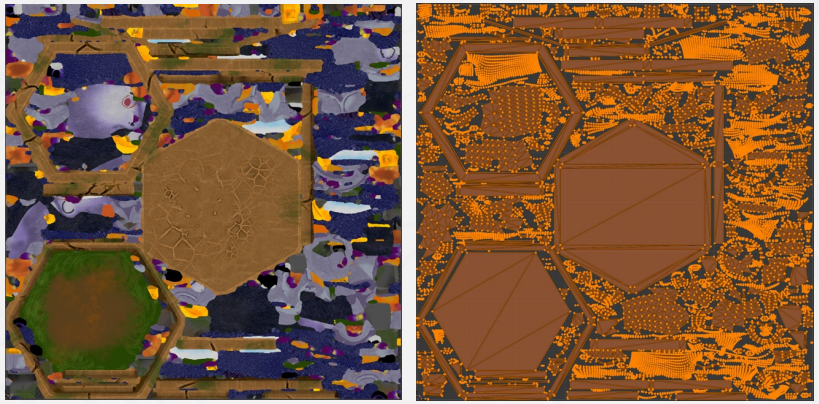
不保纹理的减面算法

不保纹理的减面算法



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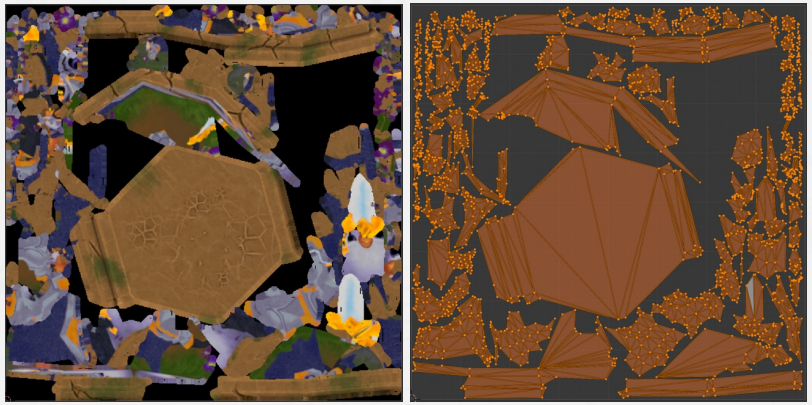

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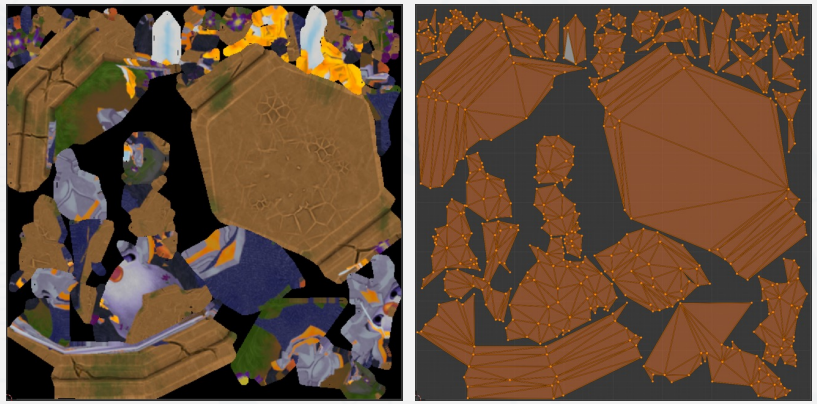

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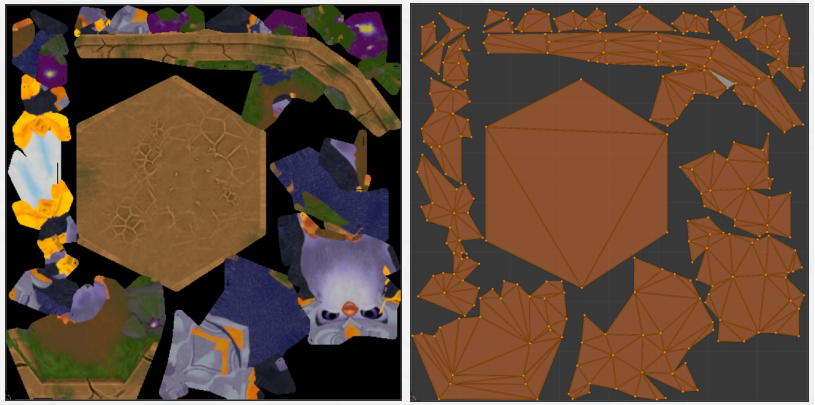

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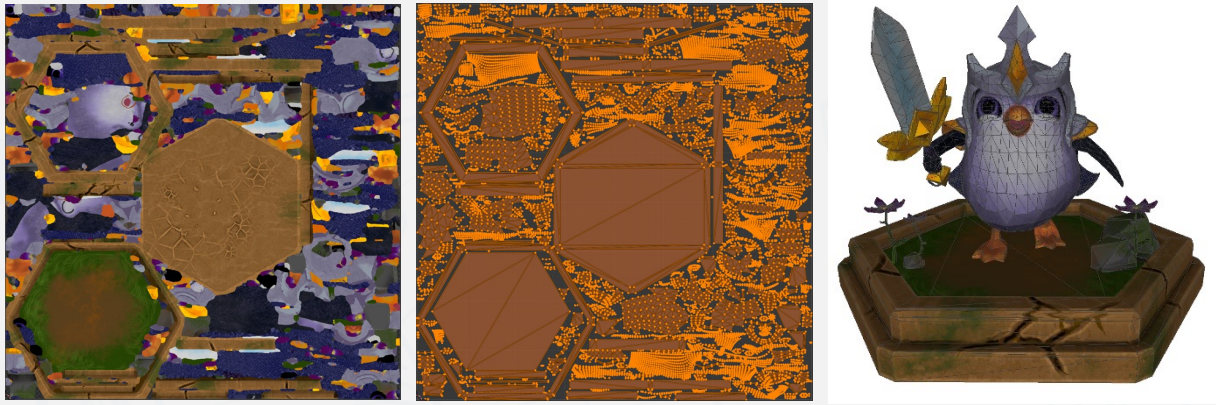
不保纹理的减面算法

Step 1 重新网格化

Step 2 展UV

Step 3 纹理烘焙



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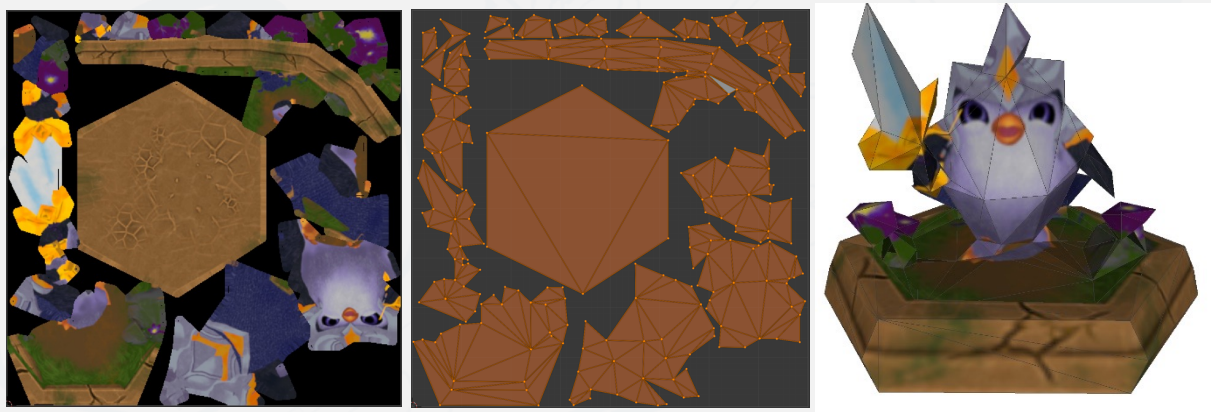

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不保纹理的减面算法

Step 1 重新网格化

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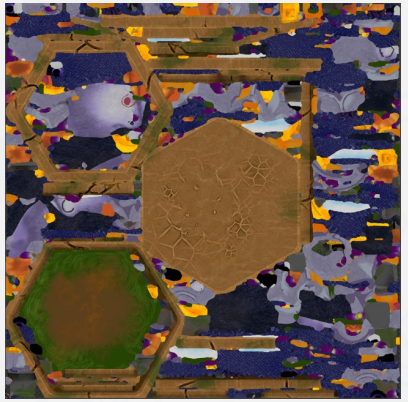
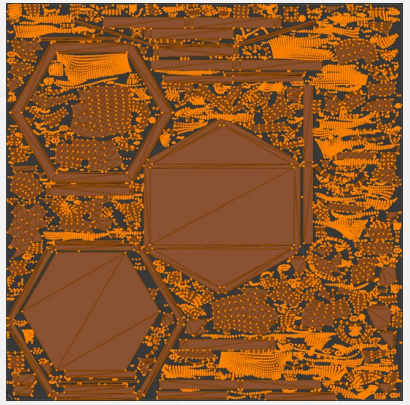

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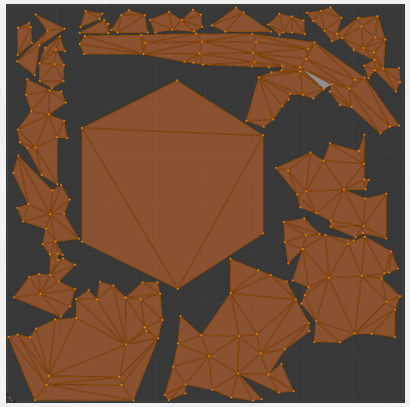

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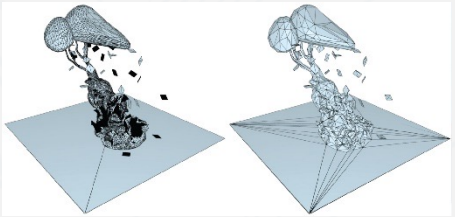
不保纹理的减面算法 – 重新网格化

[Xavier et al, 2003]

[Botsch et al, 2004]

[Nan et al, 2017]

[Gao et al. 2022]



[Zhen et al, 2023]

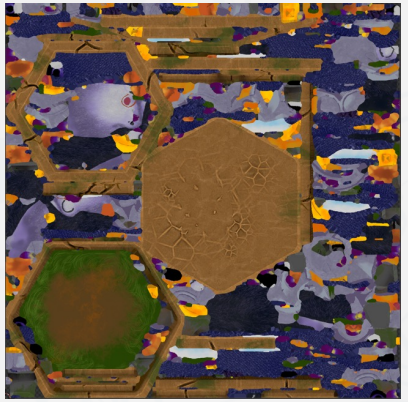
- [Xavier et al, 2003] Xavier Décoret, Frédo Durand, François X. Sillion, and Julie Dorsey, “Billboard clouds for extreme model simplification,” ACM Trans. Graph. (July 2003), 2003.
- [Botsch et al, 2004] M. Botsch and L. Kobbelt, “A remeshing approach to multiresolution modeling,” In Proceedings of the 2004 Eurographics/ACM SIGGRAPH symposium on Geometry processing, 2004.
- [Nan et al, 2017] Liangliang Nan and Peter Wonka. PolyFit: Polygonal Surface Reconstruction from Point Clouds. ICCV 2017.
- **[Gao et al. 2022] Xifeng Gao, Kui Wu, Zherong Pan, "Low-poly Mesh Generation for Building Models," Proceedings of SIGGRAPH, 2022.**
- [Zhen et al, 2023] Zhen Chen, Zherong Pan, Kui Wu, Etienne Vouga, Xifeng Gao, “Robust Low-Poly Meshing for General 3D Models”, ACM Transactions on Graphics (Proceedings of SIGGRAPH 2023), 2023

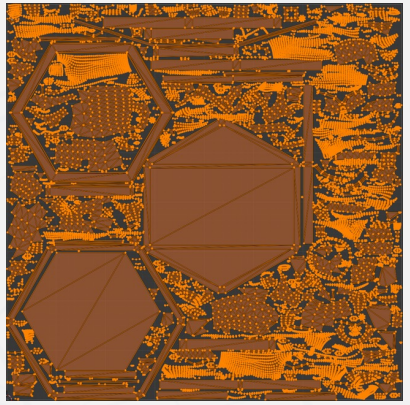
不保纹理的减面算法

Step 1 重新网格化

Step 2 展UV

Step 3 纹理烘焙





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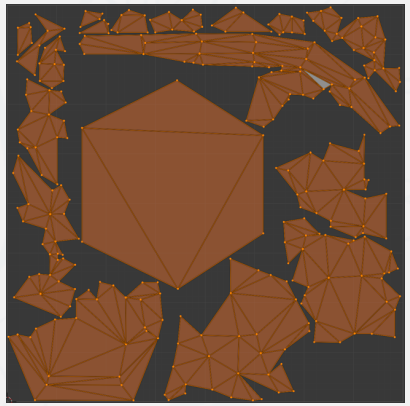

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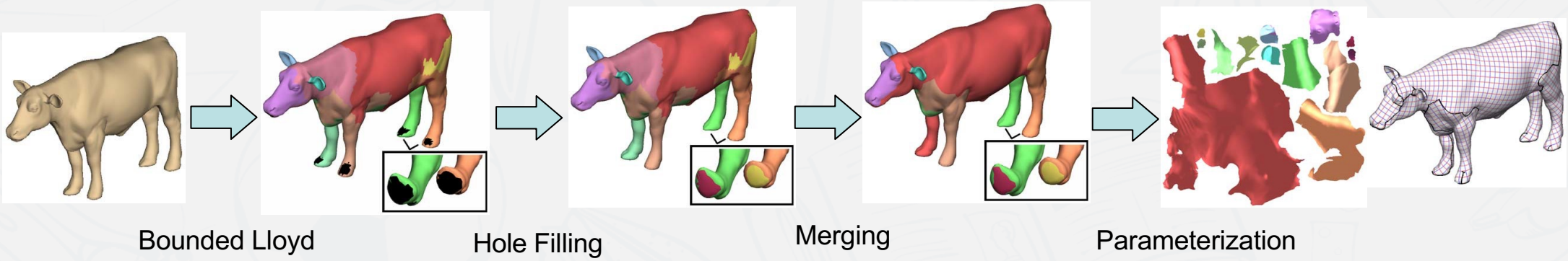
不保纹理的减面算法 – 展UV



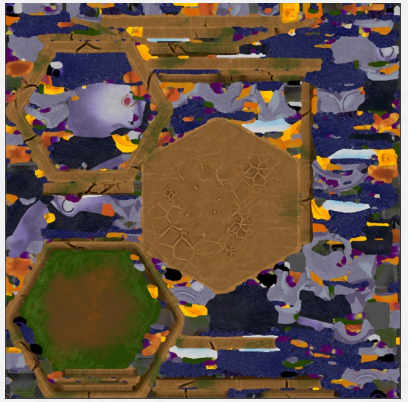
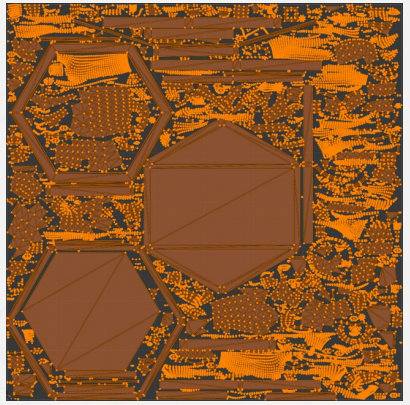
- K. Hormann, B. Lévy, and A. Sheffer. Mesh Parameterization: Theory and Practice
- P. Sander, Z. Wood, S. Gortler, J. Snyder, and H. Hoppe. Multi-Chart Geometry Images
- **D. Julius, V. Kraevoy, and A. Sheffer. D-Charts: Quasi-Developable Mesh Segmentation**
- B. Lévy, S. Petitjean, N. Ray, and J. Maillot. Least Squares Conformal Maps for Automatic Texture Atlas Generation
- O. Sorkine, D. Cohen-Or, R. Goldenthal, and D. Lischinski. Bounded-distortion Piecewise Mesh Parameterization
- Michael Rabinovich, Roi Poranne, Daniele Panozzo, Olga Sorkine-Hornung, “Scalable Locally Injective Mappings,”, ACM Transactions on Graphics, 2017
- Jian-Ping Su, Chunyang Ye, Ligang Liu, Xiao-Ming Fu, “Efficient Bijective Parameterizations”, ACM Transactions on Graphics (SIGGRAPH), 39(4), 2020.

不保纹理的减面算法

Step 1 重新网格化

Step 2 展UV

Step 3 纹理烘焙

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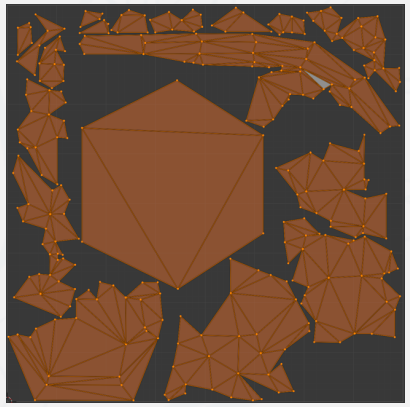

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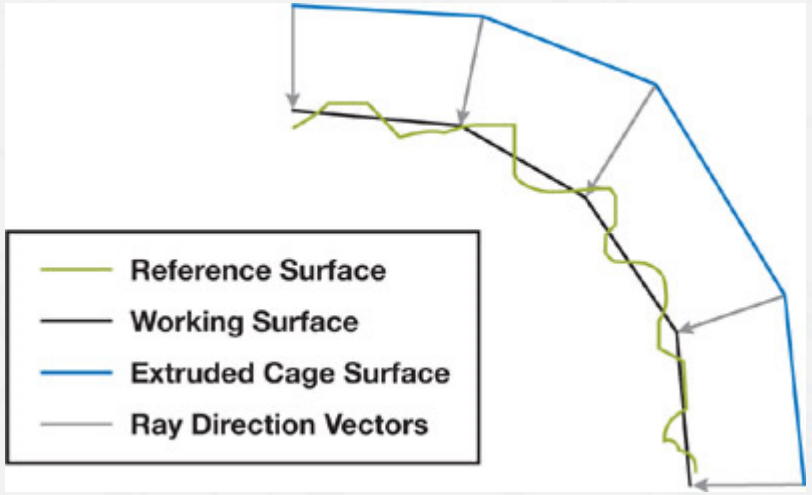
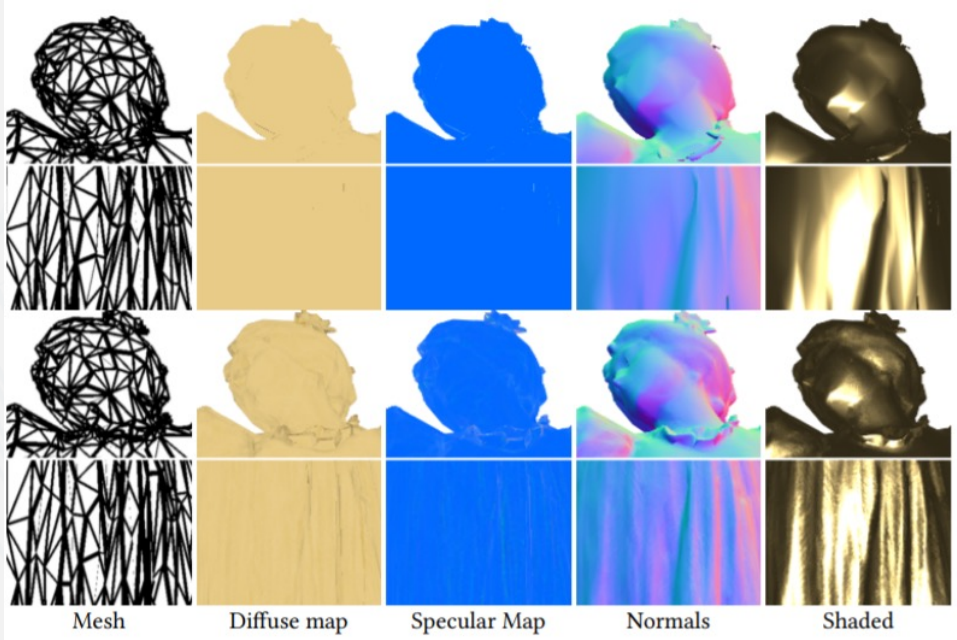
不保纹理的减面算法 – 纹理烘焙



[Ray Casting]



[Differentiable Rendering]

- **Alain Galvan and Jeff Russell, “A Ray Casting Technique for Baked Texture Generation,” GPU Zen 2, Chapter baked texture generation, 2019**
- **Jon Hasselgren, Jacob Munkberg, Jaakko Lehtinen, Miika Aittala and Samuli Laine, “Appearance-Driven Automatic 3D Model Simplification”, Eurographics Symposium on Rendering 2021**

