Geometric Granularity Aware Pixel-to-Mesh Supplementary Material

1. Patching Algorithm

Pruning operation encourages holes to generate, but it leads to non-closed boundaries at the same time, which has been mentioned in Deep Mesh[3]. Figure 1 (a) shows an example mesh which outputs from the pruning module in our framework. The non-closed boundaries are marked with green lines while faces they belong to are marked as light green. Meshes with non-closed boundaries are abnormal and unable to be directly applied in rendering, rigging and other subsequent applications. In order to solve the non-closed problem, we propose a patching algorithm, which has already shown in 3.3 of the text. Given a mesh after pruning, we first detect its non-closed boundaries by a boundary detecting algorithm [1]. The principle is that the open edge only belongs to one face. So the success rate of finding non-closed boundaries is 100%. All non-closed boundaries consist of line segments connected end to end, because they are the outer contour of one or more triangles with shared sides. Therefore, detected non-closed boundaries on a mesh can be represented as a series of circles $C_1, C_2, ..., C_l$. Through massive observation and analysis, we divide non-closed boundaries which are to be repaired into two categories. Category 1 has parallel boundary and is able to form parallel pairs, such as the pair C_1, C_2 and C_3, C_4. We select boundaries of Category 1 by a Matching Pair Existence Judgment as follows:

$$dist(C_i, C_j) < \gamma \tag{1}$$

If a circle satisfies Matching Pair Existence Judgment, we think that it has a parallel circle nearby. For boundaries of Category 1, we repair them by constructing faces between parallel pairs. Specifically, for every vertex on circle, we find its corresponding vertex on another circle by minimizing Euclidean distance and connect them. After connecting operation, new faces which are triangle or quadrilateral emerge. New faces can be split into triangles by Delaney triangulation. The results are in Figure 1 (b).

If the boundary does not satisfy the Matching Pair Existence Judgment 1, like C_5 in Figure 2 (a) it will be classified as the Category 2. Boundaries of Category 2 have no parallel circle and they vary greatly between different models. The common characteristic of various Category 2 circles is that the turning points are critical points of the model's different parts. We divide the circle into multiple sections by turning points. Then connecting adjacent turning points, which are $P_1, P_2, ..., P_8$ in Figure 2 (a), we can get five new circles. Finally, find the center of every new circle and connect it with every point on the circle, we can add faces to the circles and repair the non-closed boundaries. The result of Category 2 is shown in Figure 2 (b). The turning points here are found by the change of the curvature on the circle along one direction. For rare models with complex circle changing, we design an interactive tool to modify turning points manually.

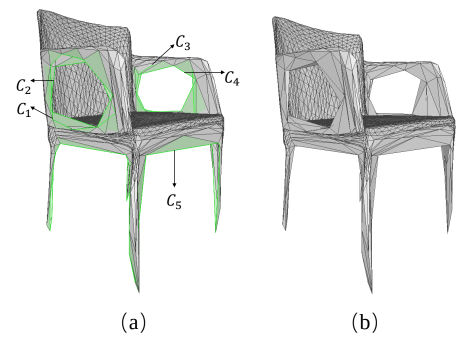

Figure 1. The side view of a chair. (a) Before repairing (b)After repairing

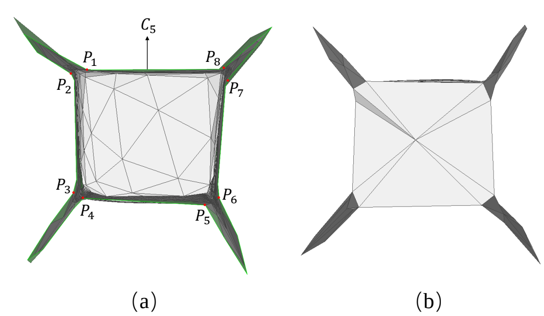

Figure 2. The bottom view of a chair. (a) Before repairing (b)After repairing

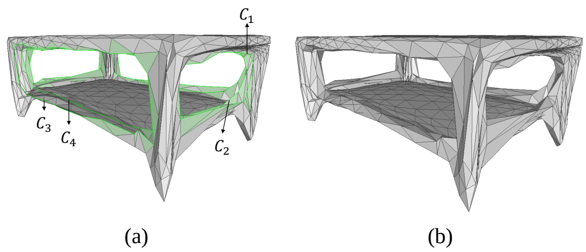

Figure 3. The side view of a table. (a) Before repairing (b) After repairing

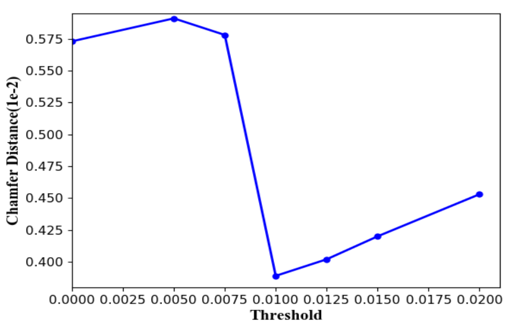

Figure 4. Ablation study on the threshold of pruning

Another example is shown in Figure 3. The table has four holes, each of which belongs to Category 1. Using the patching algorithm we proposed, the abnormal mesh in Figure 3 (a) can be transformed into the model in Figure 3 (b). In order to display the repaired closed meshes clearly, we upload a video in the archive.

