Supplementary Material for Auto-BPA: An Enhanced Ball-Pivoting Algorithm with Adaptive Radius using Contextual Bandits

Houda Saffi [1] Naima Otberdout [1] Youssef Hmamouche [1]

Amal El Fallah Seghrouchni [1,2]

[1] Ai movement - International Artificial Intelligence Center of Morocco
University Mohammed VI Polytechnic, Rabat, Morocco
[2] Sorbonne Université, LIP6 - UMR 7606 CNRS, France

{houda.saffi, naima.otberdout, youssef.hmamouche, amal.elfallah-seghrouchni}@um6p.ma

1. Surface quality

This supplementary material offers in-depth information regarding the computation metrics employed for surface quality evaluation. We evaluate the overall quality of the reconstructed meshes using the proposed approach Auto-BPA using several metrics. These include Chamfer Distance (CD1), squared Chamfer Distance (CD2), and F-Score (F1) for shape evaluation, as well as the evaluation of surface normals using Normal Consistency (NC) and Normal Reconstruction error in degrees (NR). To ensure the preservation of sharp edges, we extend our evaluation to include Edge Chamfer Distance (ECD1) and Edge F-Score (EF1) for the reconstructed meshes. It is important to note that the computation of metrics CD1, CD2, and F1 necessitates dense point sampling across the entire surface, whereas ECD1 and EF1 exclusively employ points sampled in proximity to edges and corners. Our evaluation protocol follows the methodology outlined in the research works [1, 2]. Given two shapes, the ECD1 and EF1 metrics are essentially the Chamfer Distance (CD1) and F1 score computed based on their respective edge samples. To assess the quality of shapes, we sample 10^5 points on both the ground truth and reconstructed meshes. By Equations 1 and 2, we present the definitions for Chamfer Distance and F-score; Given the ground truth mesh M_1 and the reconstructed mesh M_2, we uniformly sample the same number of points (*e.g.* 10^5) on each of them. Let the sampled point clouds be S_1 and S_2, respectively. We define the Chamfer Distance between S_1, $S_2 \subseteq \mathbb{R}^3$ as:

$$d_{\mathrm{CD1}}(S_1, S_2) = \frac{1}{|S_1|}\sum_{x\in S_1}\min_{y\in S_2}\|x-y\|_2 + \frac{1}{|S2|}\sum_{x\in S_2}\min_{y\in S_1}\|x-y\|_2 \quad (1)$$

The initial term assesses the completeness of the reconstructed mesh, while the subsequent term evaluates its accuracy. In the case of squared Chamfer Distance (CD2), $|x-y\|_2$ is substituted with $\|x-y\|_2^2$. The computation of the F-score adheres to its conventional definition:

$$\mathrm{F1} = \frac{2\times \text{ recall } \times \text{ precision}}{\text{recall } + \text{ precision}} \quad (2)$$

The recall and precision are calculated as:

$$\text{recall } = \frac{1}{|S_1|}\sum_{x\in S_1}\mathbf{1}\left(\left(\min_{y\in S_2}\|x-y\|_2\right) < \epsilon\right) \quad (3)$$

$$\text{precision } = \frac{1}{|S_2|}\sum_{x\in S_2}\mathbf{1}\left(\left(\min_{y\in S_1}\|x-y\|_2\right) < \epsilon\right) \quad (4)$$

Where ϵ represents a small threshold for distance, and $\mathbf{1}(\cdot)$ denotes the indicator function.

The results obtained from α-shapes [4] and ball-pivoting methods are computed using the latest `pymeshlab` [7], while Poisson Surface Reconstruction (PSR) [5] calculations are performed using `open3d` [8], with the depth parameter set to 9. We note that when comparing our proposed approach, Auto-BPA, with BPA1 [3] and BPA2 [7], we employ the same BPA algorithm for reconstructing 3D meshes using the Pymeshlab library. The distinction between these methods lies in how the radius parameter is computed. Specifically, the radius of BPA2 [7] is computed using the equation $1\% \times l_D$ with l_D is the the bounding box diagonal of a point cloud P following the same approach mentioned in CircNet [6].

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