不保纹理的减面算法

Step 1 重新网格化

Step 2 展UV

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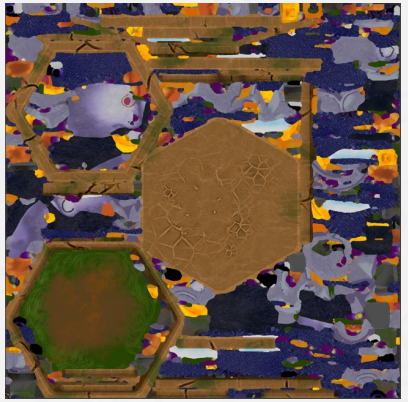
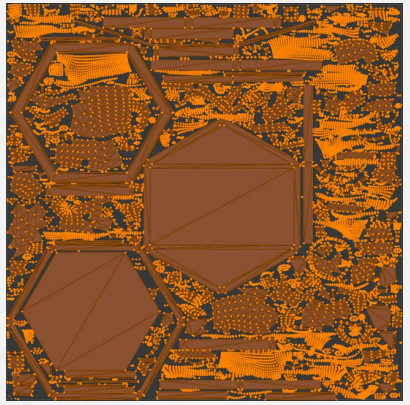

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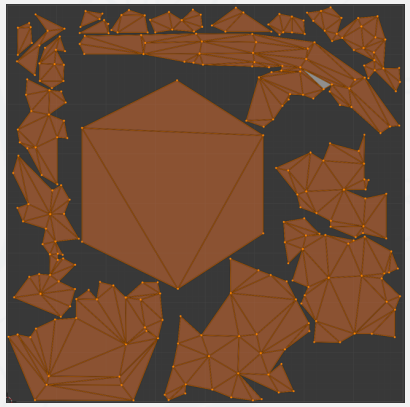

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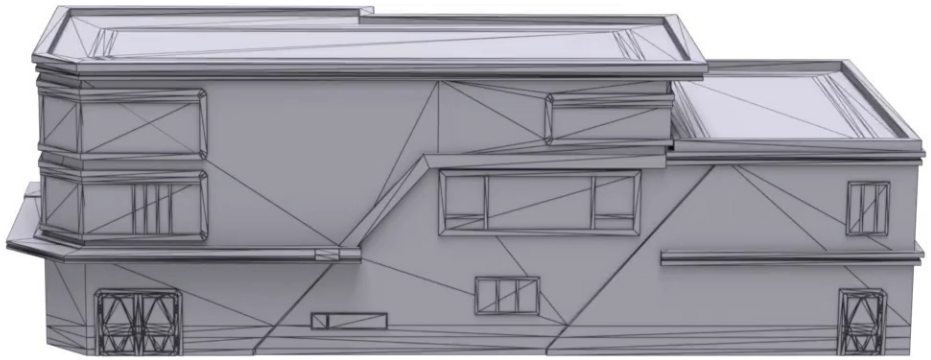
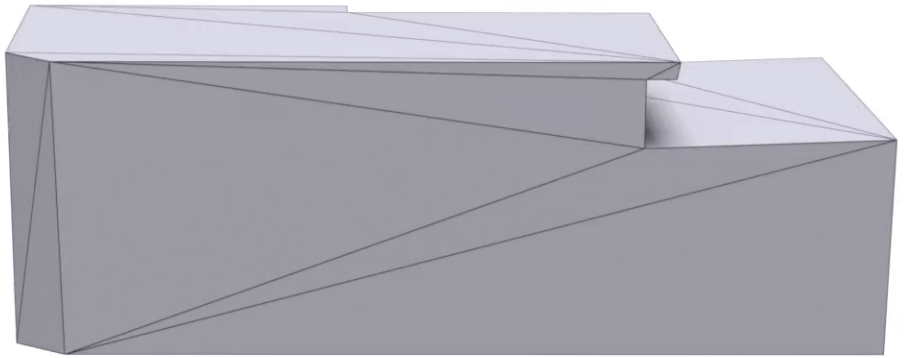
重新网格化：要求

5502 Triangles



78 Triangles

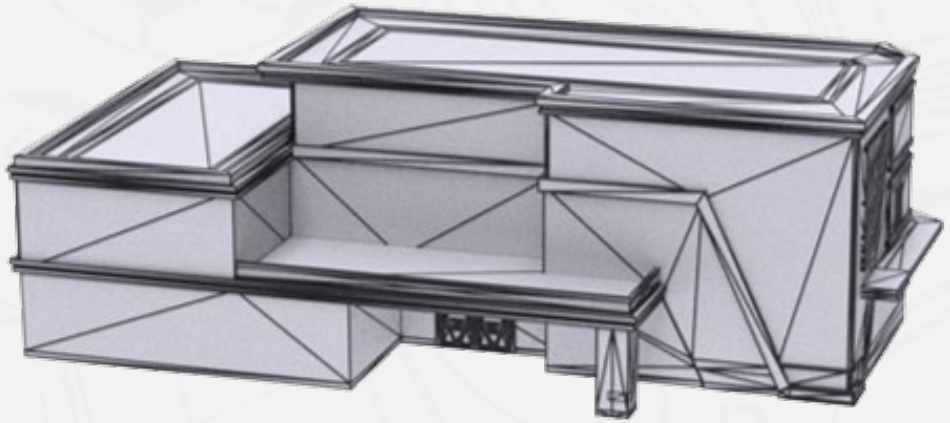


- Preserve visual appearance
- Has a small number of triangles

- Has a clean topology and geometry

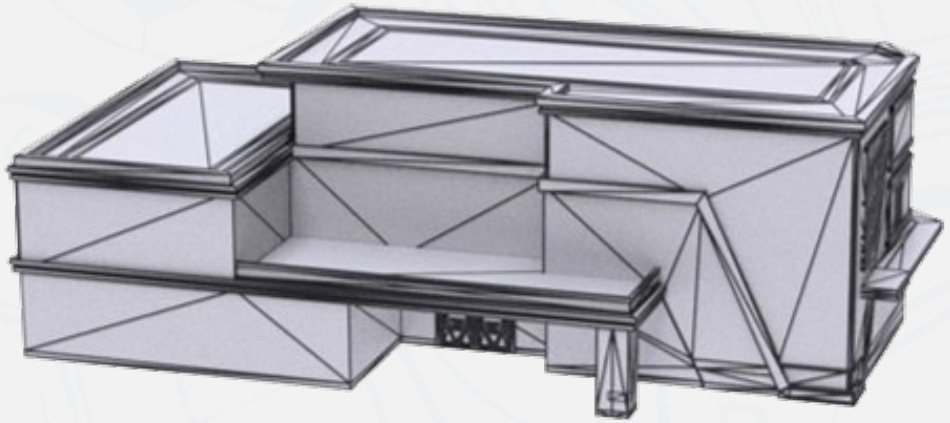
重新网格化：挑战

Building models in games often looks simple and nice but have very complex geometry and topology

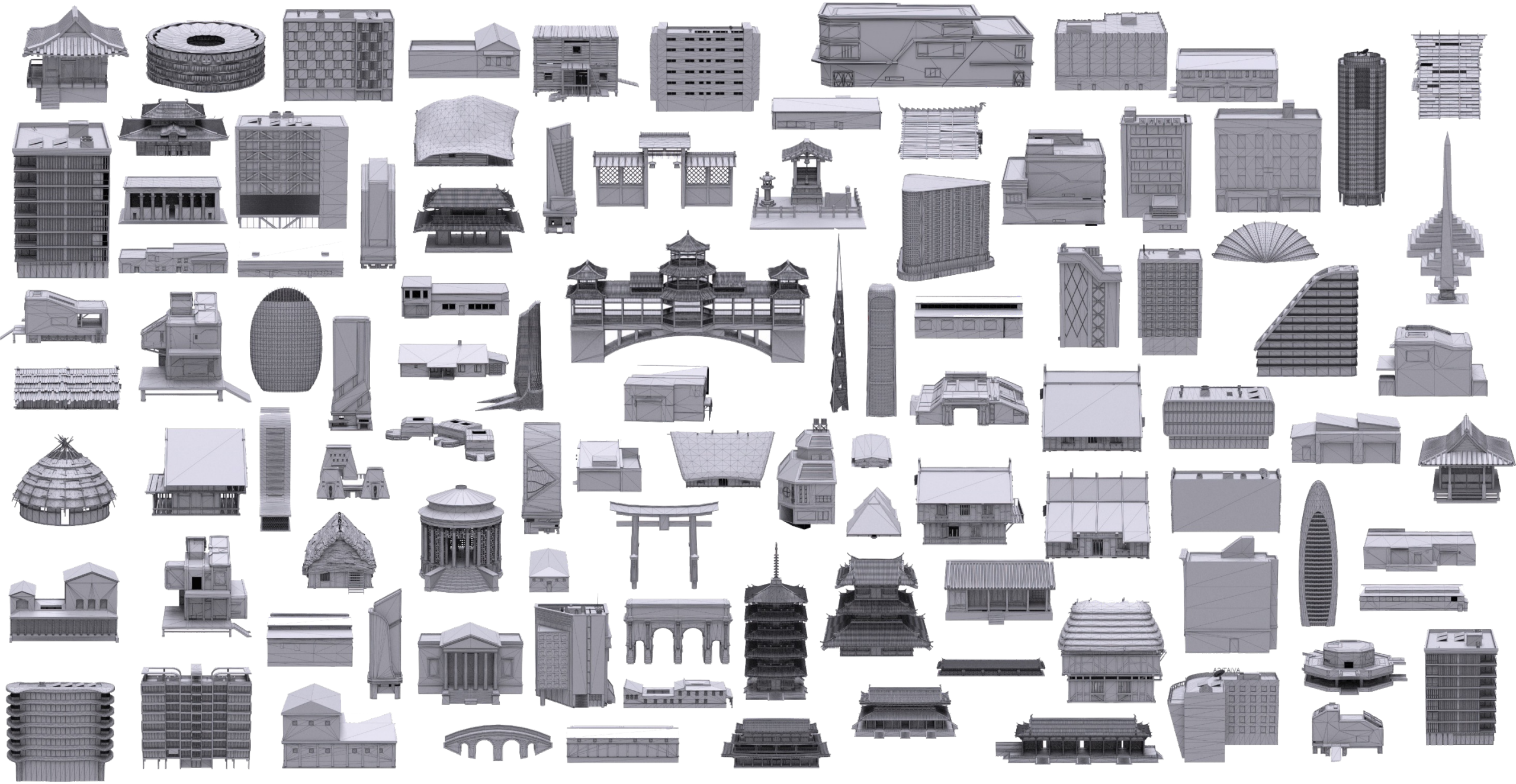


重新网格化：挑战

Building models in games often looks simple and nice but have very complex geometry and topology



- 6K Triangles
- 151 components
- 5K intersected tri-pairs
- Non-manifold
- Big and small holes

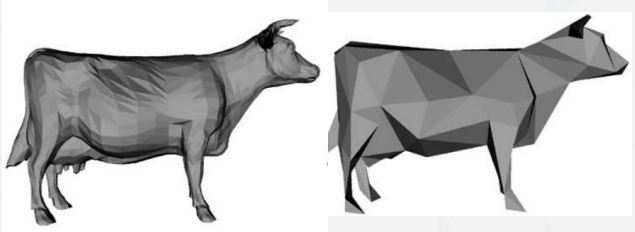


重新网格化：具体实践

- Artists spend **weeks** to craft the low-poly models

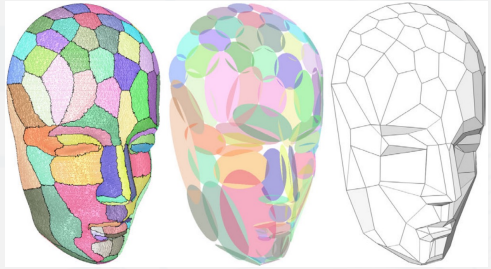
重新网格化：现有工业界方案

重新网格化：现有学术界方案

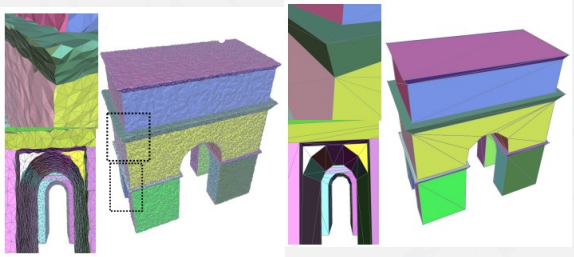


[Garland et al., SIGGRAPH 1997]

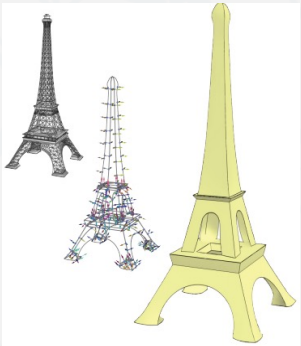
MeshLab



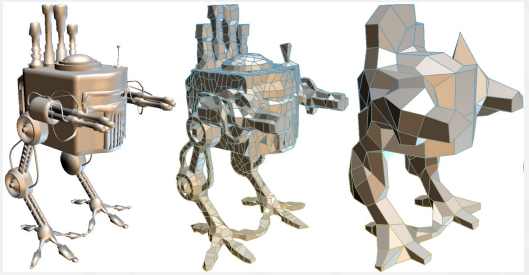
[Steiner et al., TOG 2004]



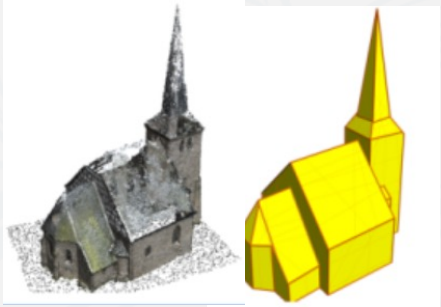
[Salinas et al., CGF 2015]



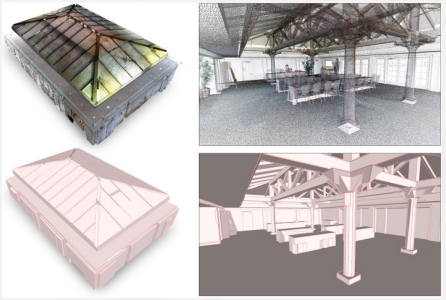
[Mehra et al., SIGGRAPH ASIA 2009]



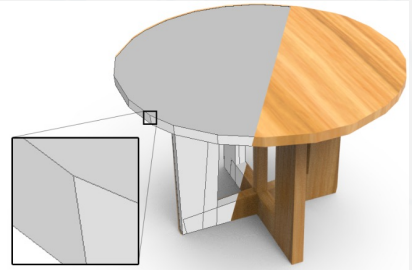
[Calderon et al., SIGGRAPH 2017]



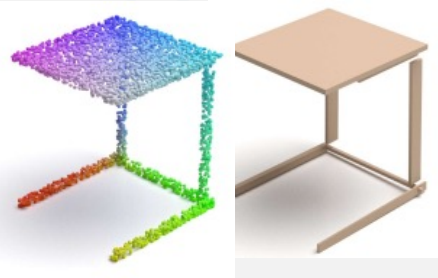
[Nan et al., ICCV 2017]



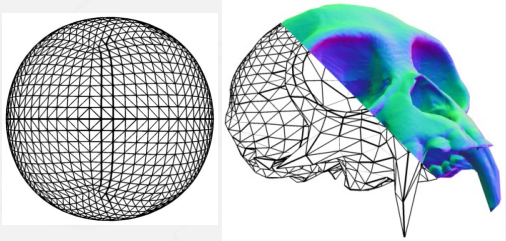
[Bauchet et al., TOG 2020]



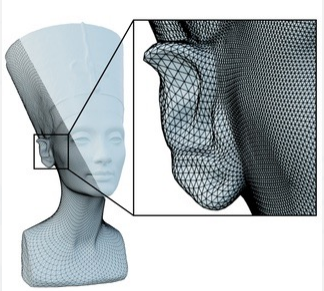
[Chen et al., CVPR 2020]



[Yang et al., TOG 2021]



[Hasselgren et al., EGSR 2021]



[Nicolet et al., TOG 2021]

重新网格化：问题很难

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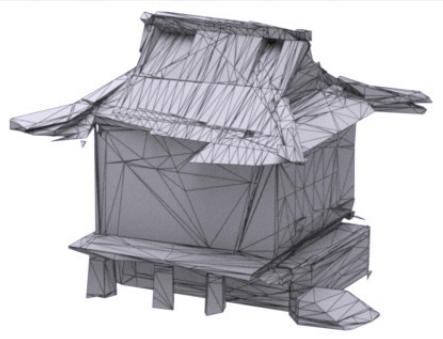

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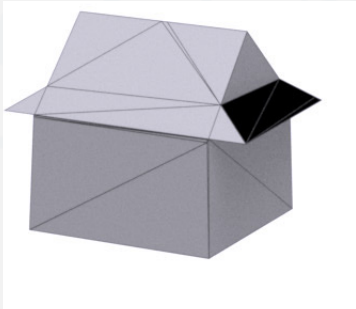

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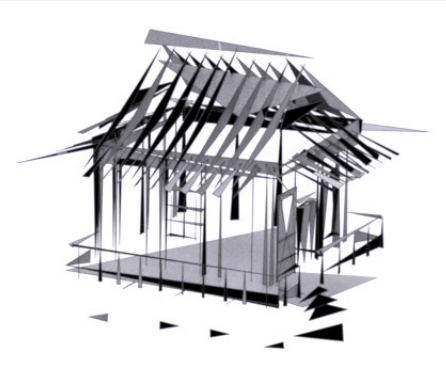
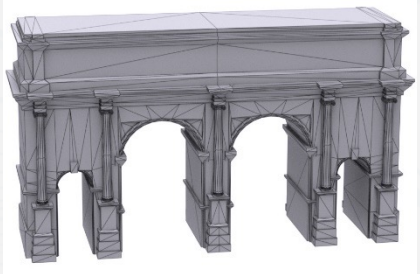


376

Crashed



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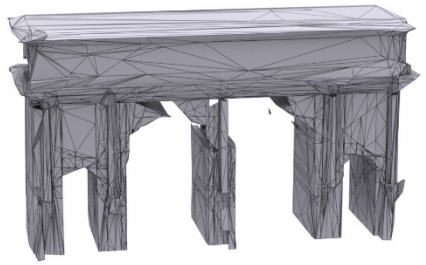

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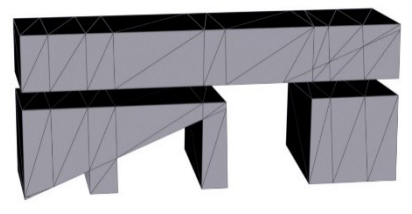
KSR

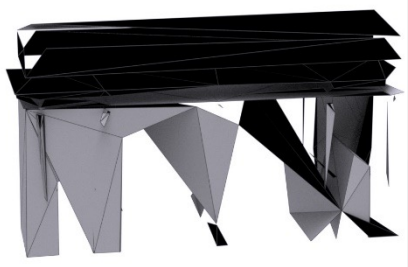


196

PolyFit

1941

Blender



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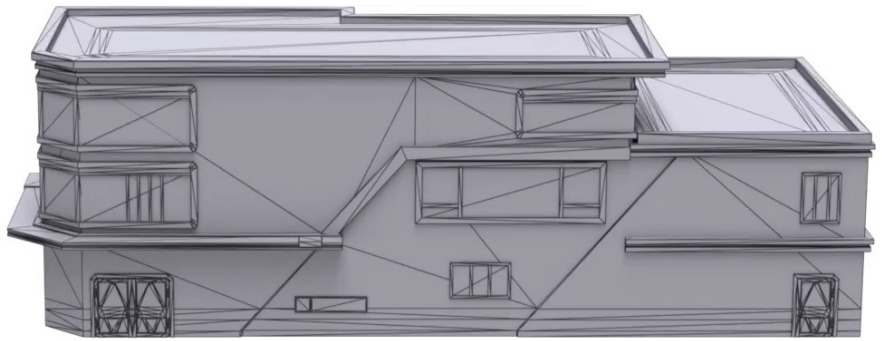
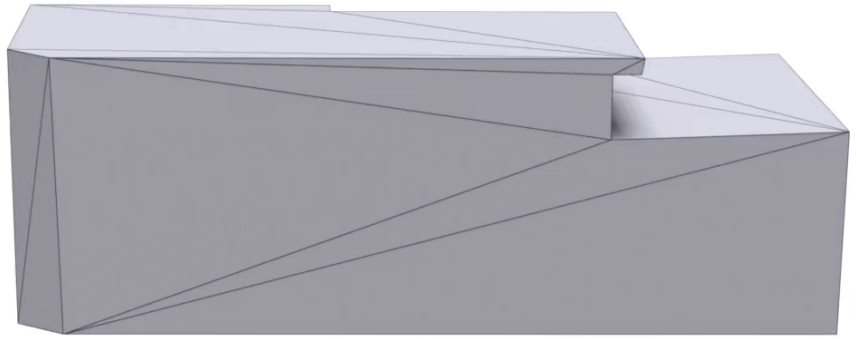
SPRED

重新网格化：我们的方法



Input: 5502 Triangles



Low-poly: 78 Triangles

Xifeng Gao, Kui Wu, Zherong Pan, "Low-poly Mesh Generation for Building Models," Proceedings of SIGGRAPH, 2022.

