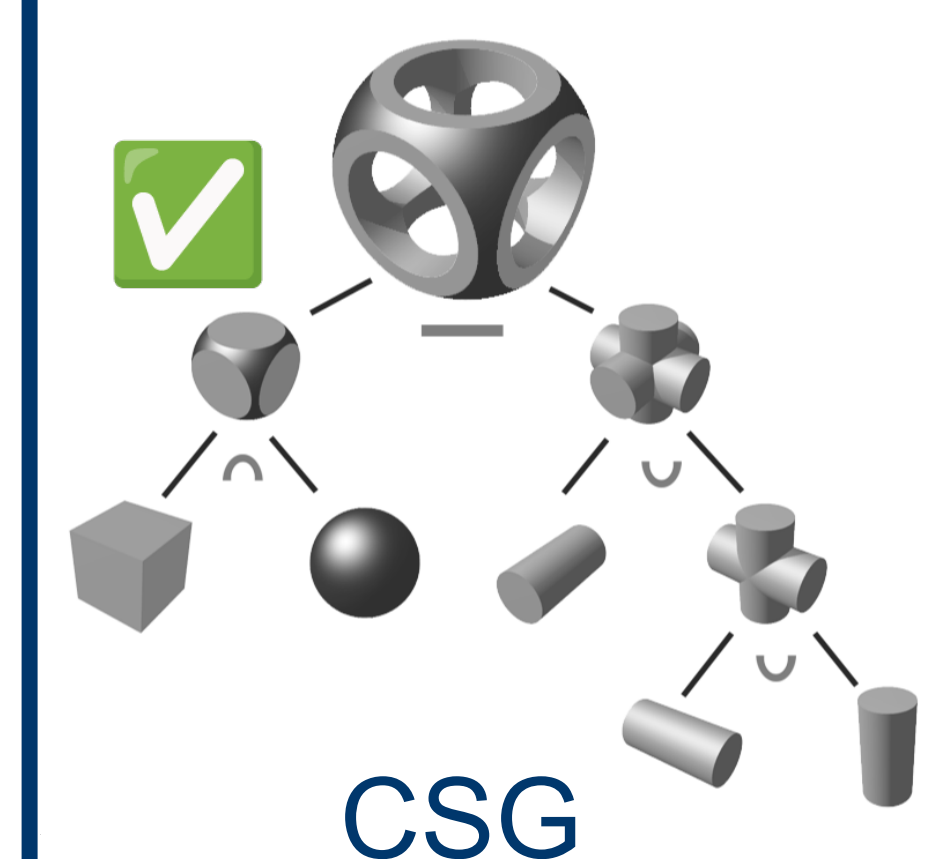
Existing approaches generate Pointclouds, Voxel Grids, Neural Radiance Fields or Meshes.



Engineers need true parametric curves and surfaces.

