SHARP Challenge 2023: Solving CAD History and pArameters Recovery from Point clouds and 3D scans. Overview, Datasets, Metrics, and Baselines.

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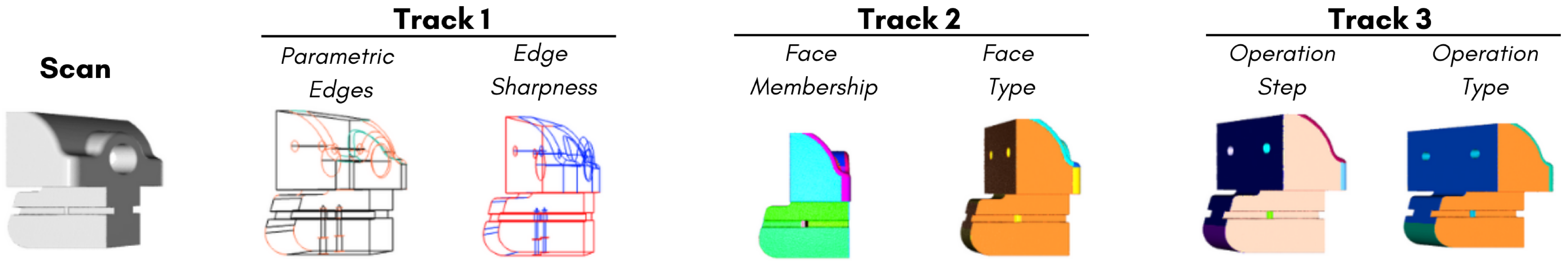
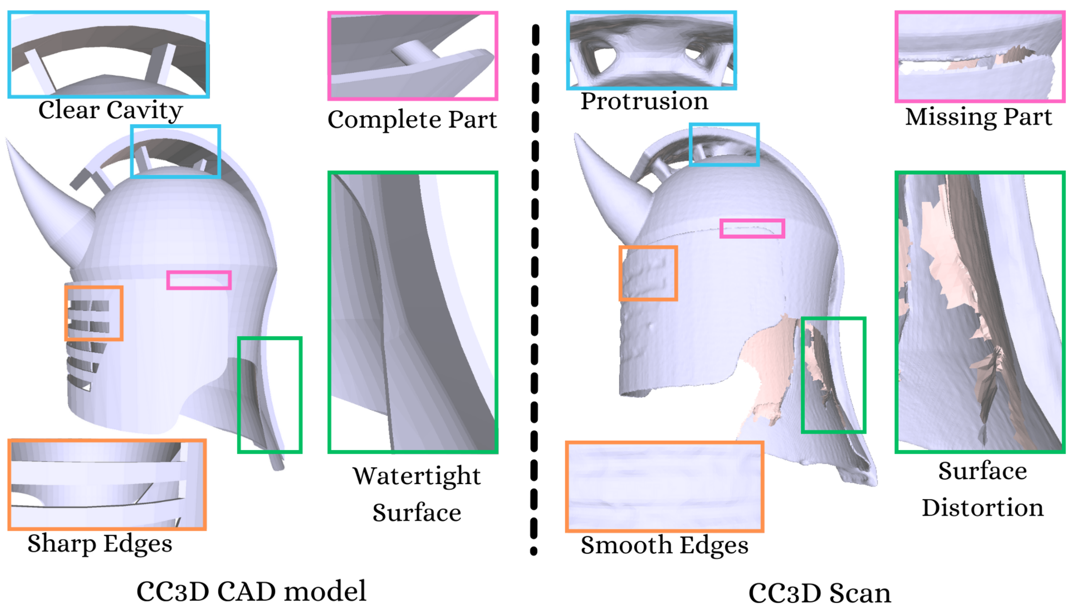
Challenge



Edge Type: Line, Circle, Spline	**Edge Sharpness**: Sharp, Not Sharp	**Face Membership / Operation Step**: 0, 1, 2, 3, 4, 5, 6 ...
Face Type: Plane, Cylinder, B Spline Surface, Torus	**Operation Type**: ExtrudeSide, ExtrudeEnd, CutExtrudeSide, Chamfer, Fillet	

Introduction



- **3D Reverse Engineering** (3D-RE) is the deduction of intermediate design steps, complete history, and final intent from a **3D scan** of its corresponding **Computer-Aided Design** (**CAD**) **model**.
- 3D-RE allows for fast prototyping and industrial re-editing of objects.
- 3D scanning opened a lot of doors for 3D-RE but **3D scans** are **unstructured representations**.