重新网格化：方法设计原则

- Embed the visual preservation throughout our method

重新网格化：方法设计原则

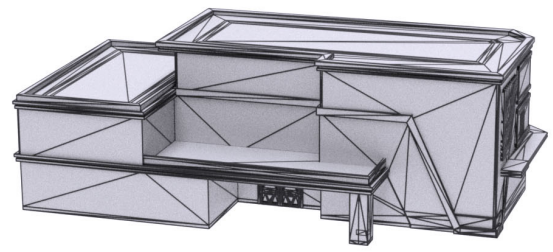
- Embed the visual preservation throughout our method
- Using **visual hull** to generate a visual-preserving and clean **proxy mesh** first

重新网格化：方法设计原则

- Embed the visual preservation throughout our method
- Using **visual hull** to generate a visual-preserving and clean **proxy mesh** first
- then obtain the low-poly through **simplification**

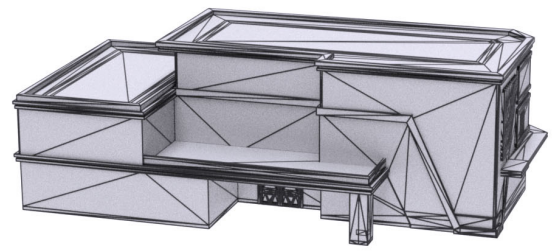
重新网格化：我们的方法

Input

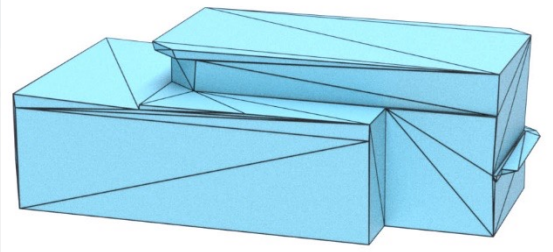


重新网格化：我们的方法

Input

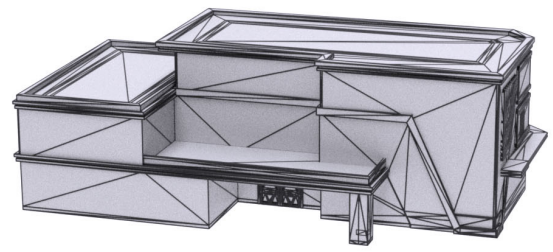


Visual Mesh

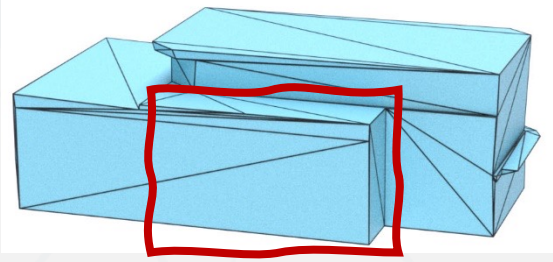


重新网格化：我们的方法

Input

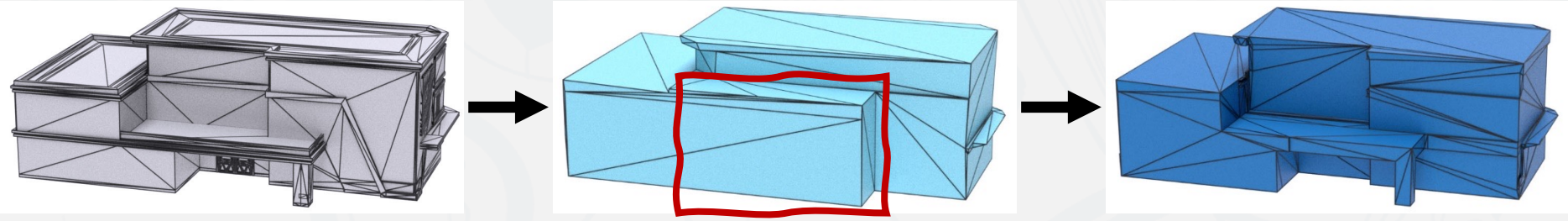


Visual Mesh



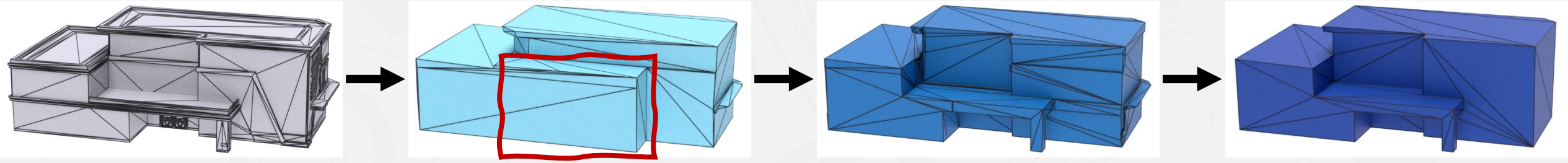
重新网格化：我们的方法

Input **Visual Mesh** **Carved Mesh**

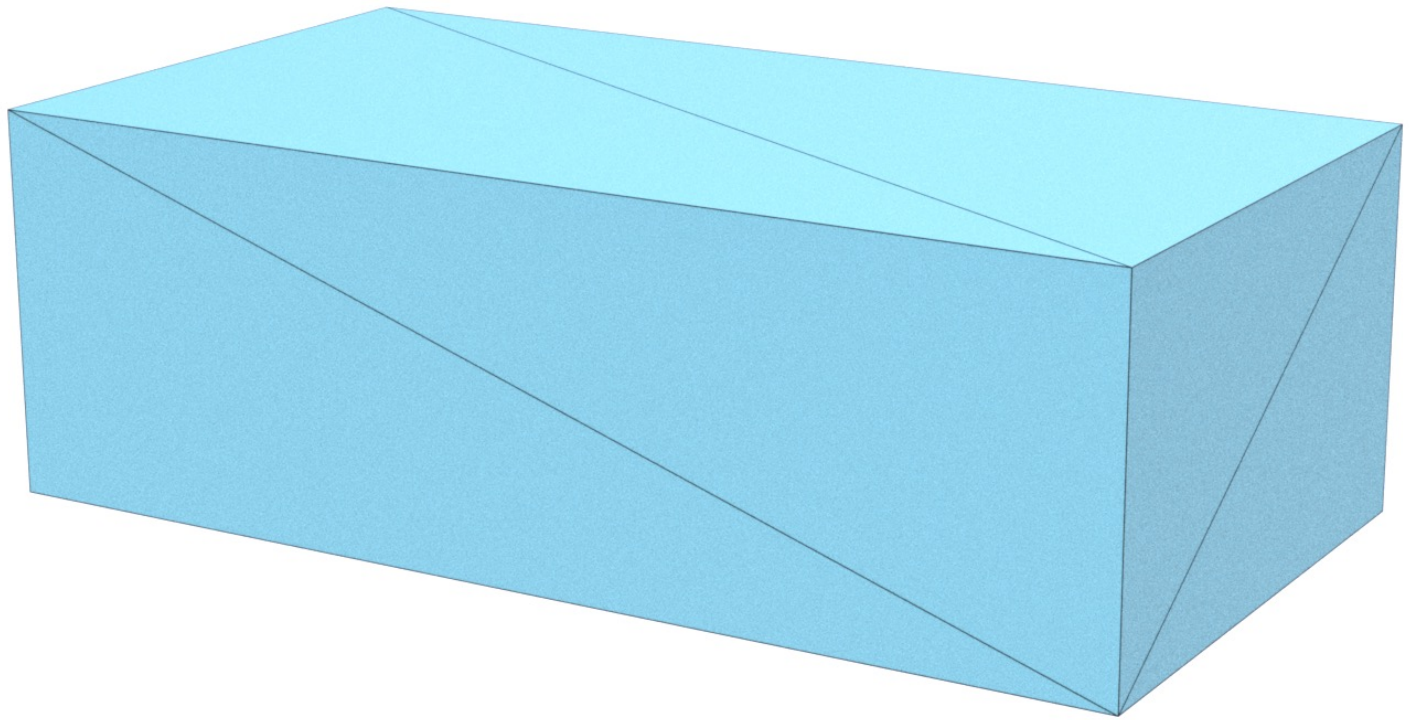


重新网格化：我们的方法

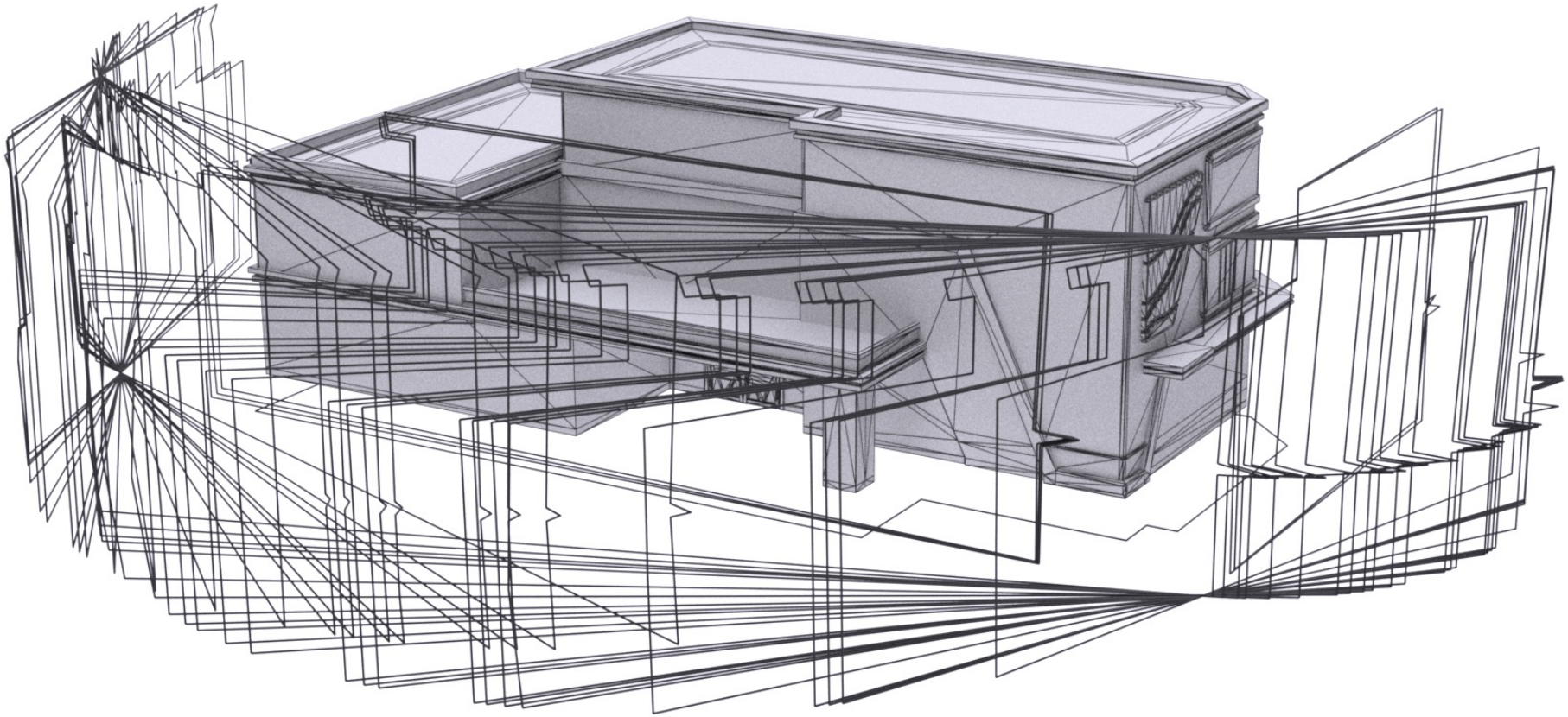
Input **Visual Mesh** **Carved Mesh** **Simplified Mesh**