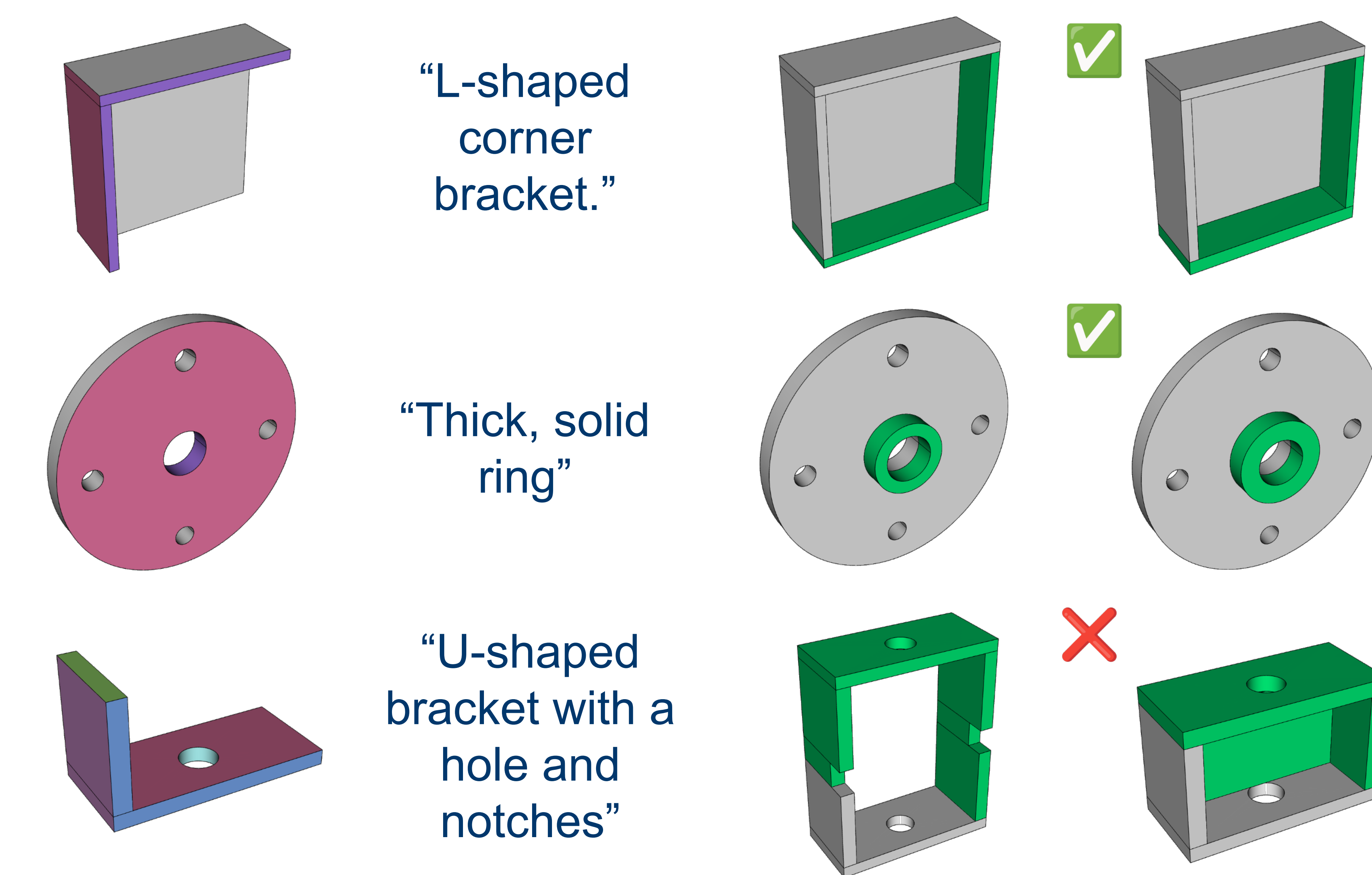


Constructive Solid Geometry (CSG) combines simple shapes.



Our Approach generates precise 3D geometries from natural language.

## Geometry Input Text Input Ground Truth Result



## Experimental Results

- Geometric Coherence:** 98% of generated models are geometrically valid (finite, connected cells with no overlaps).
- Surface Adherence:** 83% of models conformed to the input surface geometry.
- Text Guidance:** Textual input improves ground truth alignment, but only in low-complexity (low cell count) cases.

without text	0.45	0.22	0.14	0.06	0.02	0.01	0.00	0.00	0.00
with text	0.51	0.25	0.14	0.06	0.02	0.01	0.00	0.00	0.00
	1	2	3	4	5	6	7	8	9

Share of Geometries, where Output = Ground Truth. Text Annotations increase the likelihood of hitting the ground truth for low cell counts.

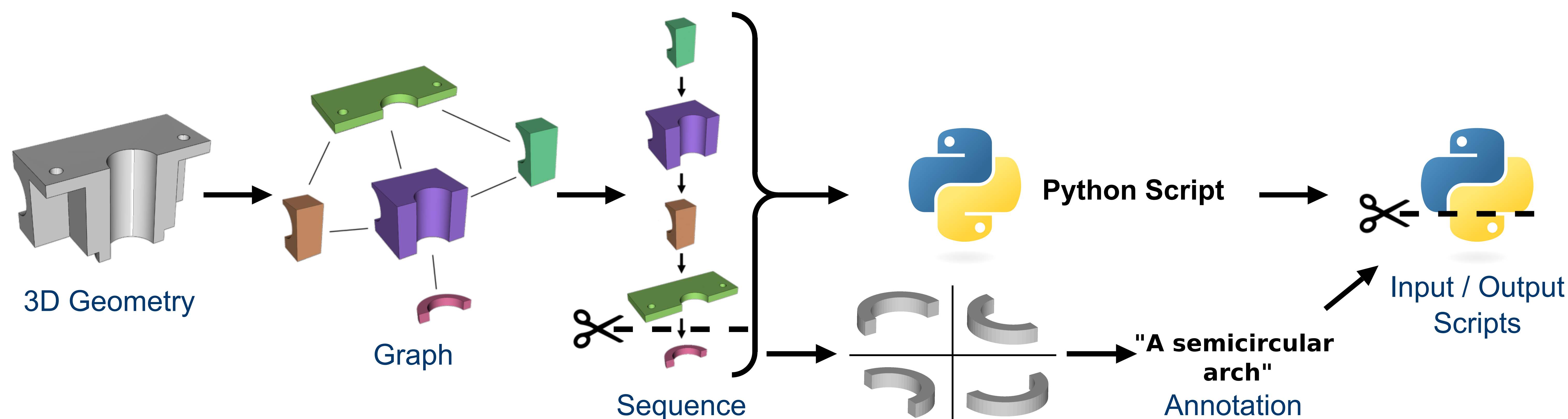
9	0.00	0.00	0.20	0.00	0.20	0.20	0.00	0.20	0.20
8	0.00	0.01	0.02	0.11	0.23	0.23	0.17	0.12	0.07
7	0.00	0.01	0.07	0.09	0.20	0.23	0.26	0.07	0.03
6	0.01	0.06	0.08	0.20	0.19	0.25	0.10	0.05	0.02
5	0.02	0.07	0.16	0.18	0.31	0.13	0.07	0.03	0.01
4	0.03	0.13	0.17	0.40	0.11	0.09	0.04	0.02	0.01
3	0.04	0.15	0.52	0.12	0.07	0.05	0.02	0.01	0.00
2	0.08	0.64	0.11	0.07	0.04	0.03	0.01	0.01	0.00
1	0.84	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00
	1	2	3	4	5	6	7	8	9

Distribution of the number of cells generated by ground truth cell count. Our model generates cell counts closely matching the ground truth.