- **The geometry and topology** of a CAD model are stored as a Boundary Representation (**B-Rep**) which is a graph structure encoding **parametric** faces and edges, loops, and vertices.
- The **design history** of a CAD model consists of the set of **ordered steps** that were followed by the designer using a CAD software.
- The **SHARP Challenge 2023** aims at pushing the research a step closer to the **real-world scenario of 3D-RE** through **dedicated datasets** and **tracks**.

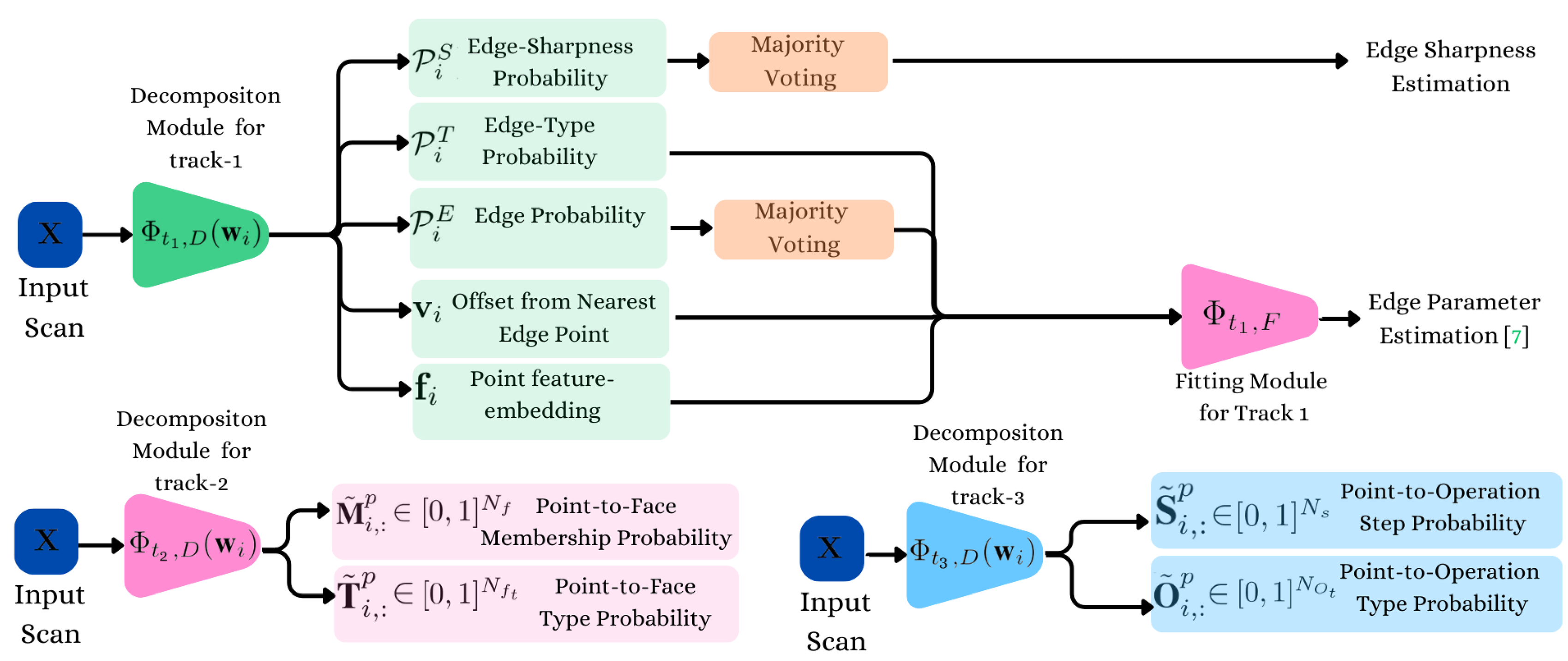
SHARP 2023 Challenge

- The **SHARP 2023** challenge focuses on **three different tasks** to bridge the gap between **realistic 3D scans** and their corresponding **CAD models**.
- **Track 1** and **Track 2** focus on **inferring geometrical** and **topological** properties of the **B-Rep** of the CAD model.
- **Track 3** is centered around **predicting** attributes of the **design history** of the CAD model.
- The **input** for all tracks is a realistic **3D scan**.
- In **Track 1** the **output** is a set of **parametric edges** with their corresponding **sharpness**. The **output** of **Track 2 and 3** are **per-point labels**.