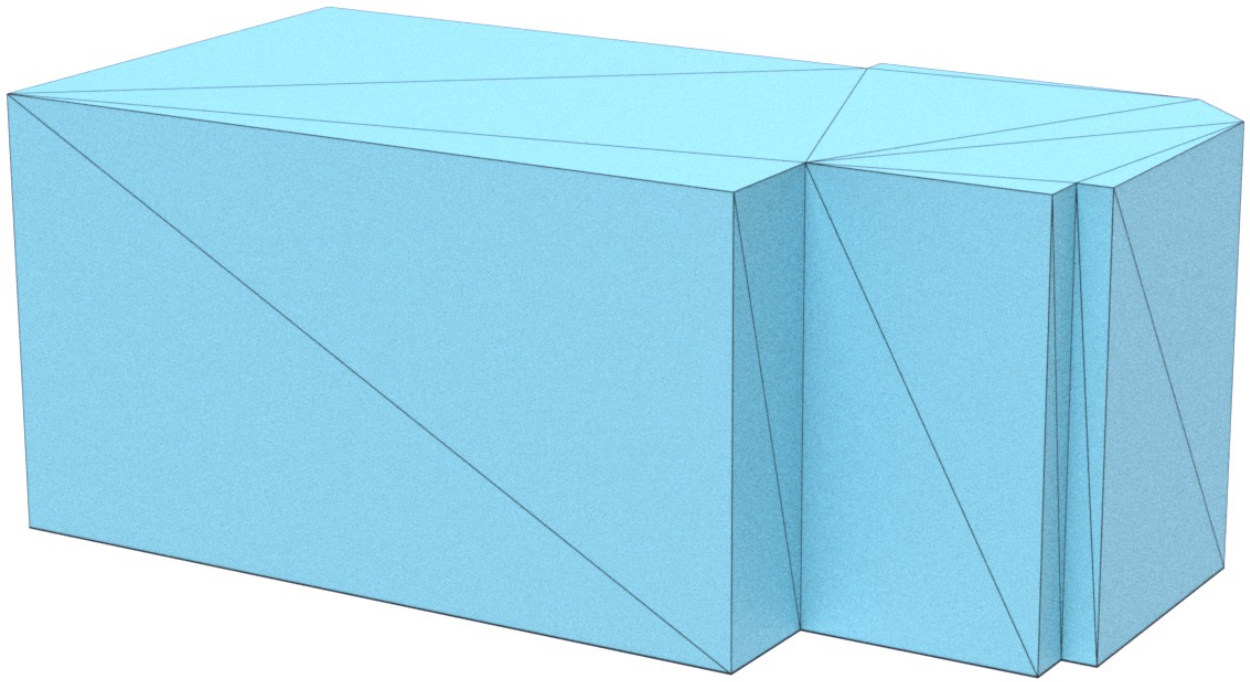
Visual Mesh Generation



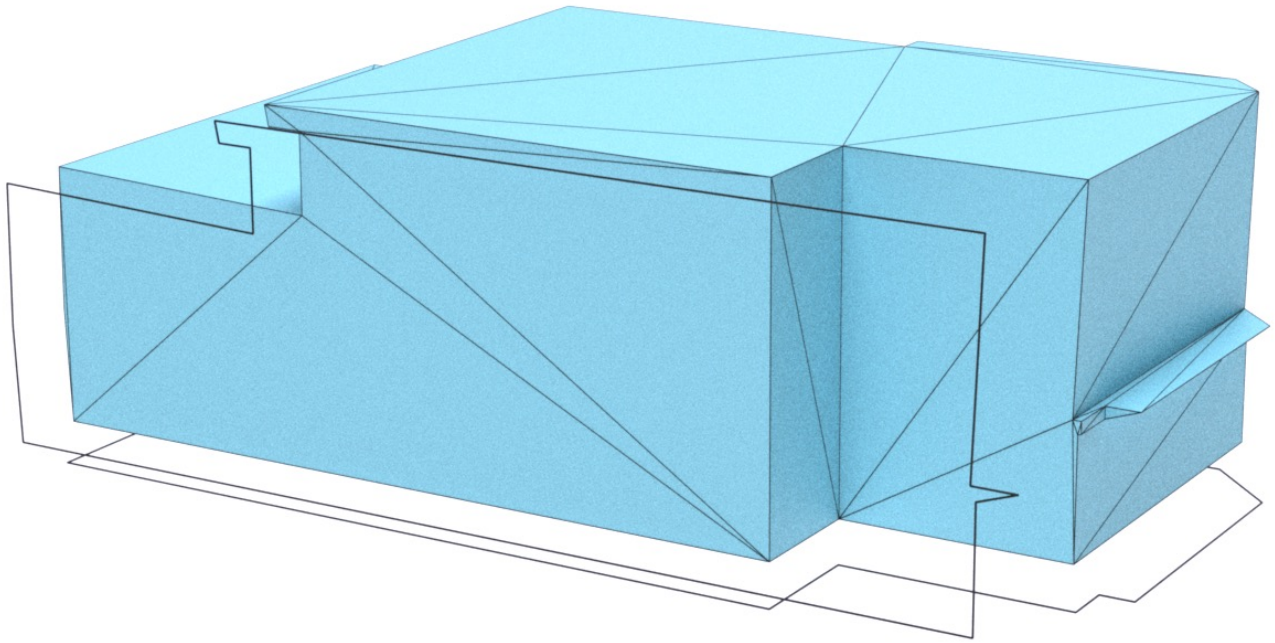
Visual Mesh Generation



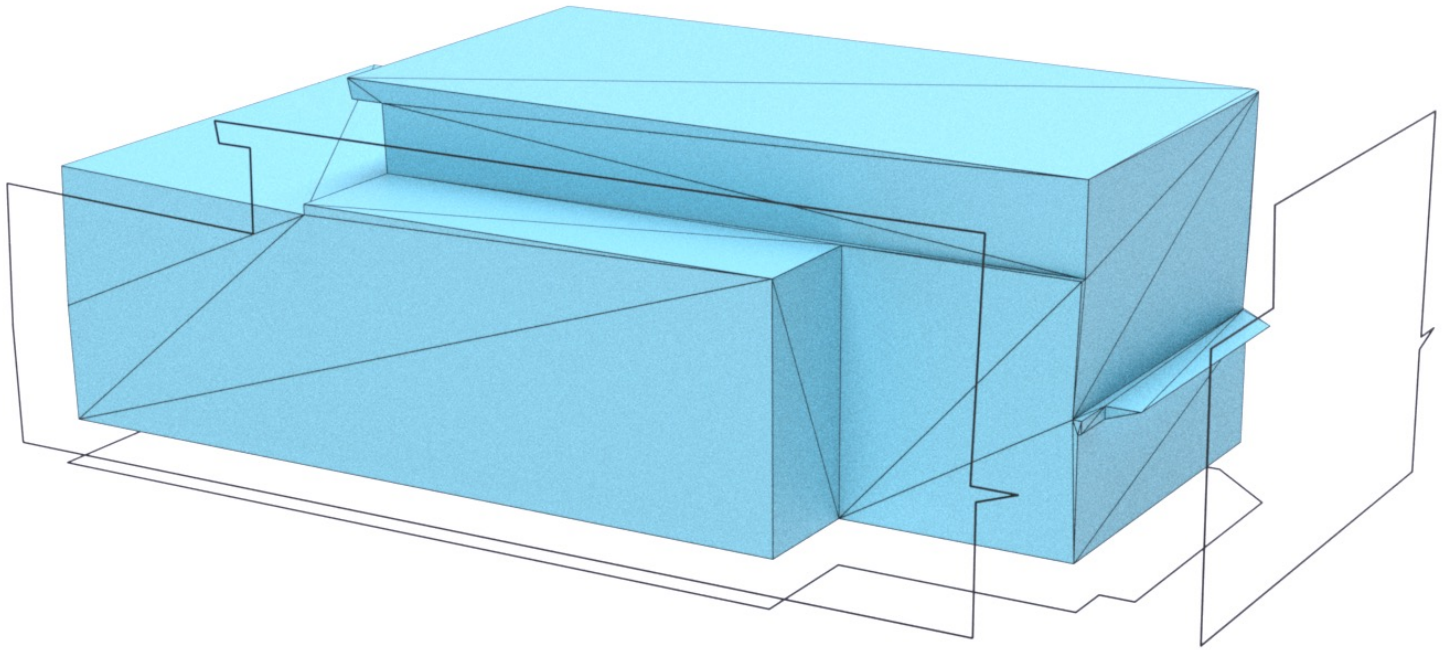
Visual Mesh Generation



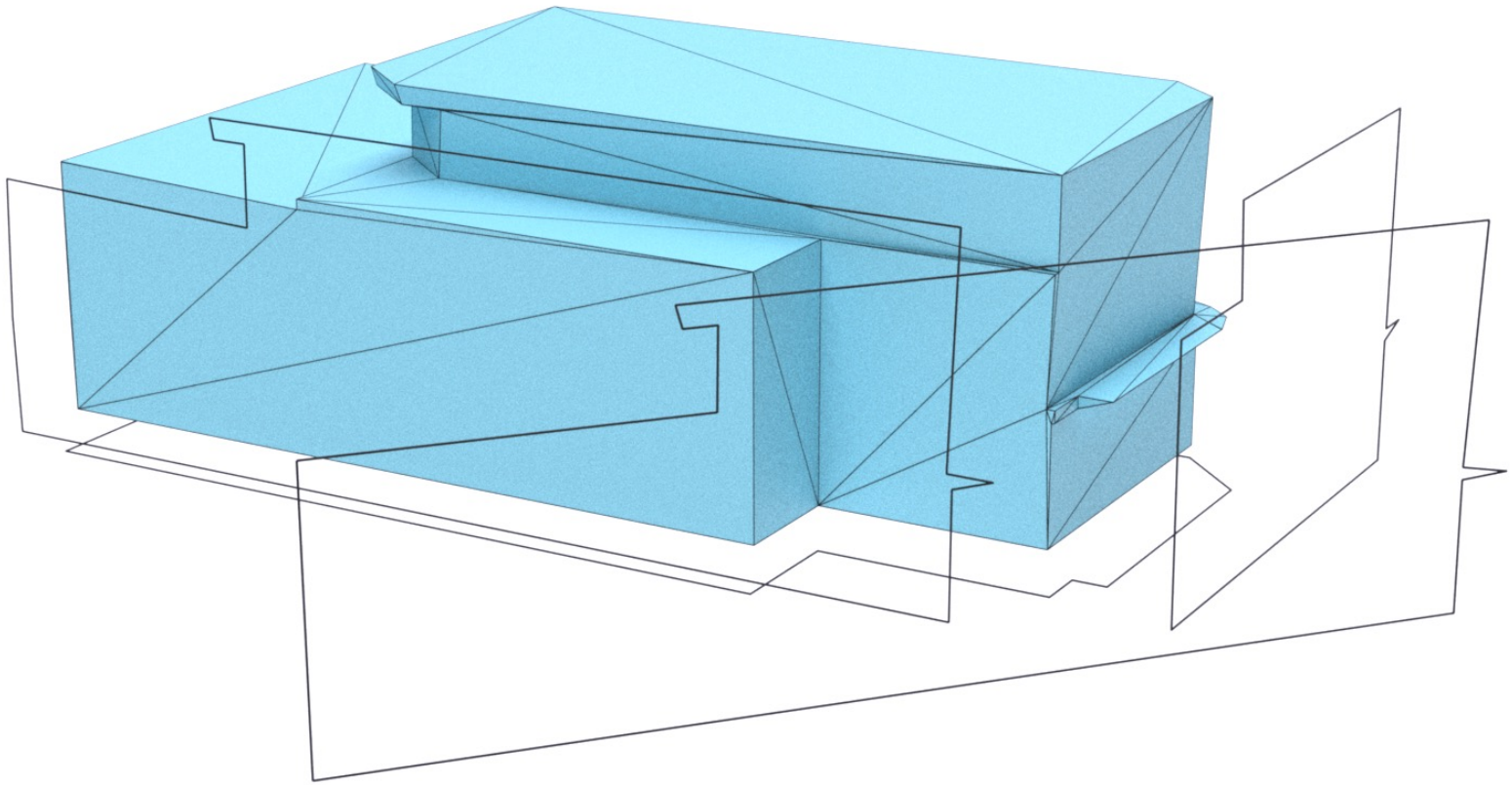
Visual Mesh Generation



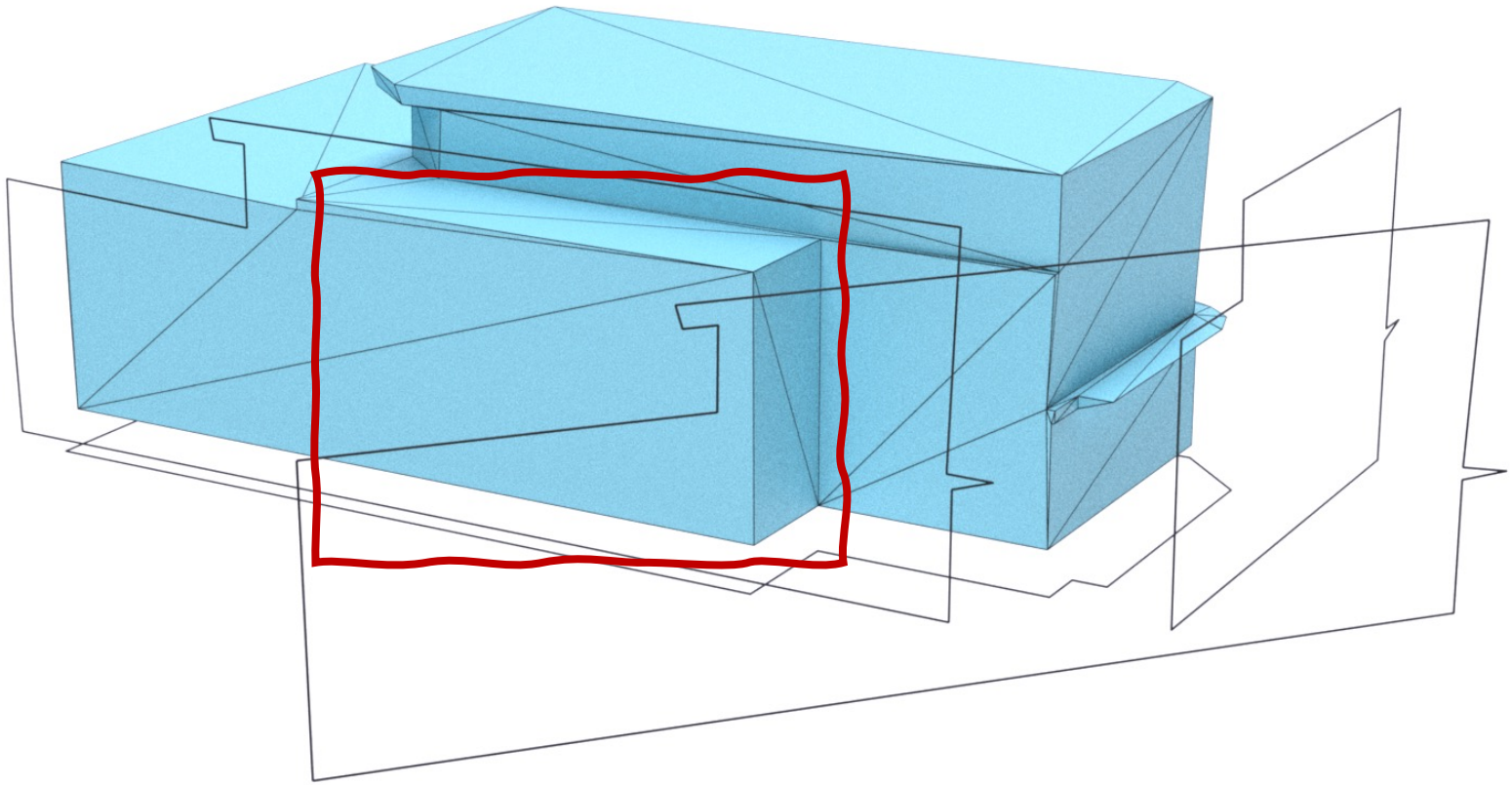
Visual Mesh Generation



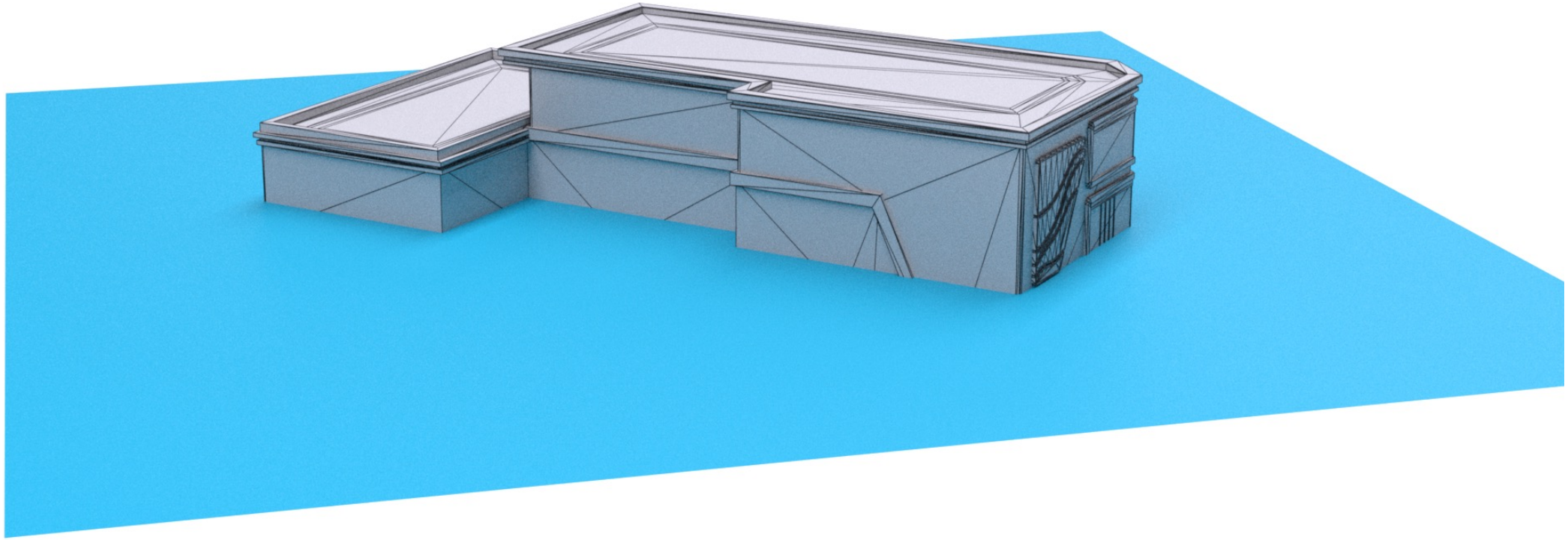
Visual Mesh Generation



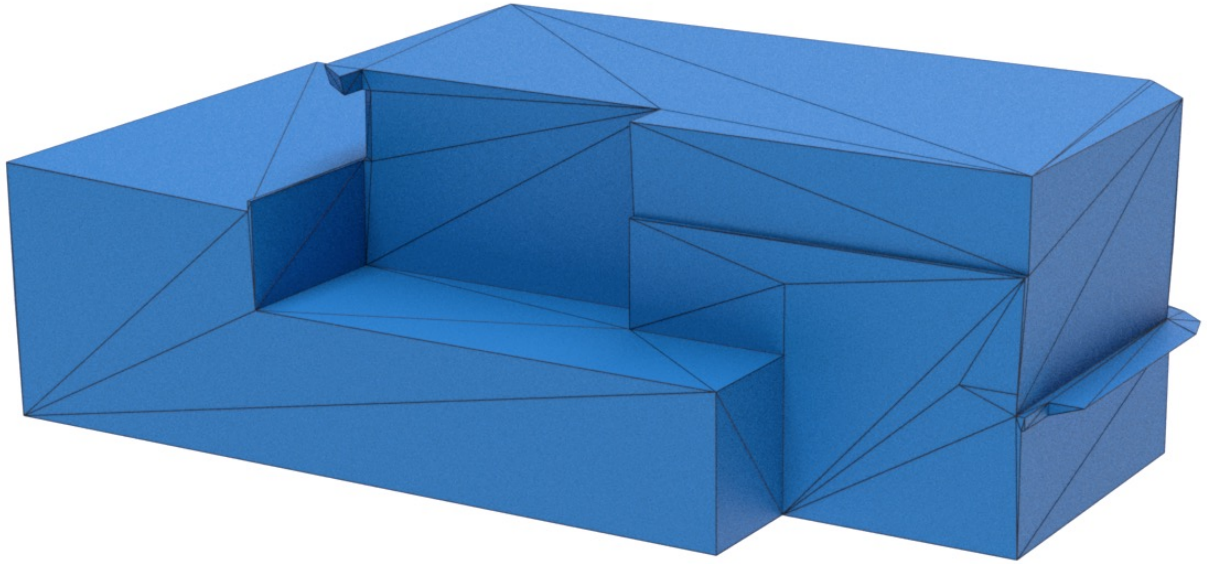
Visual Mesh Generation



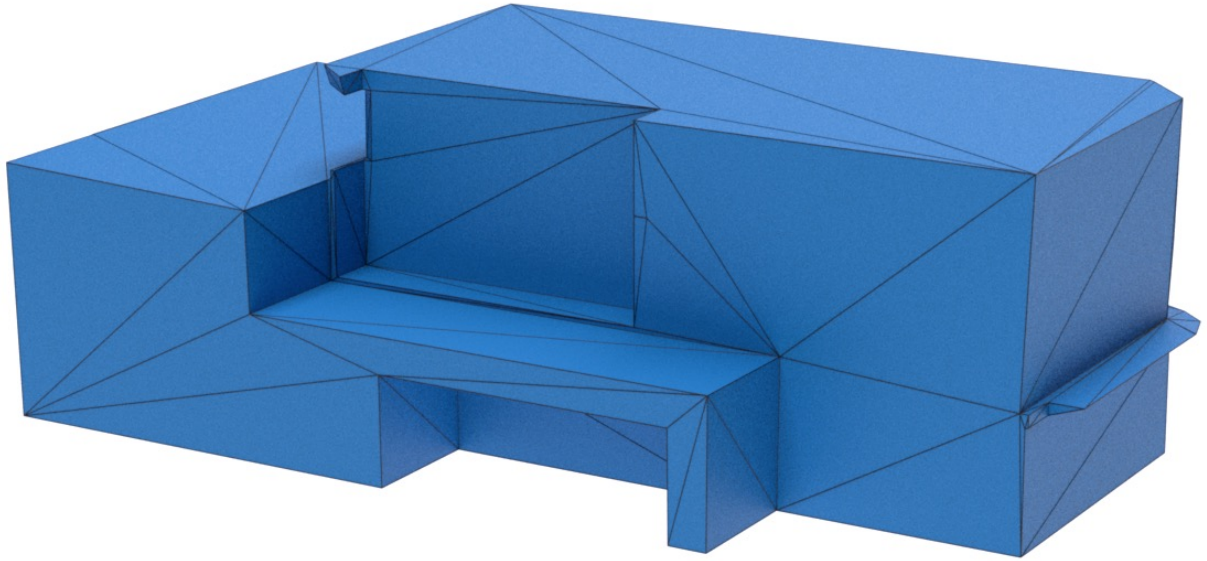
Carved Mesh Generation



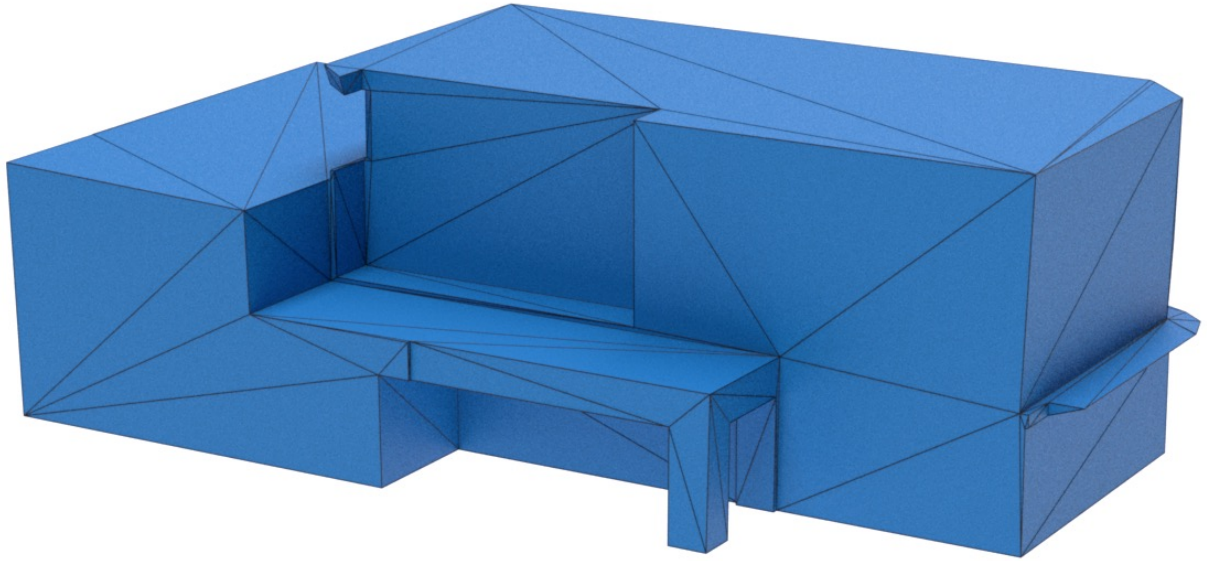
Carved Mesh Generation



Carved Mesh Generation



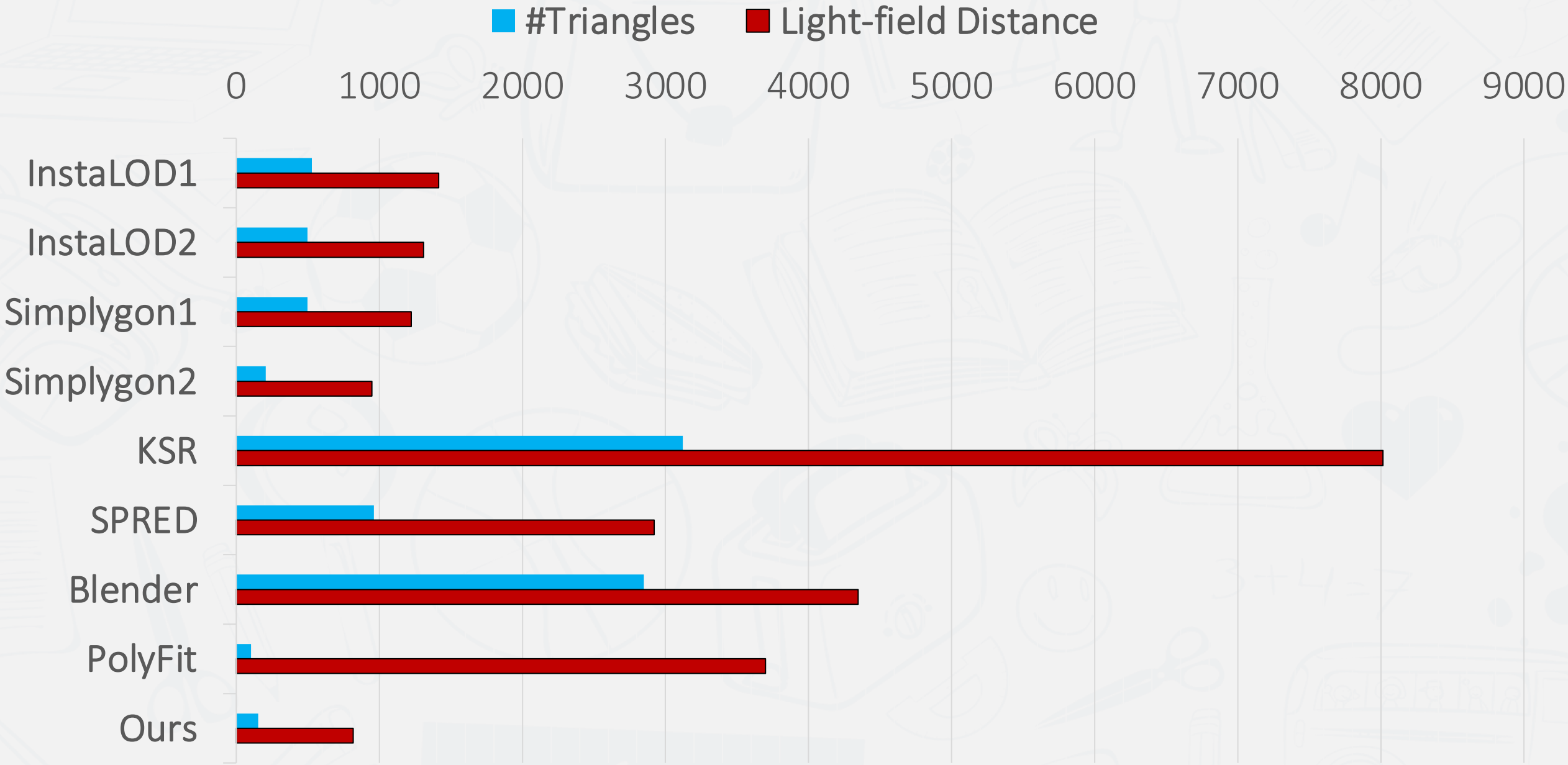
Carved Mesh Generation



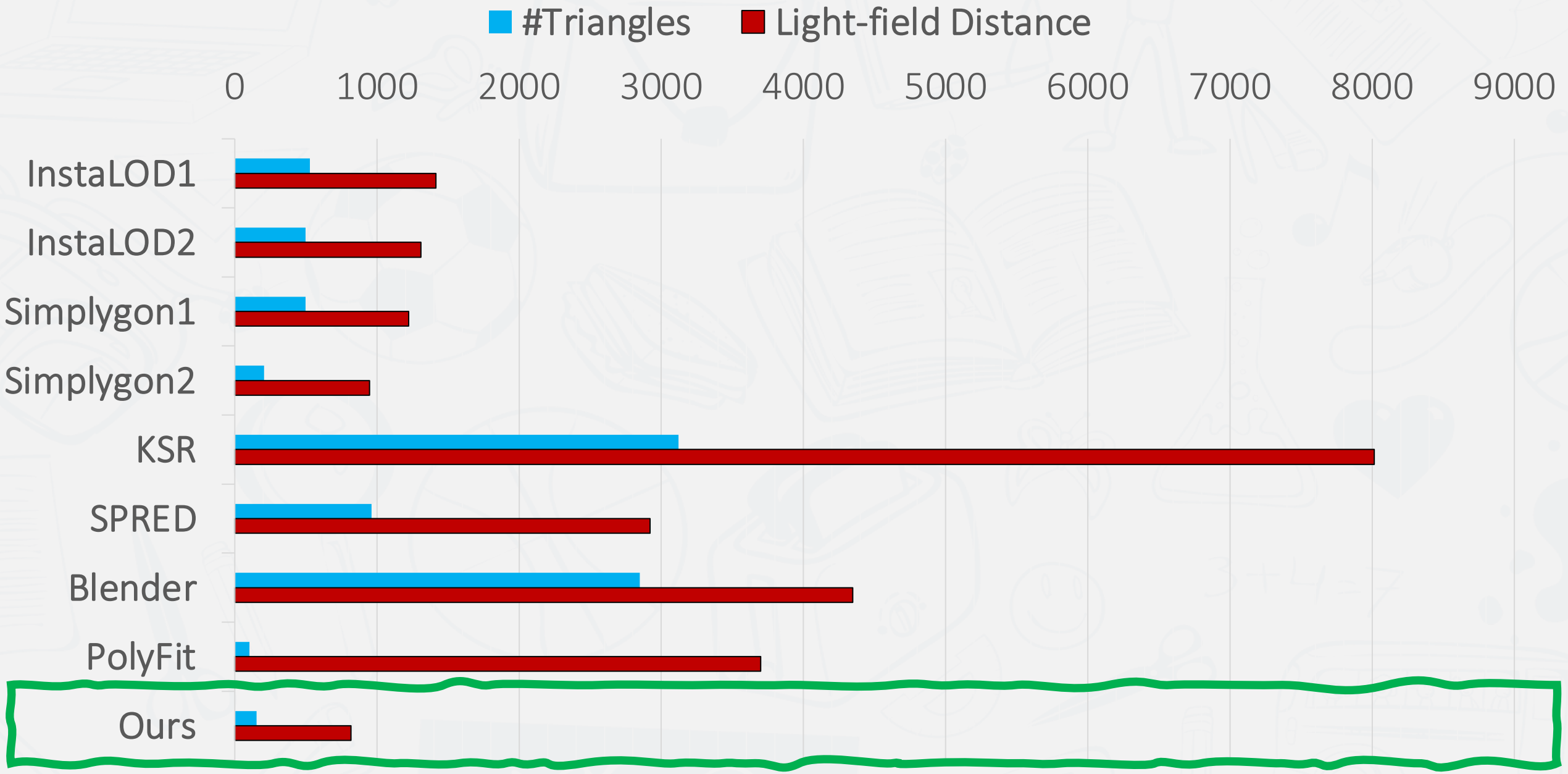
Low-poly Output

重新网格化：结果

重新网格化：结果


#Triangles
Light-field Distance
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
InstaLOD1
InstaLOD2
Simplygon1
Simplygon2
KSR
SPRED
Blender
PolyFit
Ours