2.Ablation studies on the thresholds of super-resolution and pruning

The thresholds of super-resolution and pruning are related variables, which means we cannot explore them at a same time. Therefore, through several sets of random experiments, we set the super-resolution thresholds empirically and study the impact of the pruning threshold. When setting the super-resolution thresholds, we mainly refer to the number of faces. Although the accuracy may be more high if the faces is more, we keep the number of faces within 10,000 to guarantee the complexity of the model. Then, setting the $\tau_1 = 0.001$, $\tau_2 = 0.01$, we test the corresponding suitable pruning thresholds on the reconstruction of chairs. Figure 4 shows the results, which indicates that pruning threshold $\tau = 0.01$ is a good choice.

3. Ablation study of the GSE module

According to Tab2 in the paper, local geometry structure constraint can improve the surface details of reconstruction

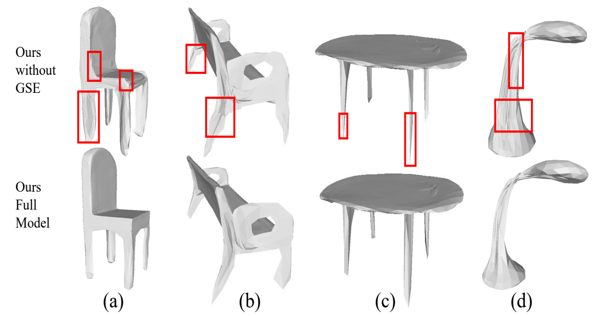

Figure 5. Ablation study of the GSE module. The red box highlights areas where details are well learned.

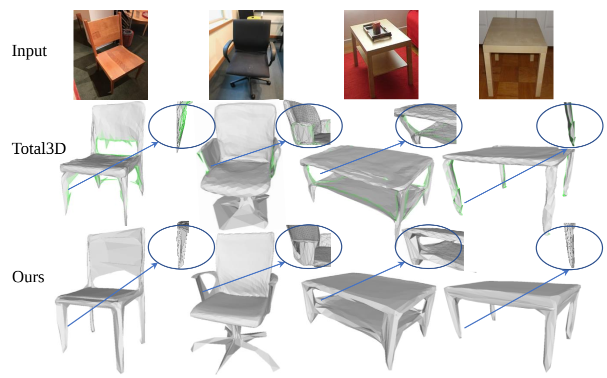

Figure 6. Comparisons on Pix3D. Non-closed boundaries are highlighted with green

details. In order to validate the effectiveness of geometry structure extractor(GSE), we show the qualitative results in Figure 5. The red box highlights areas where details are not well learned without GSE. The results show that GSE can make the edges more sooth and restore more information in corners.

4. Reconstruction results on Pix3D

We also train our model on real dataset Pix3D [4] and compare with the reconstruction module of the Total3DUnderstanding [2], which is an extension of DeepMesh [3]. The input is the images with masks. Some test results are shown in Figure 6. Comparing with Total3D, our results perform better in local geometries, including the reconstructed structures and the fine-grained prune on the error faces. Besides, we avoid non-closed boundaries, being adaptive to downstream tasks.

References

[1] Marco Attene, Marcel Campen, and Leif Kobbelt. Polygon mesh repairing: An application perspective. *ACM Computing Surveys (CSUR)*, 45(2):1–33, 2013.

[2] Yinyu Nie, Xiaoguang Han, Shihui Guo, Yujian Zheng, Jian Chang, and Jian Jun Zhang. Total3dunderstanding: Joint layout, object pose and mesh reconstruction for indoor scenes from a single image. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pages 55–64, 2020.

[3] Junyi Pan, Xiaoguang Han, Weikai Chen, Jiapeng Tang, and Kui Jia. Deep mesh reconstruction from single rgb images via topology modification networks. In *Proceedings of the IEEE/CVF International Conference on Computer Vision*, pages 9964–9973, 2019.

[4] Xingyuan Sun, Jiajun Wu, Xiuming Zhang, Zhoutong Zhang, Chengkai Zhang, Tianfan Xue, Joshua B Tenenbaum, and William T Freeman. Pix3d: Dataset and methods for single-image 3d shape modeling. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pages 2974–2983, 2018.