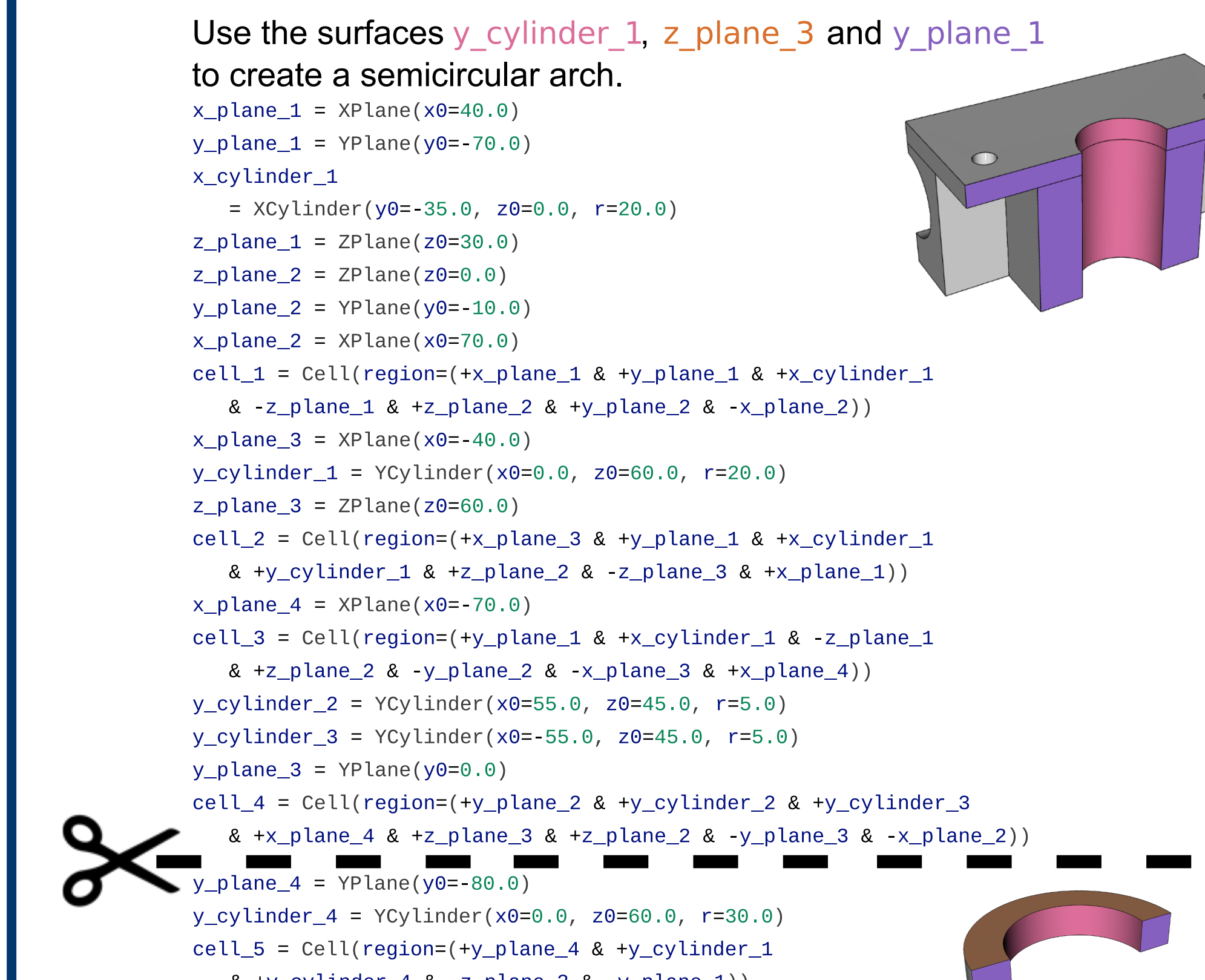
## Contributions

- Developed** a pipeline to convert BREP geometries from CAD software into surface-based CSG Python scripts.
- Generated** natural language descriptions of 3D geometries using GPT-4o.
- Fine-tuned** a 1.3B code generation LLM on 37,000 geometry-description pairs to enable plausible 3D geometry completion from text.

## Pipeline for Dataset Creation



## Data Sample



## More Results