重新网格化：结果

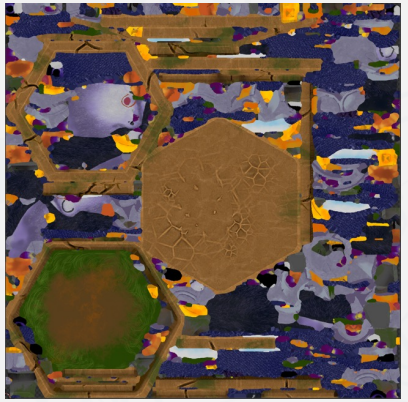

#Triangles
Light-field Distance
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
InstaLOD1
InstaLOD2
Simplygon1
Simplygon2
KSR
SPRED
Blender
PolyFit
Ours

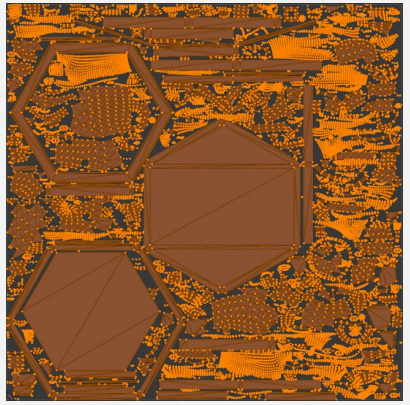
不保纹理的减面算法

Step 1 重新网格化

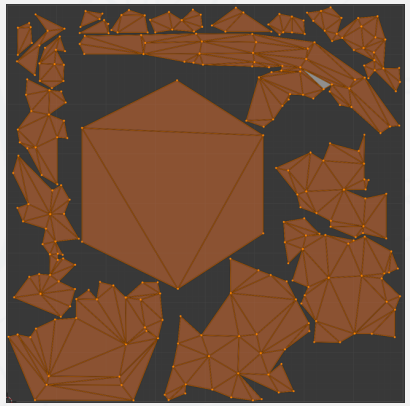
Step 2 展UV

Step 3 纹理烘焙





面数：18163



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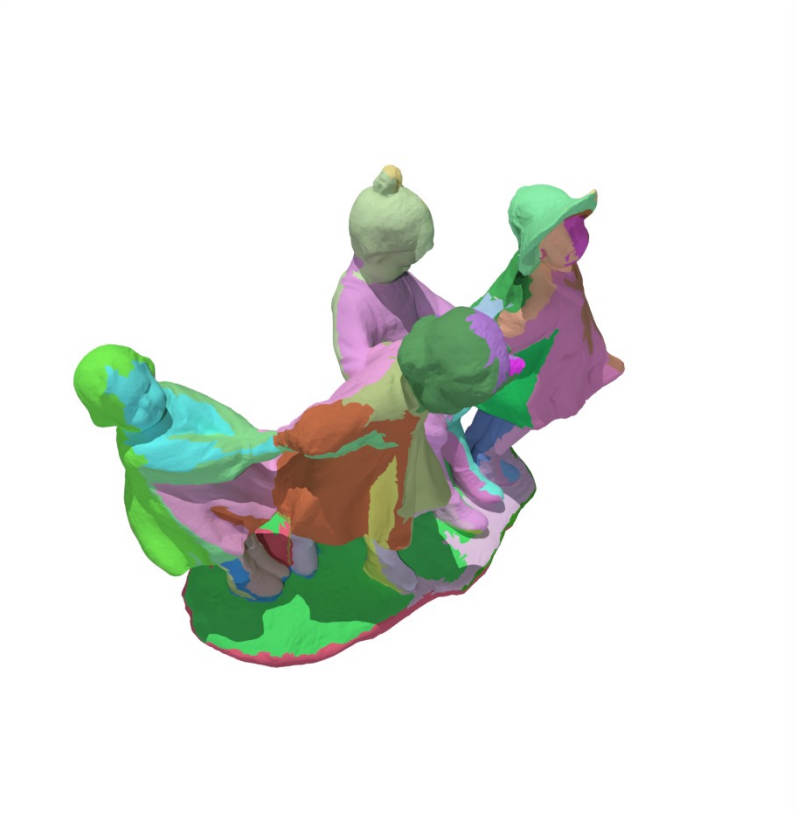
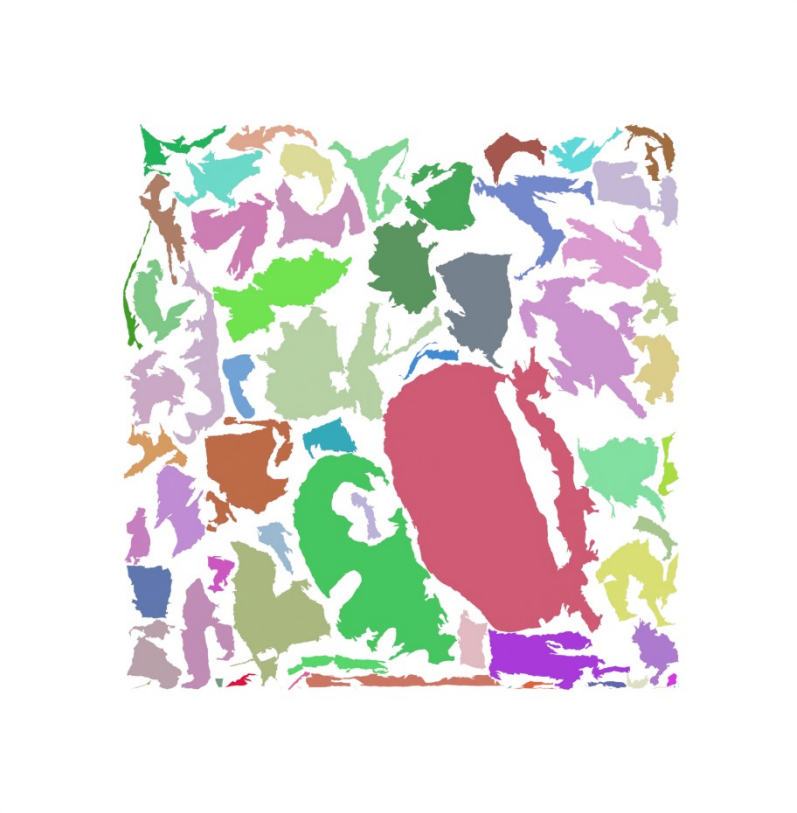
展UV

- 输入
  - 2D/3D 网格
- 输出
  - UV 网格
- 要求
  - 无翻转
  - 无自相交
  - 切割短
  - 扭曲小
  - 装箱面积小



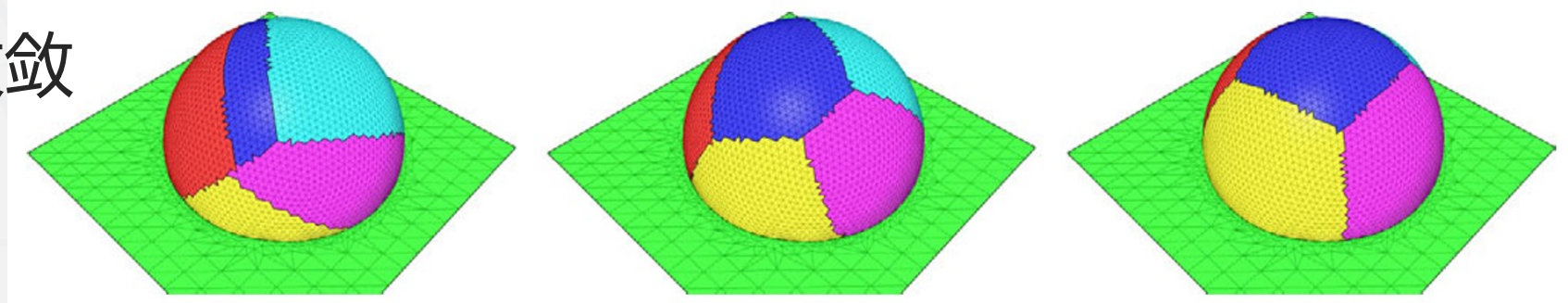


D. Julius, V. Kraevoy, and A. Sheffer. D-Charts: Quasi-Developable Mesh Segmentation

展UV：基于 Lloyd的模型分割框架

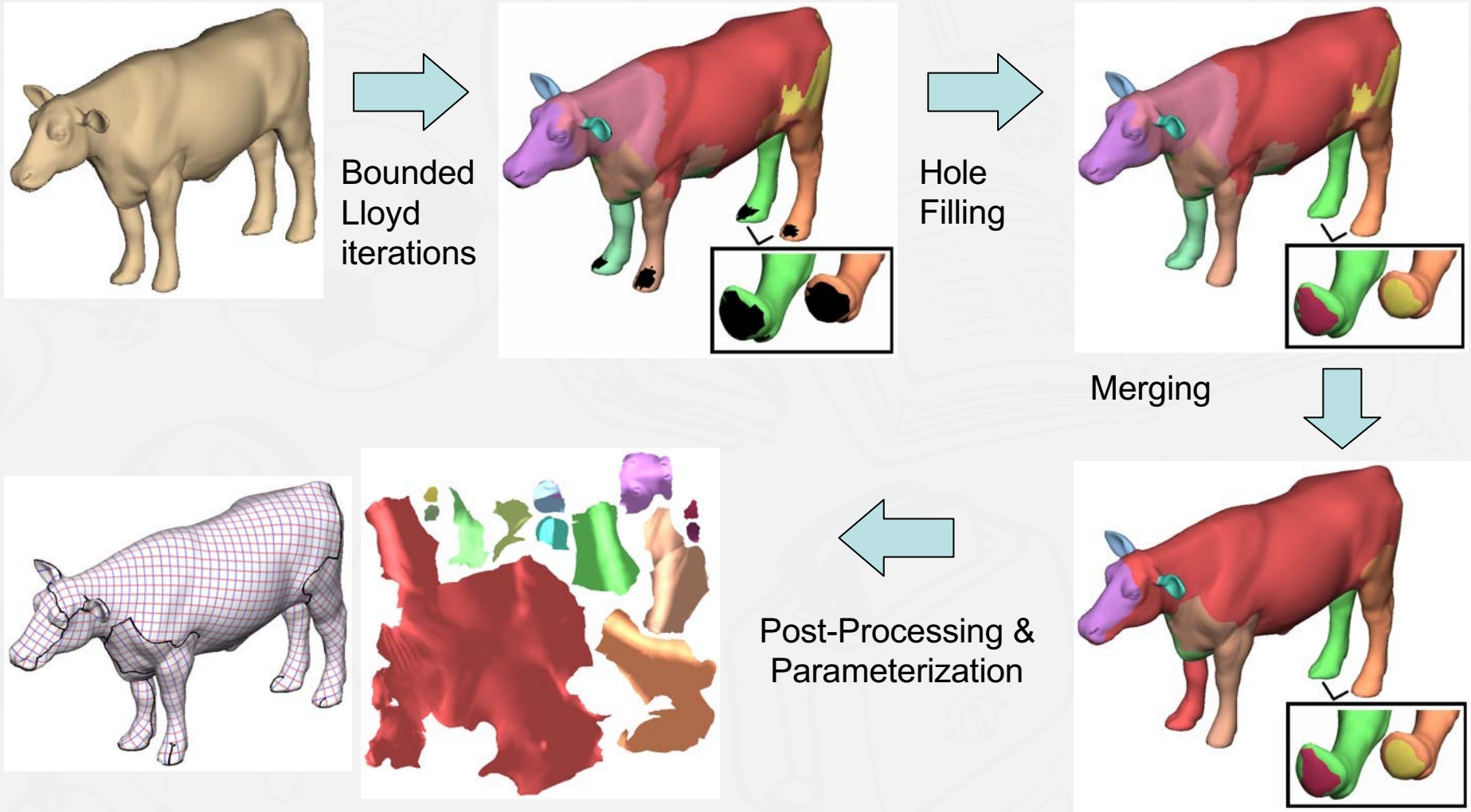
迭代循环以下步骤：

1. 选择随机三角形作为种子
2. 基于贪心的方式从种子周围扩张区域
3. 对每个区域更新它的代理信息（法向和误差）
4. 重复2-3直到收敛



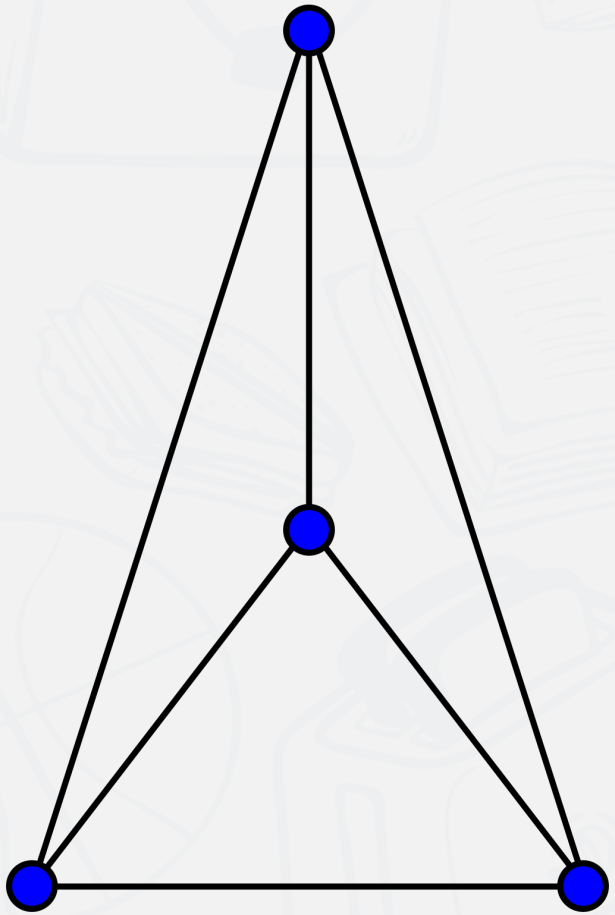
David Cohen-Steiner, Pierre Alliez, and Mathieu Desbrun, “Variational shape approximation,” ACM Trans. Graph., 2004.

展UV：算法流程



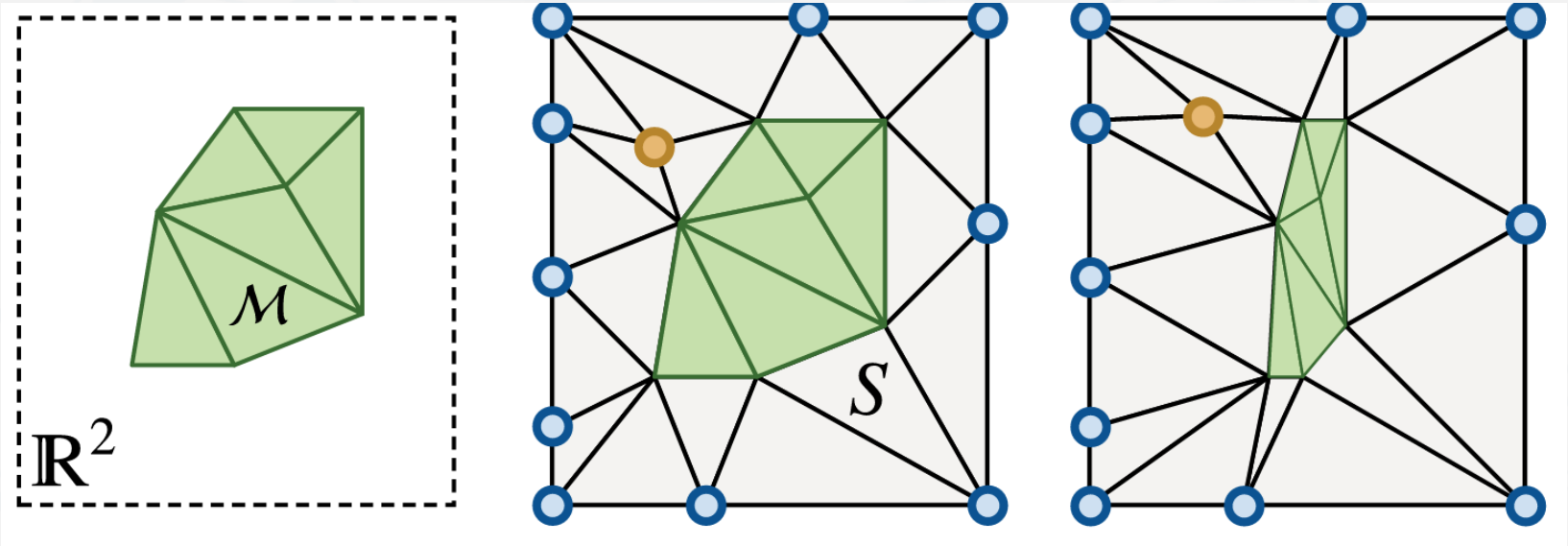
D. Julius, V. Kraevoy, and A. Sheffer. D-Charts: Quasi-Developable Mesh Segmentation