CC3D Datasets

- **Three versions** of the **CC3D dataset** [1] are used in these tracks. The CC3D dataset is derived from open CAD repositories .
- 3D scans were obtained by **virtually scanning** the corresponding CAD models.
- The total number of samples of the CC3D dataset used in SHARP challenge is **31185**.

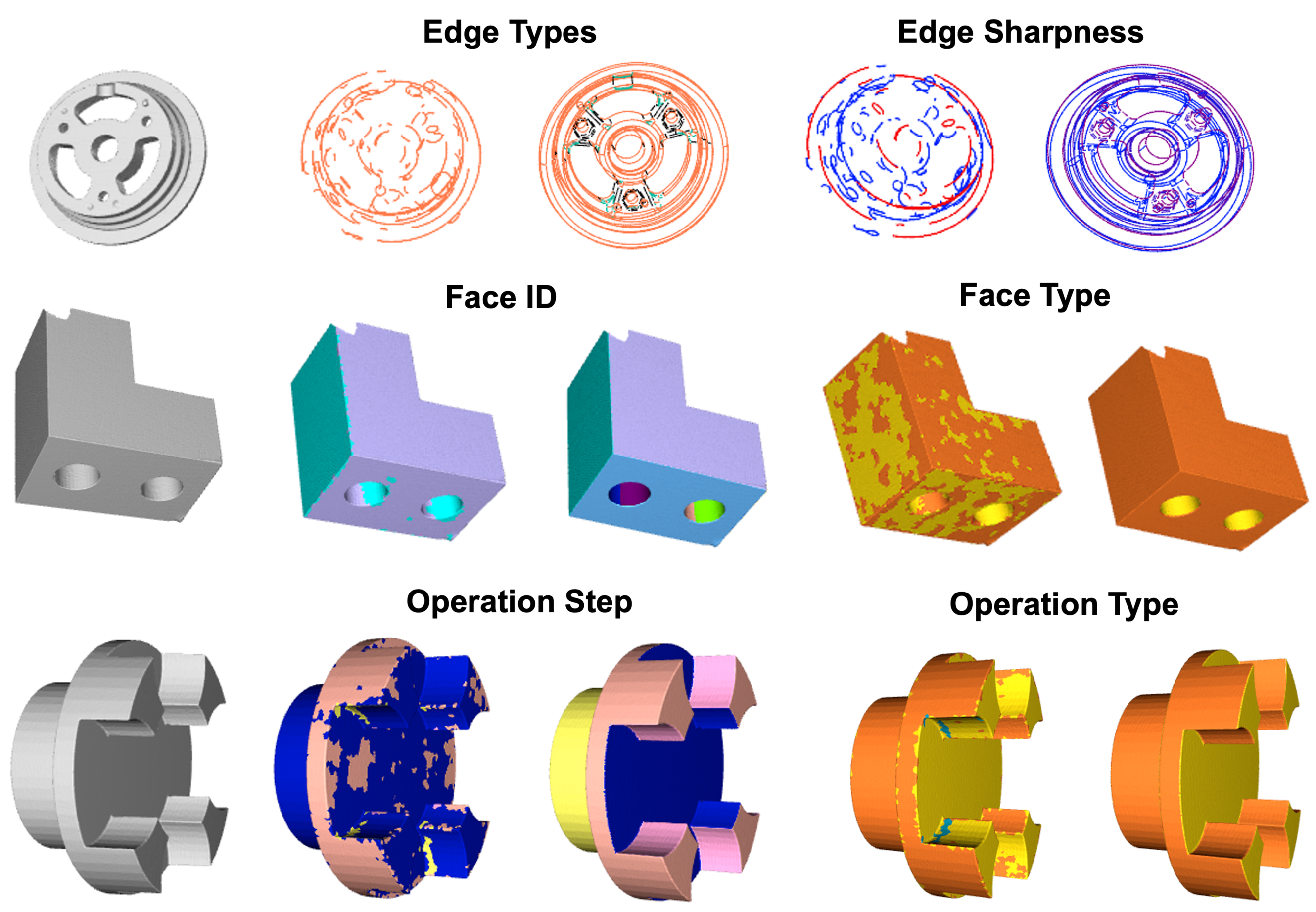
Baseline Methods



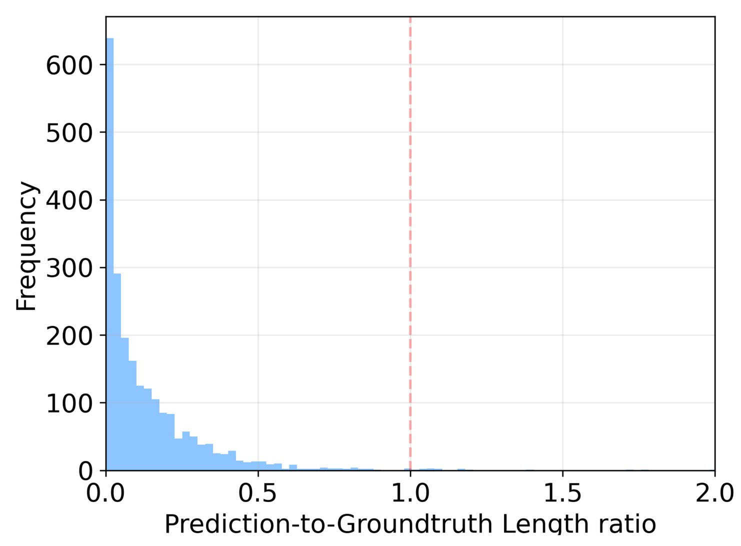
Evaluation Metrics

- For all tracks a final score between 0 and 1 is computed by combining different metrics.
- The metrics for **Track 1** are a **Edge Recovery Score**, a **Edge Length Score** and **Sharpness Score**;
- For **Track 2**: a **Face Membership Score** and a **Face Type Score**;
- For **Track 3**: a **CAD Step Score** and a **CAD Type Score**.

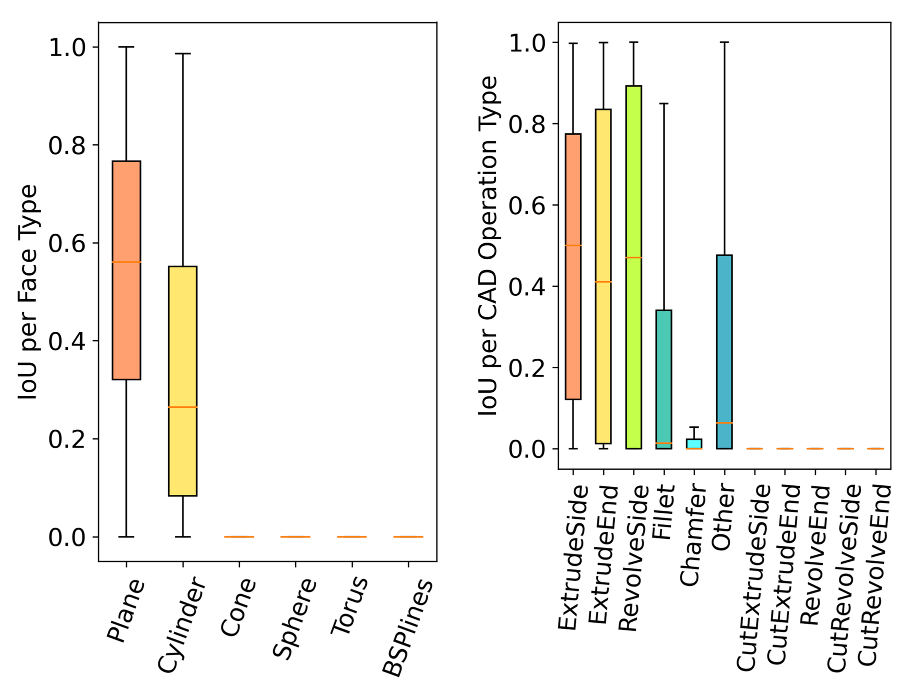
Experimental Results



Qualitative results for proposed baselines for the three tracks of the challenge (one row per track). Model prediction (left) is contrasted to the ground truth labels (right).



Histogram of Prediction-to-Groundtruth edge length ratios across test samples for Track 1.



Intersection over Union IoU reported per type, for face types (Track 2) and operation types (Track 3).

Conclusion

- **SHARP challenge 2023** aims at addressing the nuances of the **Scan-to-CAD** problem through three distinct tracks.
- For every track, a new version of the **challenging CC3D dataset** is presented, along with an **exhaustive description** of the **evaluation metrics** and proposed **baseline** methodologies.
- This challenge is designed to **encourage forthcoming advancements** in **3D-RE** from 3D scans in a real-world setting.

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References

[1] Cherenkova, K. *et al.* (2020). Pvdeconv: Point-voxel deconvolution for autoencoding cad construction in 3d. ICIP.

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