展UV：Tutte Embedding



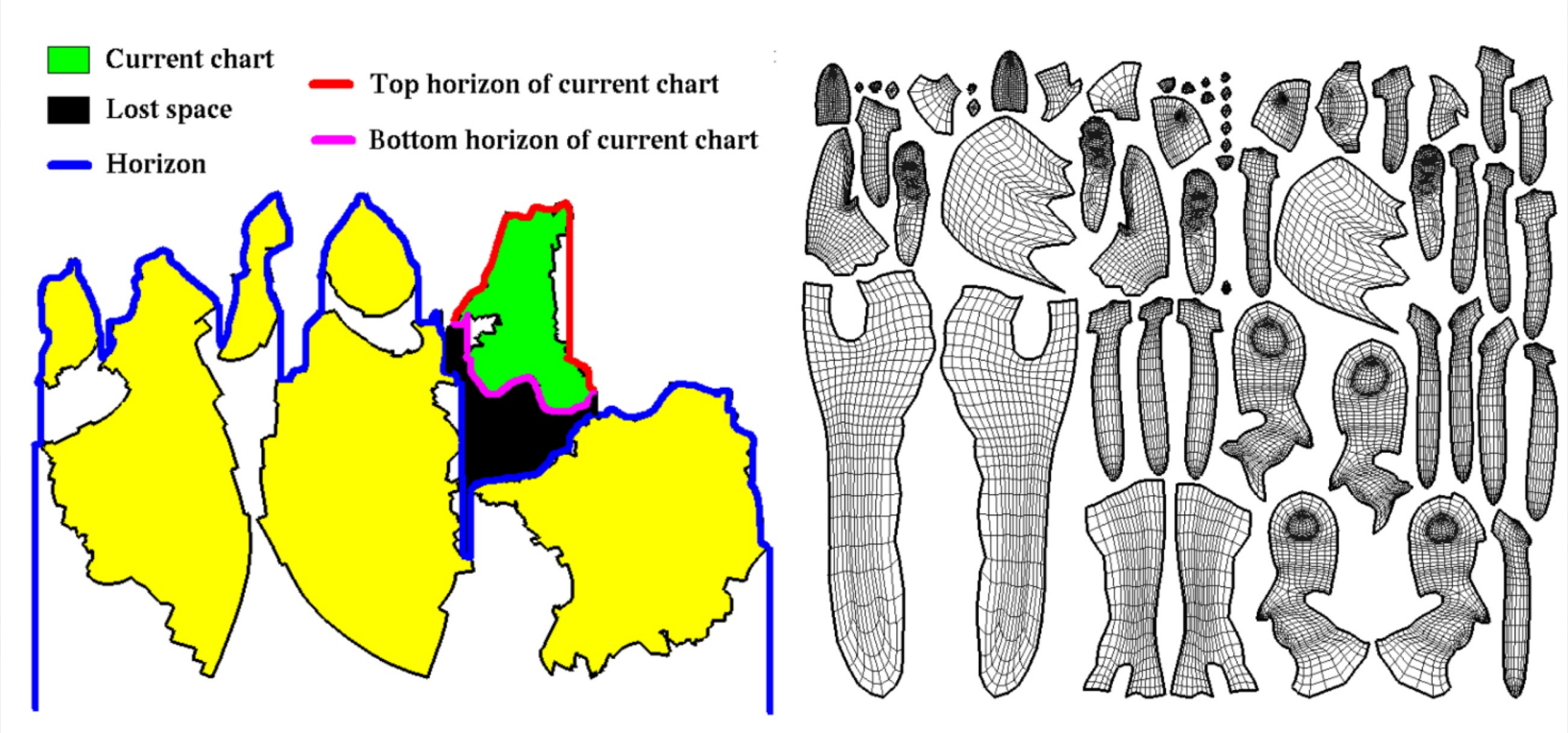
Tutte, W. T. (1963), "How to draw a graph", Proceedings of the London Mathematical Society, **13**: 743–767

展UV：Bijective Map



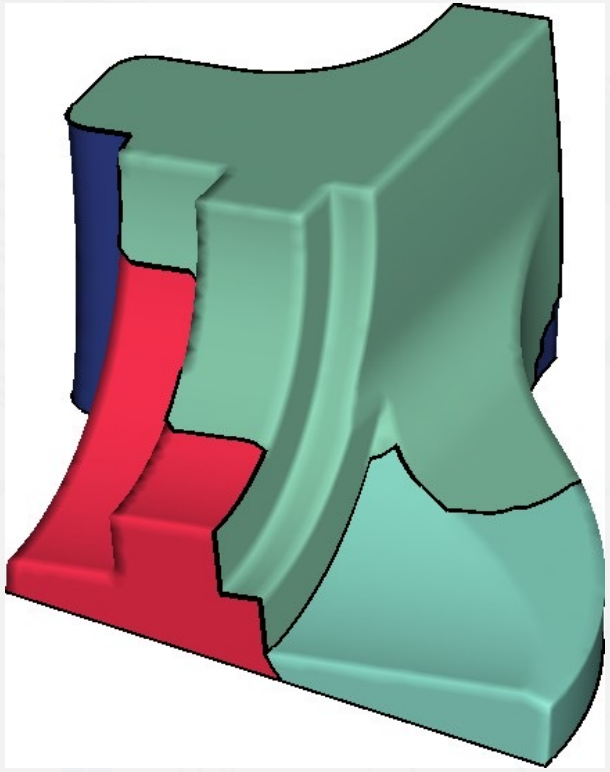
Zhongshi Jiang, Scott Schaefer, Daniele Panozzo. Simplicial Complex Augmentation Framework for Bijective Maps. *ACM Trans. on Graphics*, 2017

展UV：装箱

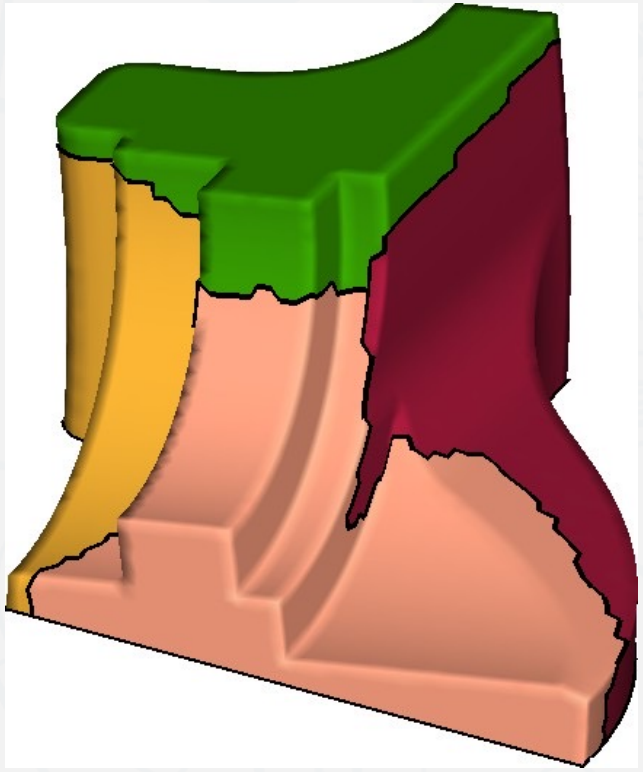


Bruno Lévy et al. Least Squares Conformal Maps for Automatic Texture Atlas Generation. ACM SIGGRAPH 2002.

展UV：结果

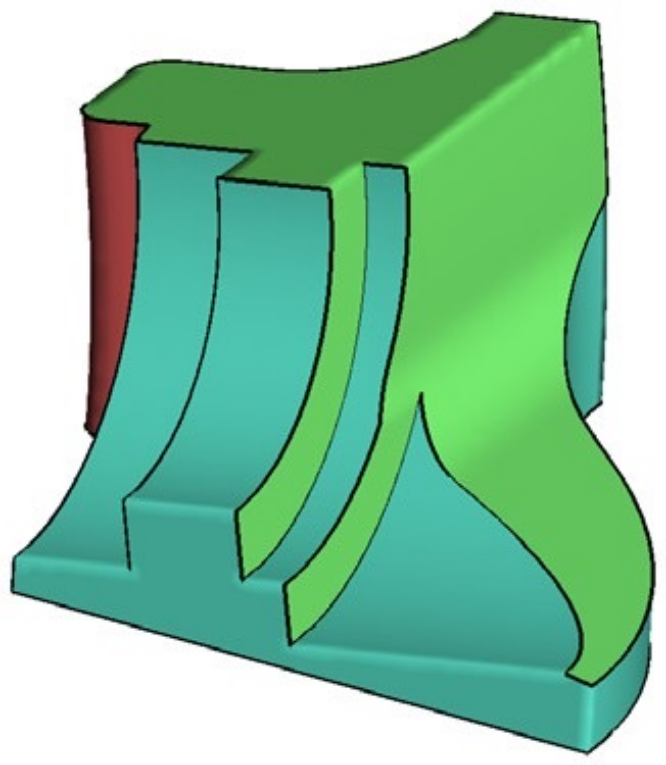


Iso-Charts, [Zhou et al. ’04]



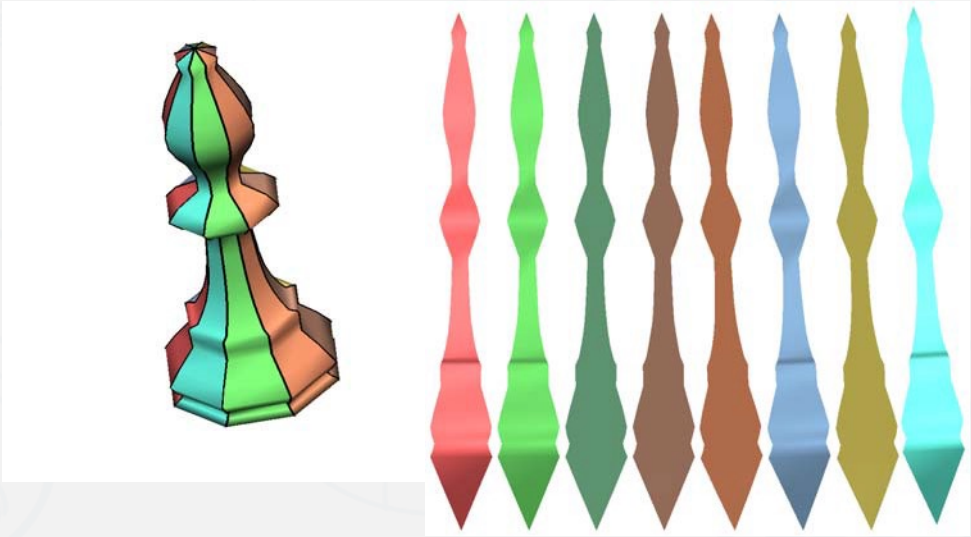
MCGIM,

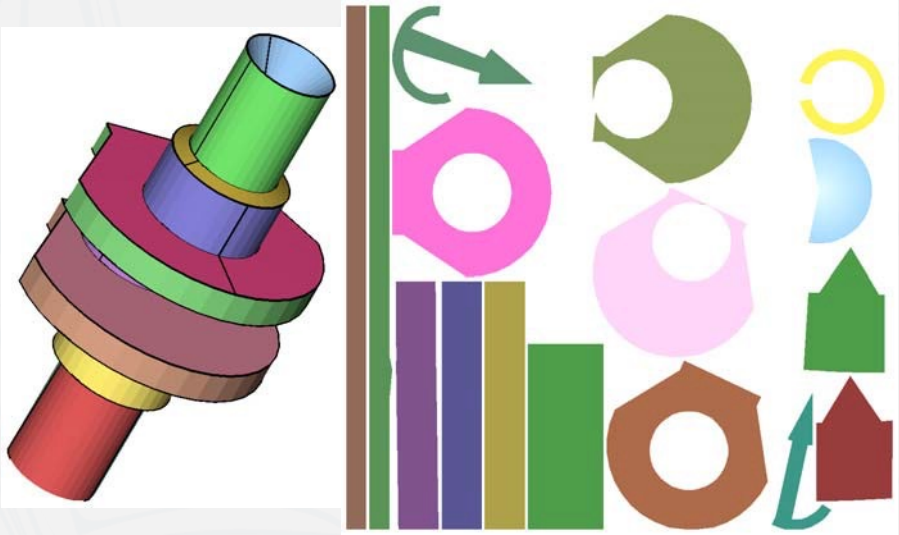
[Sander et al. ’03]

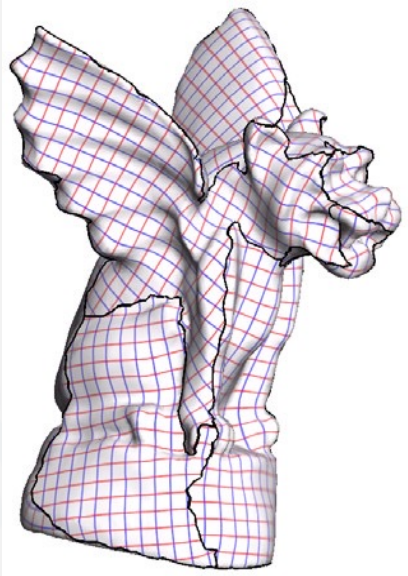


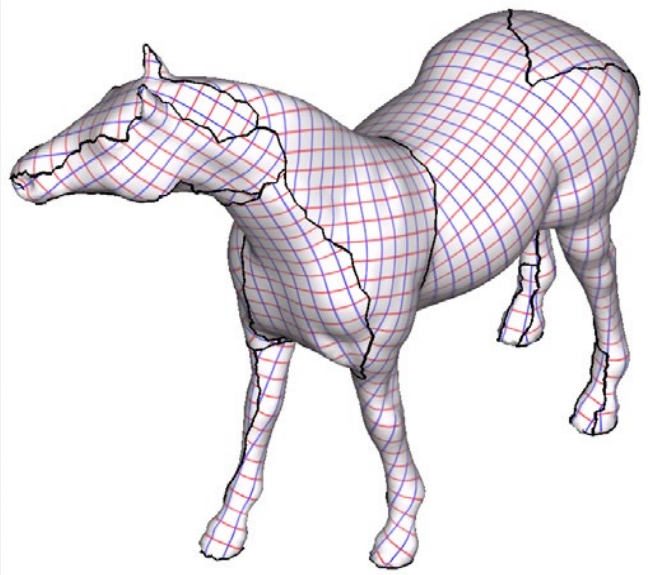
D-Charts

展UV：结果







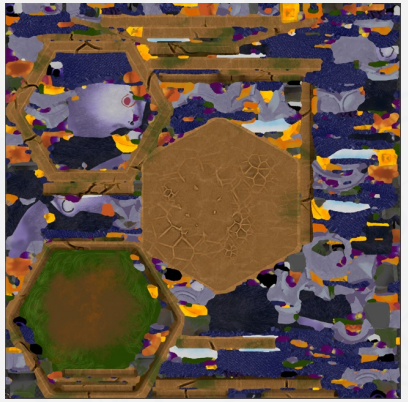
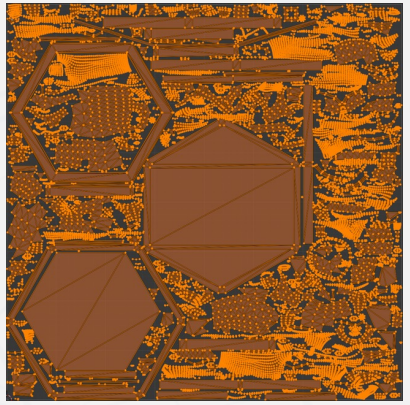


不保纹理的减面算法

Step 1 重新网格化

Step 2 展UV

Step 3 纹理烘焙

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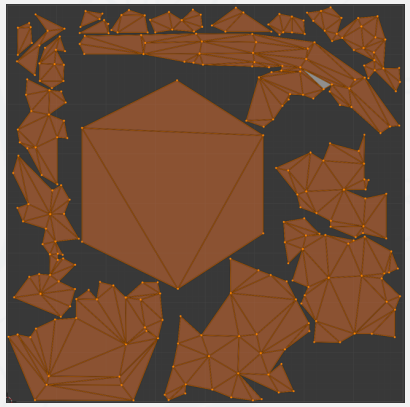

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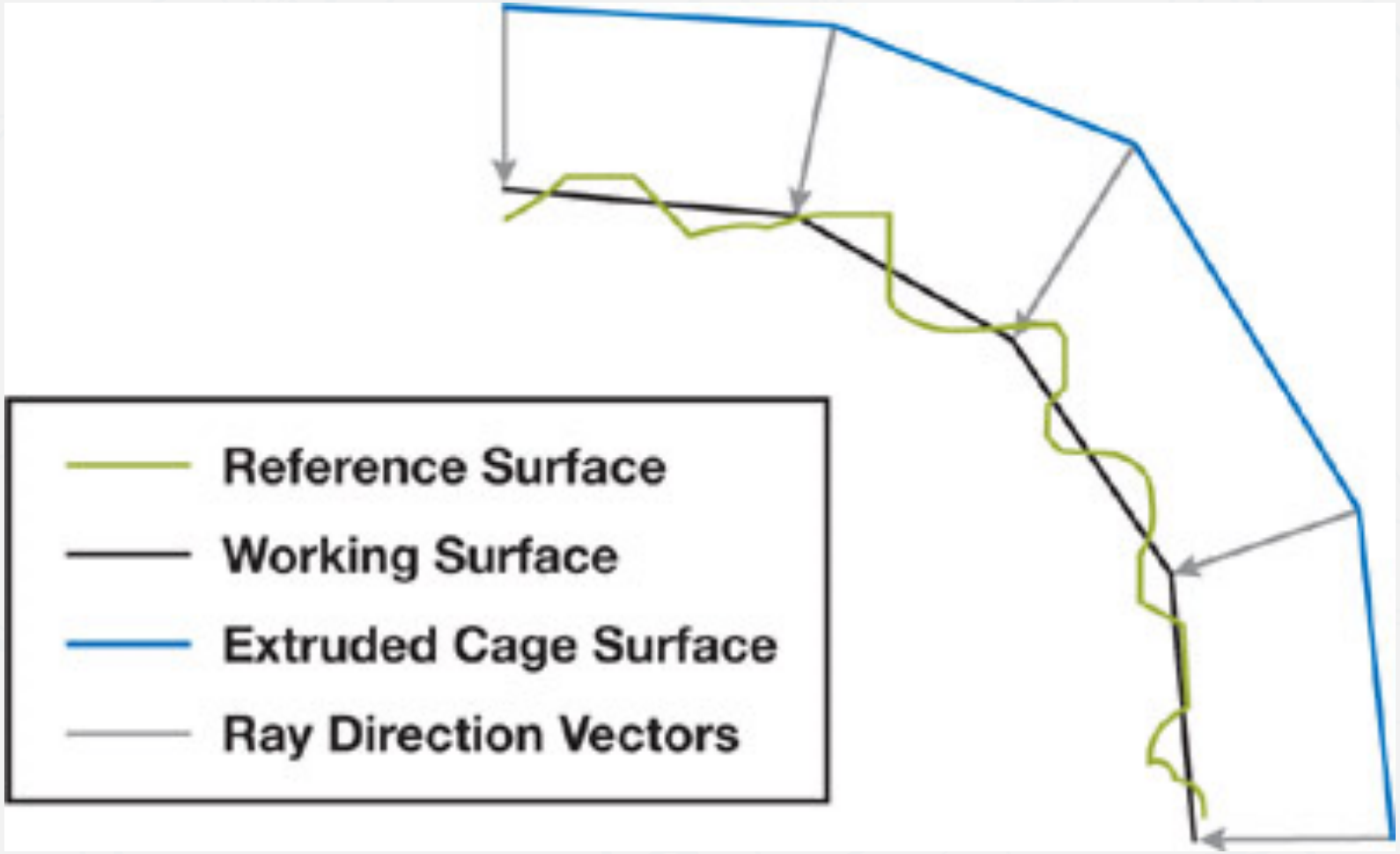
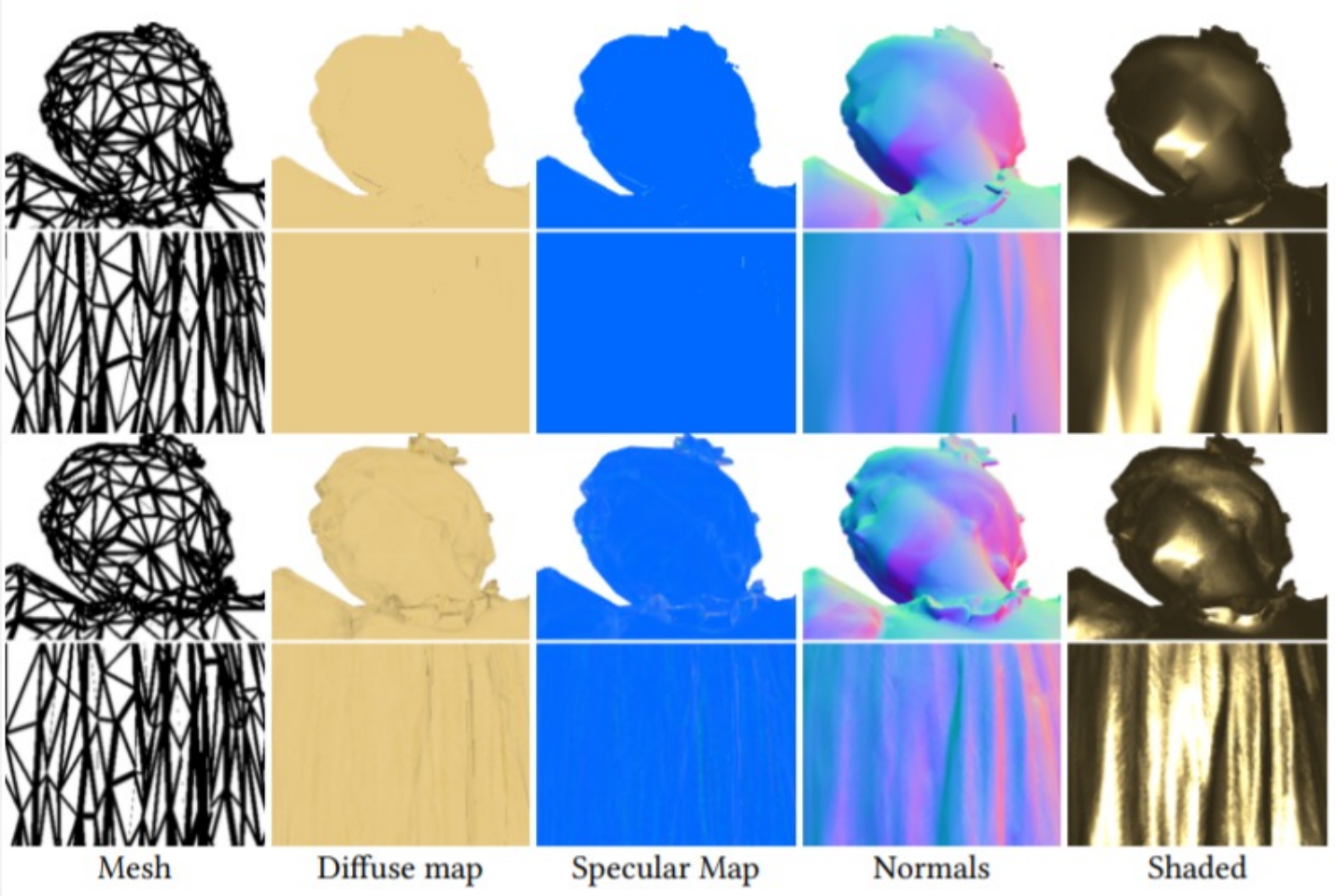
纹理烘焙 – Ray Casting



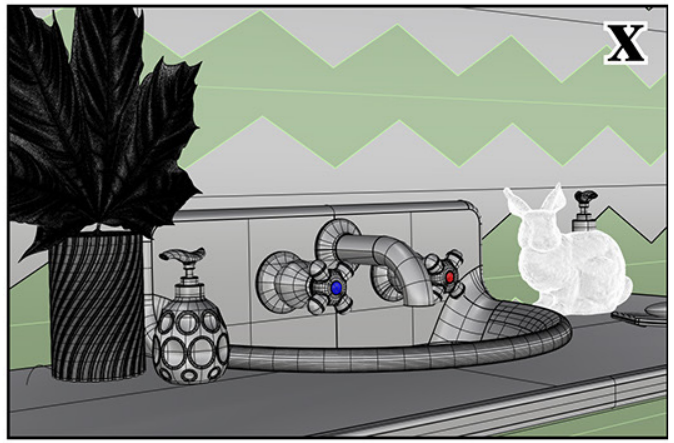
Alain Galvan and Jeff Russell, “A Ray Casting Technique for Baked Texture Generation,” GPU Zen 2, Chapter baked texture generation, 2019

纹理烘焙 – Differentiable Rendering



Jon Hasselgren, Jacob Munkberg, Jaakko Lehtinen, Miika Aittala and Samuli Laine, “Appearance-Driven Automatic 3D Model Simplification”, Eurographics Symposium on Rendering 2021

What is Differentiable Rendering?

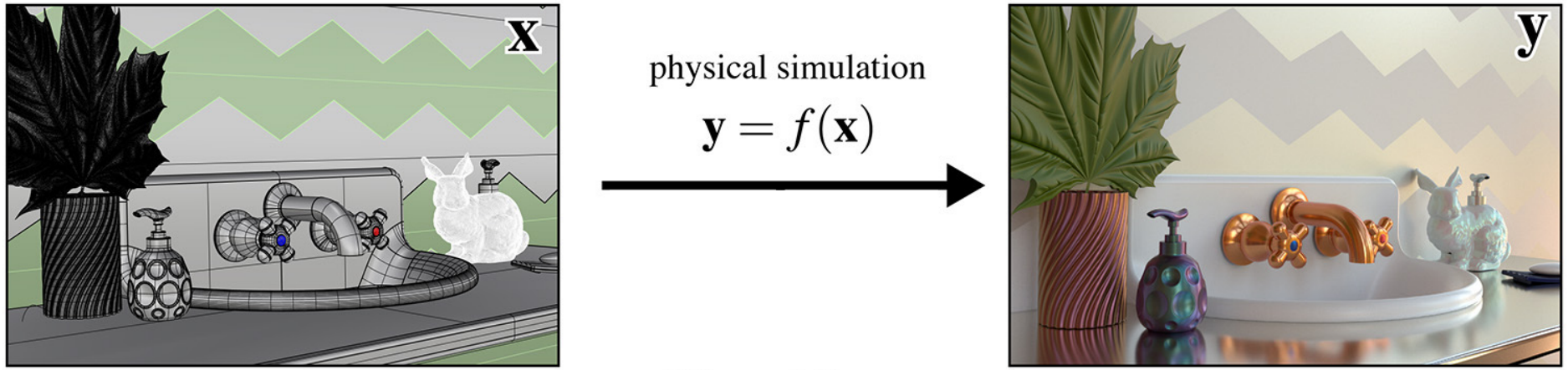


Input parameters

shape & position of objects, materials, light sources, camera pose, etc.

https://mitsuba.readthedocs.io/en/stable/src/inverse_rendering/gradient_based_opt.html

What is Differentiable Rendering?

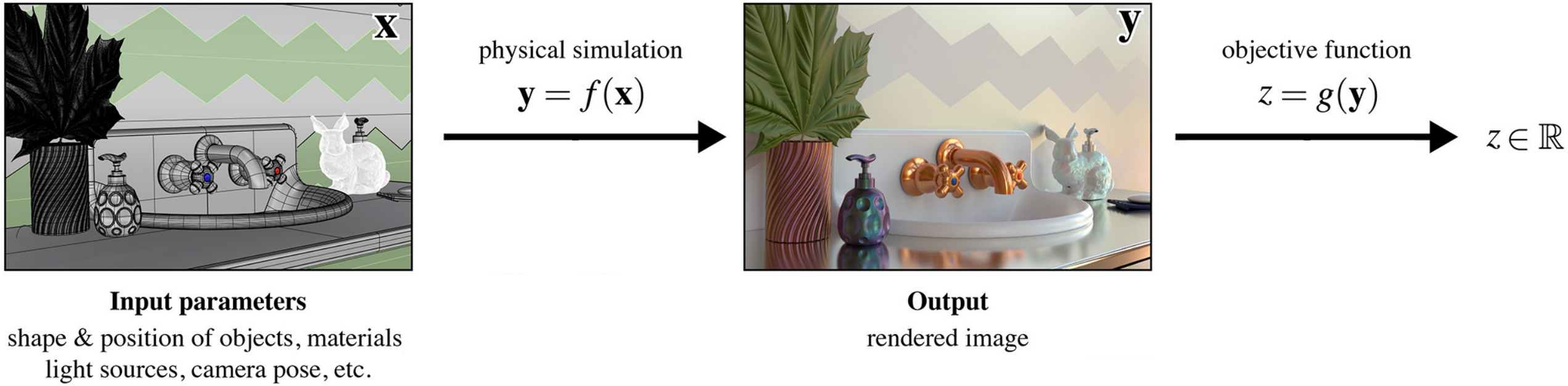


Input parameters
shape & position of objects, materials
light sources, camera pose, etc.

Output
rendered image

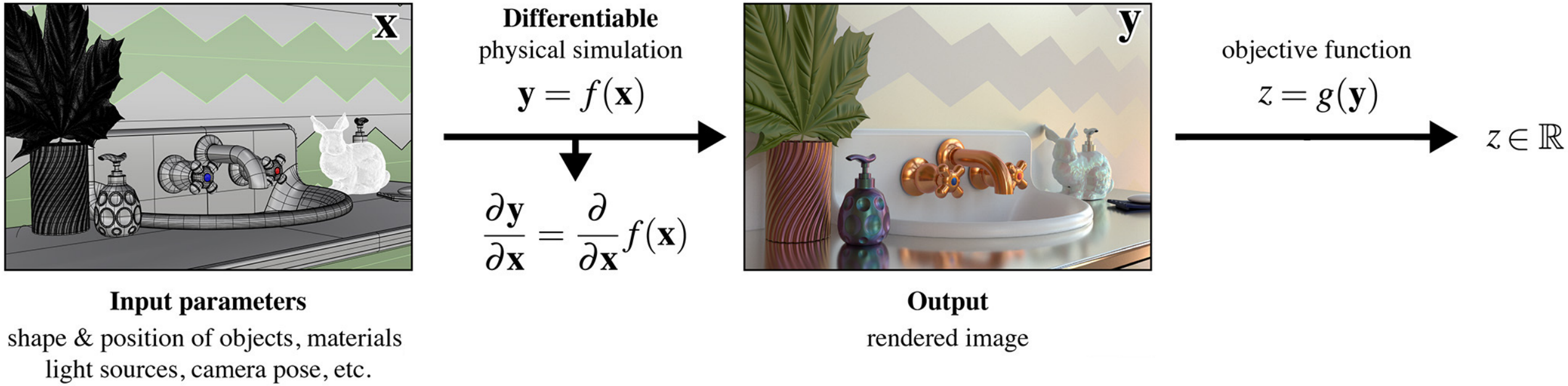
https://mitsuba.readthedocs.io/en/stable/src/inverse_rendering/gradient_based_opt.html

What is Differentiable Rendering?



https://mitsuba.readthedocs.io/en/stable/src/inverse_rendering/gradient_based_opt.html

What is Differentiable Rendering?



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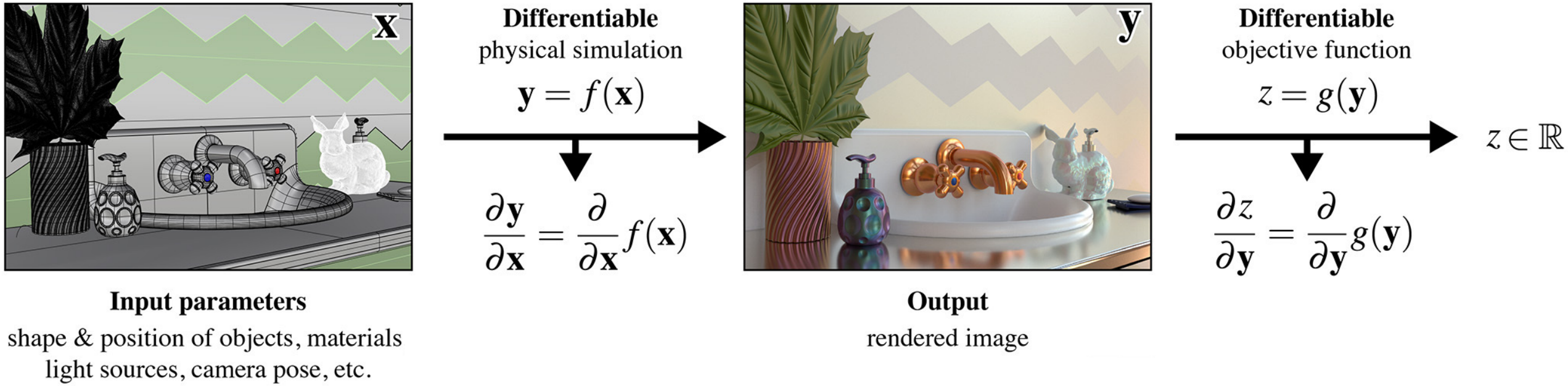

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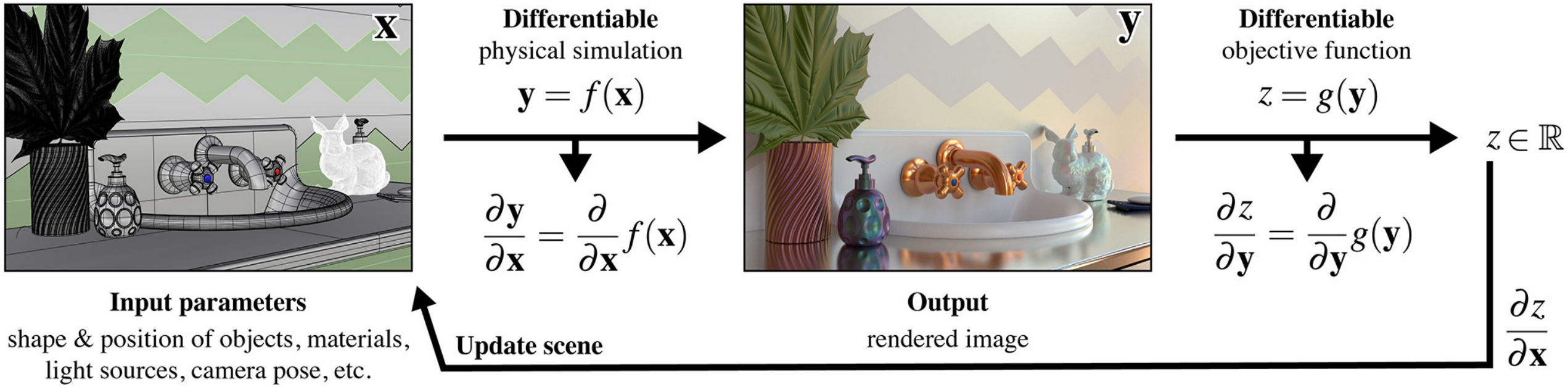

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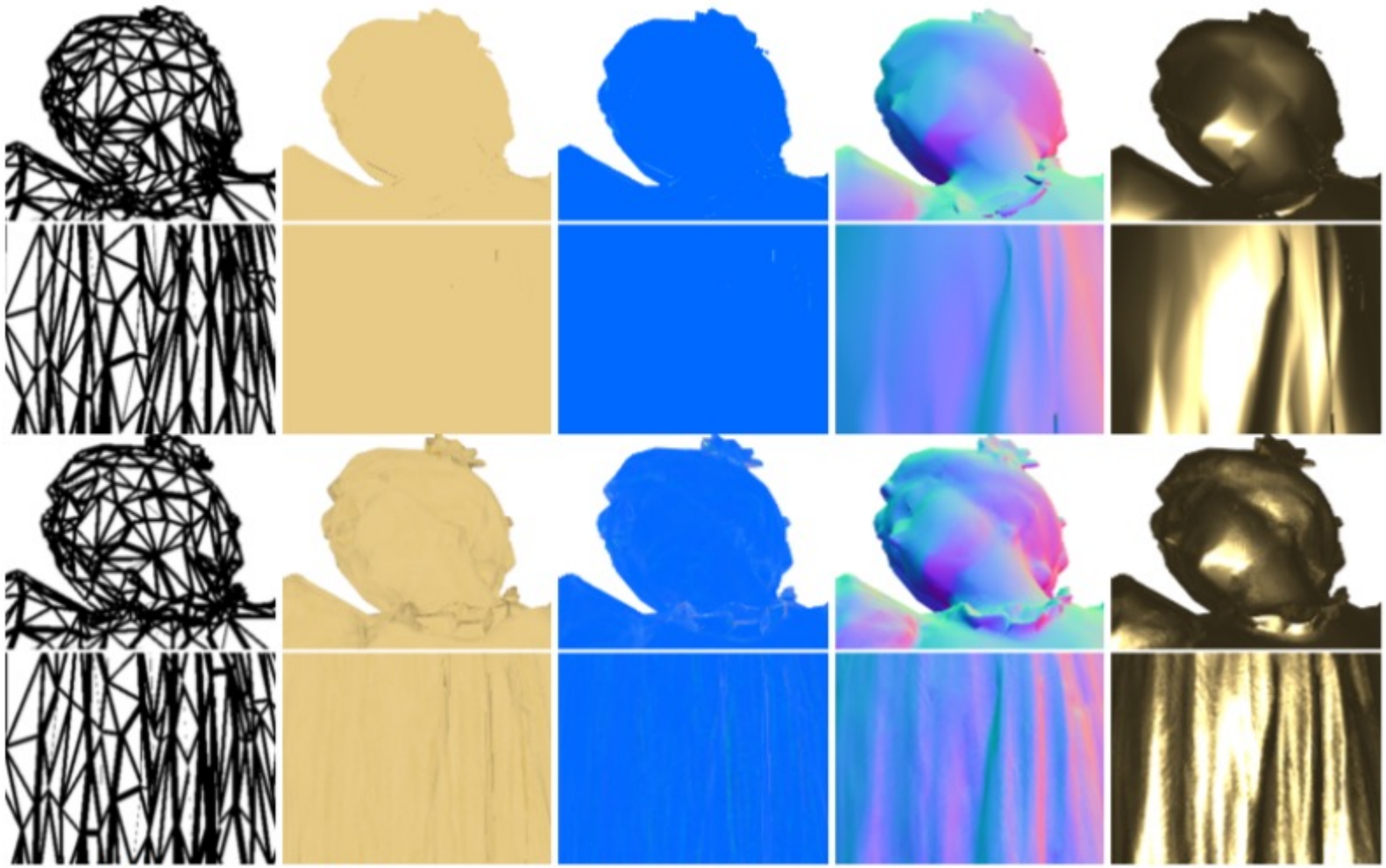
Applications

- Texture Generation



Jon Hasselgren, Jacob Munkberg, Jaakko Lehtinen, Miika Aittala and Samuli Laine, “Appearance-Driven Automatic 3D Model Simplification”, Eurographics Symposium on Rendering 2021

模型简化总结

课程内容与目标

内容

1. 涵盖三维模型的多种表示形式，在实际应用中常见的基本拓扑和几何概念，三维网格模型的不同的简化方法；

2. 重点介绍以图形渲染为应用背景的几种模型减面方法，包括保纹理的贪心式减面算法，不保纹理的重新网格化，展UV和纹理烘焙的减面管线，及对植被类场景应用的广告牌方法。

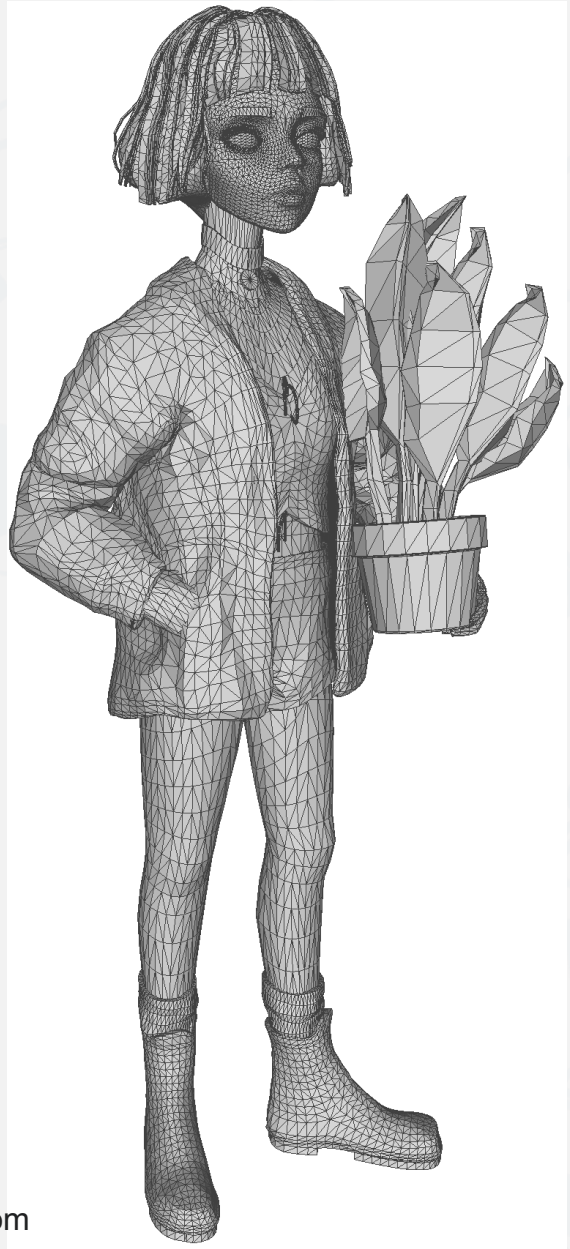
目标

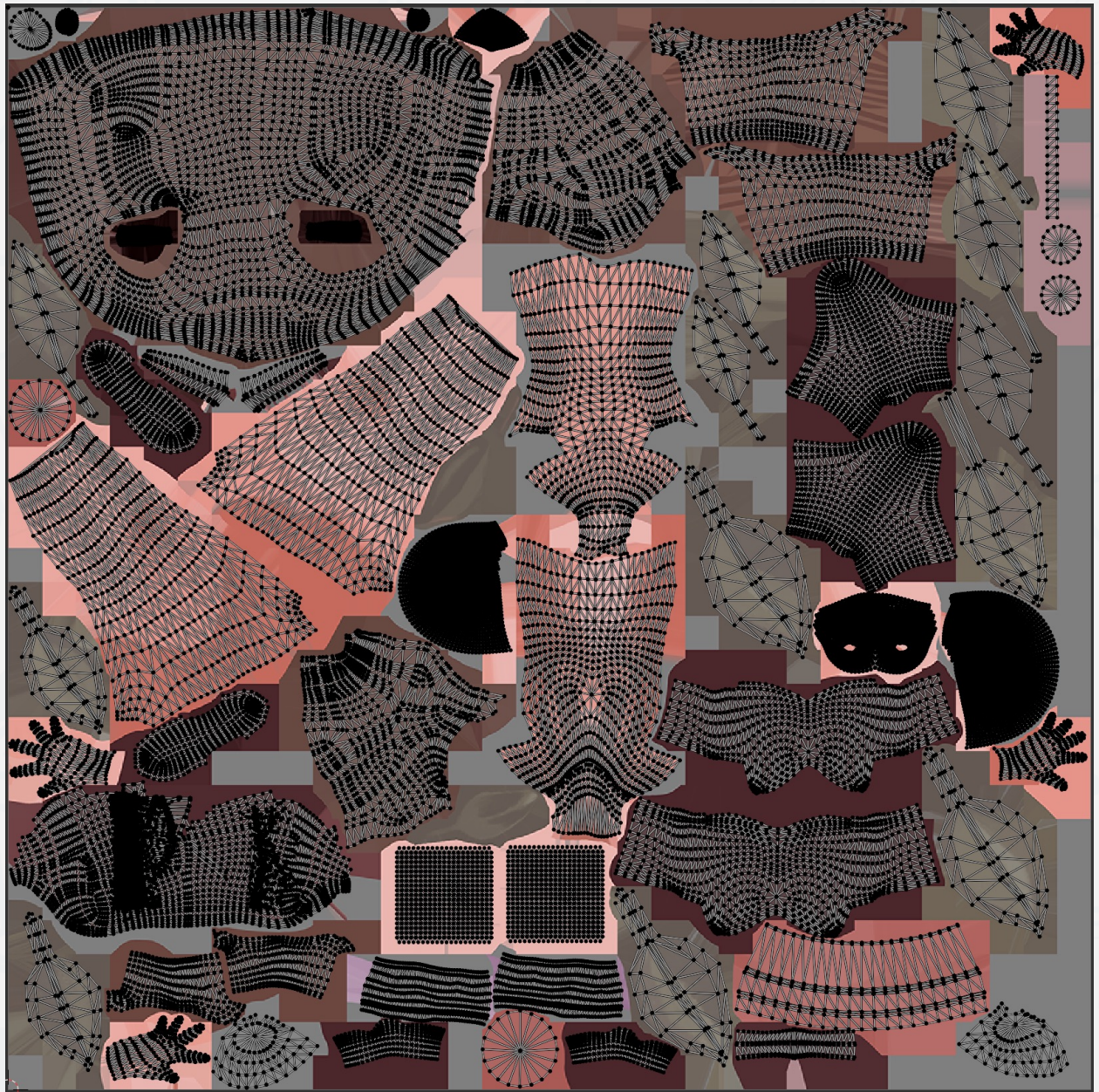
1. 理解保纹理与不保纹理减面管线的算法流程，掌握经典减面算法的核心思想；

2. 能独立的程序实现保纹理减面算法并用来处理常见的三维模型。

网格模型表示

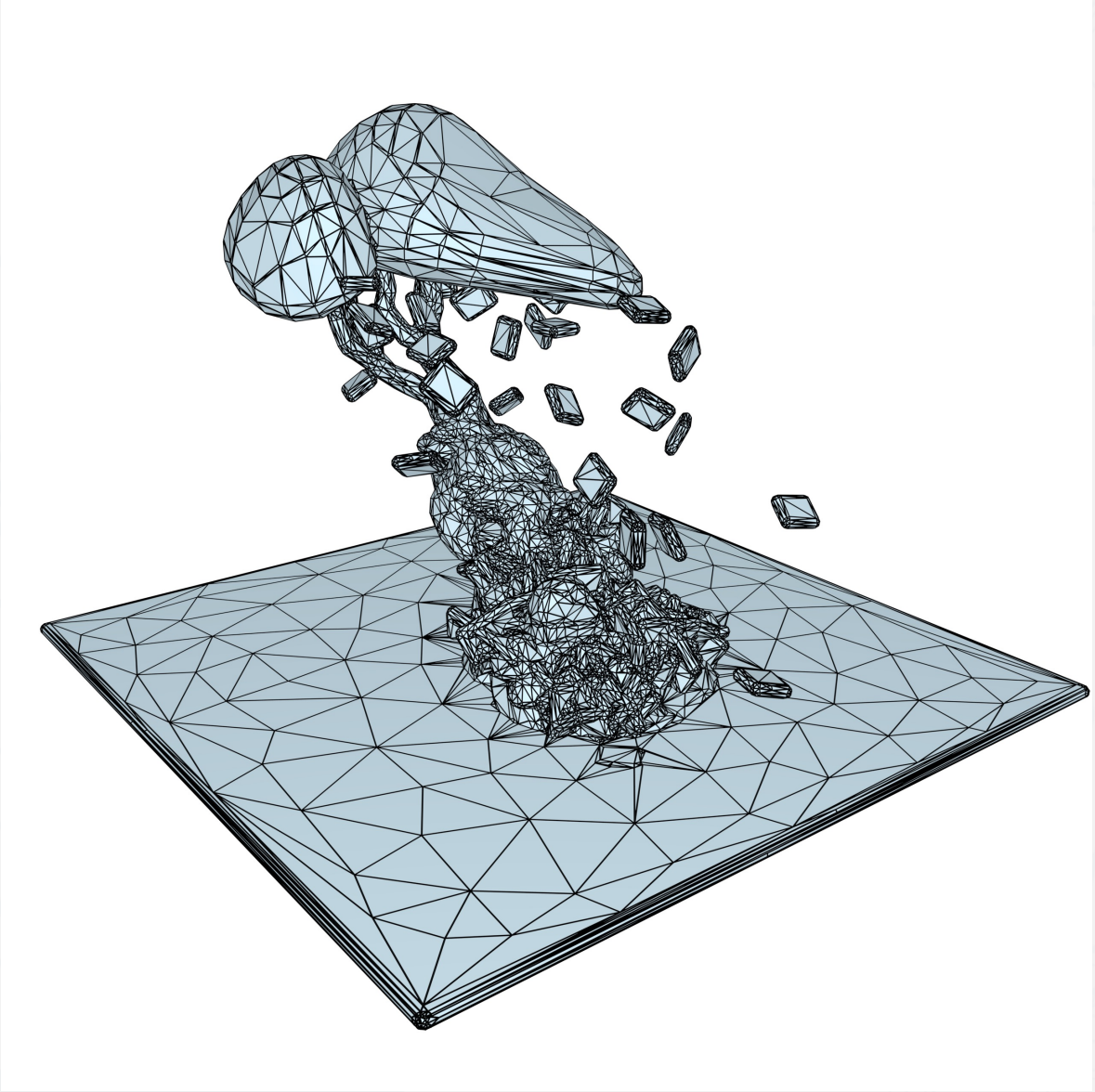
Attribution: sketchfab.com





网格模型基本概念

- 连接关系
- 拓扑
- 几何
- 数据结构



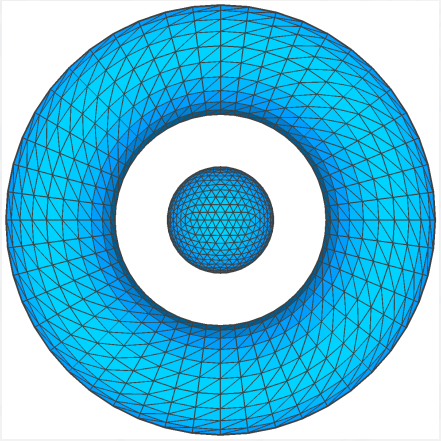
网格模型基本概念

- 连接关系
- **拓扑**
- 几何
- 数据结构

欧拉 — 庞克来公式

$$v - e + f = 2s - 2g - h$$

顶点数 边数 面数 **连通数** 亏格 洞数



网格模型基本概念

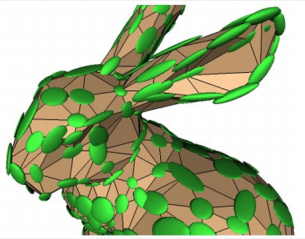
- 连接关系
- 拓扑
- **几何**
- 数据结构

边长　面积　二面角　法向　相交

退化单元　包围盒　曲率　特征

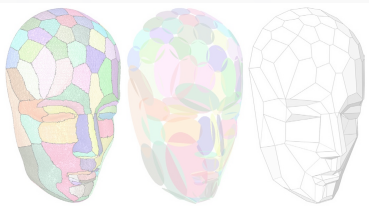
Hausdorff 距离　面翻转　凸包

保纹理的减面算法

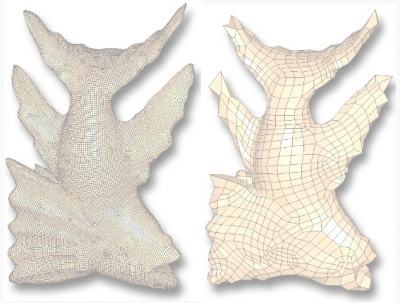


[Michael et al, 1998]

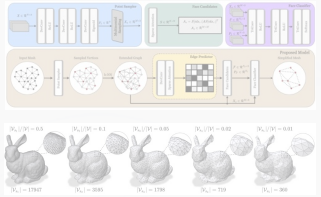
[Hugues et al, 1999]



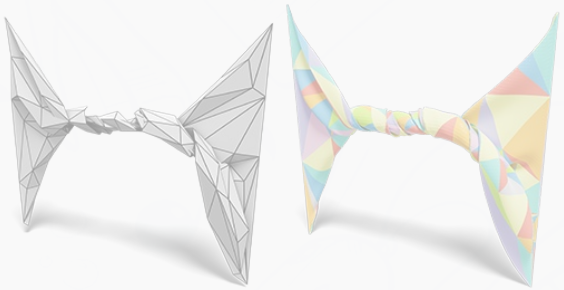
[David et al, 2004]



[Joel et al, 2008]



[Rolandos et al, 2022]



[Liu et al, 2023]

- **[Michael et al, 1998] M. Garland and P. S. Heckbert, "Simplifying surfaces with color and texture using quadric error metrics," Proceedings Visualization '98, 1998.**
- [Hugues et al, 1999] Hugues Hoppe, "New quadric metric for simplifiying meshes with appearance attributes," In Proceedings of the conference on Visualization '99: celebrating ten years (VIS '99), 1999.
- [David et al, 2004] David Cohen-Steiner, Pierre Alliez, and Mathieu Desbrun, "Variational shape approximation," ACM Trans. Graph. (August 2004), 2004.
- [Rolandos et al, 2022] R. A. Potamias, S. Ploumpis and S. Zafeiriou, "Neural Mesh Simplification," 2022 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2022.
- [Liu et al, 2023] Derek Liu, Mark Gillespie, Benjamin Chislett, Nicholas Sharp, Alec Jacobson, and Keenan Crane, "Surface Simplification using Intrinsic Error Metrics", ACM Trans. Graph. 2023.

问题描述

- 输入
  - 2D/3D 网格，UV 网格，纹理材质
  - 减面数/比例
- 输出
  - 新的2D/3D 网格和UV 网格
- 要求
  - 保拓扑
  - 无自相交
  - 保距离
  - …

简化框架

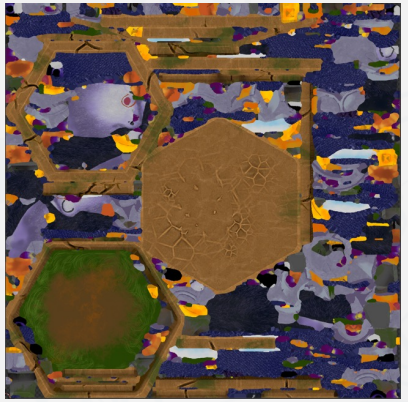
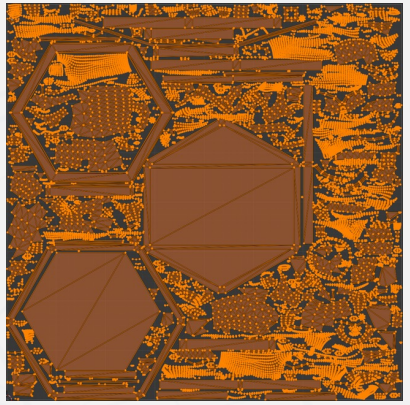
- 简化操作单元误差计算
- 构建操作单元的优先队列
- 当队列不为空并且未满足停止条件，执行
  - 取出队列的第一个操作单元
  - 针对操作单元的有效性检查
  - 如果没有通过，重复以上步骤
  - 更新邻居单元计算误差，并加入优先队列

不保纹理的减面算法

Step 1 重新网格化

Step 2 展UV

Step 3 纹理烘焙

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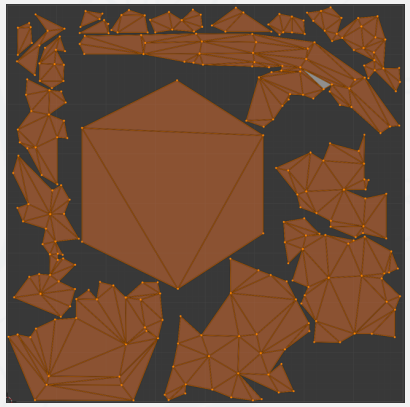

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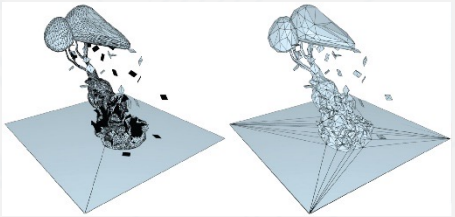
不保纹理的减面算法 – 重新网格化

[Xavier et al, 2003]

[Botsch et al, 2004]

[Nan et al, 2017]

[Gao et al. 2022]



[Zhen et al, 2023]

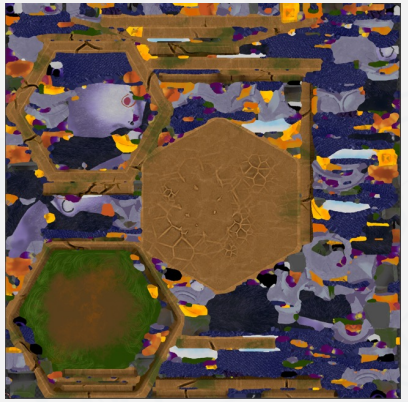
- [Xavier et al, 2003] Xavier Décoret, Frédo Durand, François X. Sillion, and Julie Dorsey, “Billboard clouds for extreme model simplification,” ACM Trans. Graph. (July 2003), 2003.
- [Botsch et al, 2004] M. Botsch and L. Kobbelt, “A remeshing approach to multiresolution modeling,” In Proceedings of the 2004 Eurographics/ACM SIGGRAPH symposium on Geometry processing, 2004.
- [Nan et al, 2017] Liangliang Nan and Peter Wonka. PolyFit: Polygonal Surface Reconstruction from Point Clouds. ICCV 2017.
- **[Gao et al. 2022] Xifeng Gao, Kui Wu, Zherong Pan, "Low-poly Mesh Generation for Building Models," Proceedings of SIGGRAPH, 2022.**
- **[Zhen et al, 2023] Zhen Chen, Zherong Pan, Kui Wu, Etienne Vouga, Xifeng Gao, “Robust Low-Poly Meshing for General 3D Models”, ACM Transactions on Graphics (Proceedings of SIGGRAPH 2023), 2023**

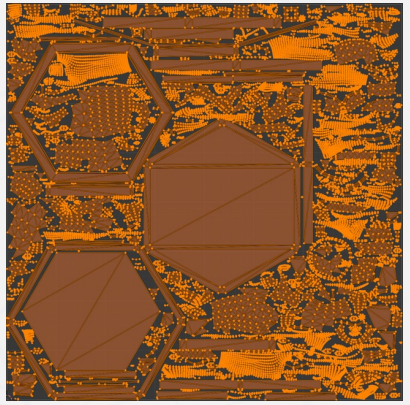
不保纹理的减面算法

Step 1 重新网格化

Step 2 展UV

Step 3 纹理烘焙





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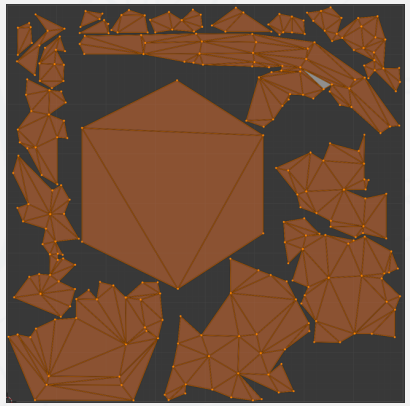

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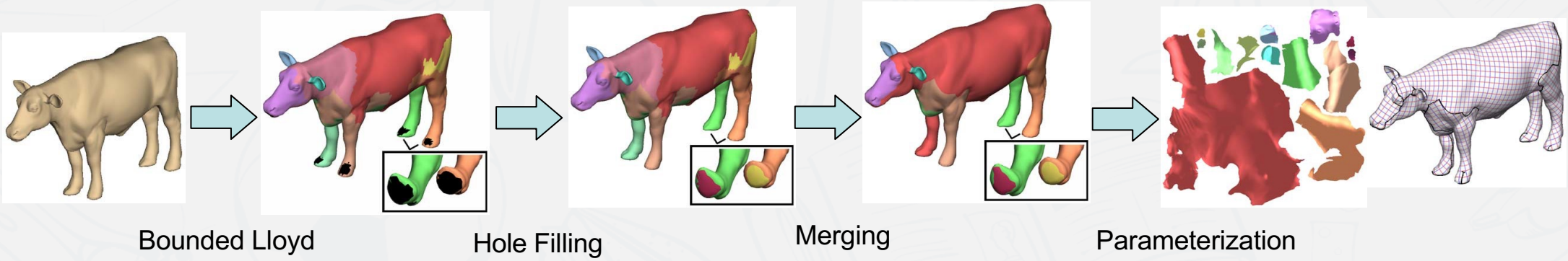
不保纹理的减面算法 – 展UV



- K. Hormann, B. Lévy, and A. Sheffer. Mesh Parameterization: Theory and Practice
- P. Sander, Z. Wood, S. Gortler, J. Snyder, and H. Hoppe. Multi-Chart Geometry Images
- **D. Julius, V. Kraevoy, and A. Sheffer. D-Charts: Quasi-Developable Mesh Segmentation**
- B. Lévy, S. Petitjean, N. Ray, and J. Maillot. Least Squares Conformal Maps for Automatic Texture Atlas Generation
- O. Sorkine, D. Cohen-Or, R. Goldenthal, and D. Lischinski. Bounded-distortion Piecewise Mesh Parameterization
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- Jian-Ping Su, Chunyang Ye, Ligang Liu, Xiao-Ming Fu, “Efficient Bijective Parameterizations”, ACM Transactions on Graphics (SIGGRAPH), 39(4), 2020.

不保纹理的减面算法

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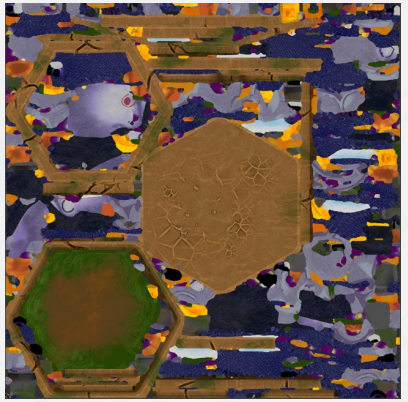
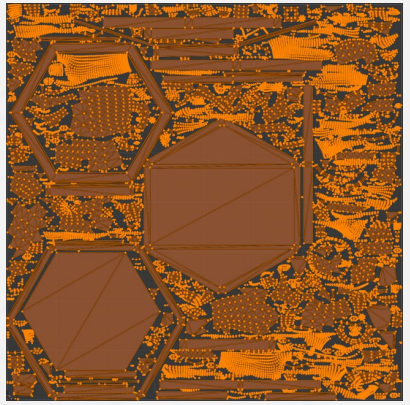

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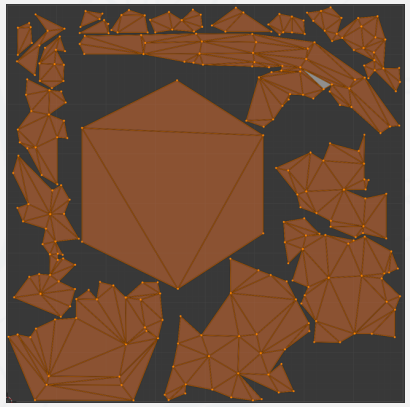

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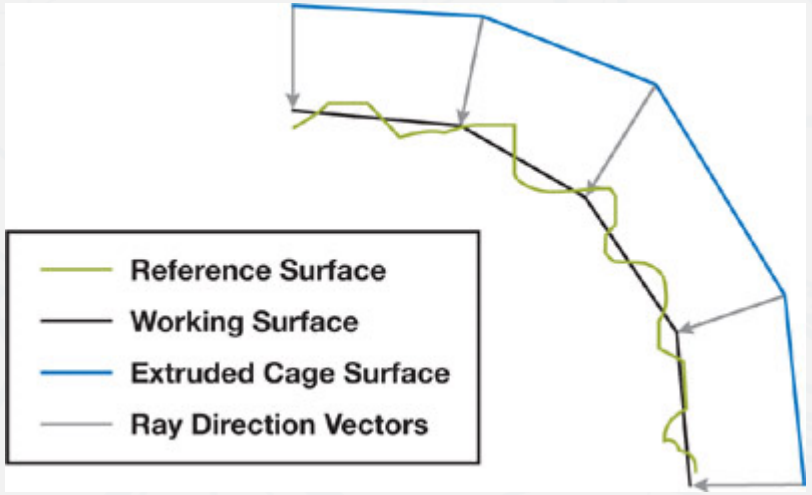
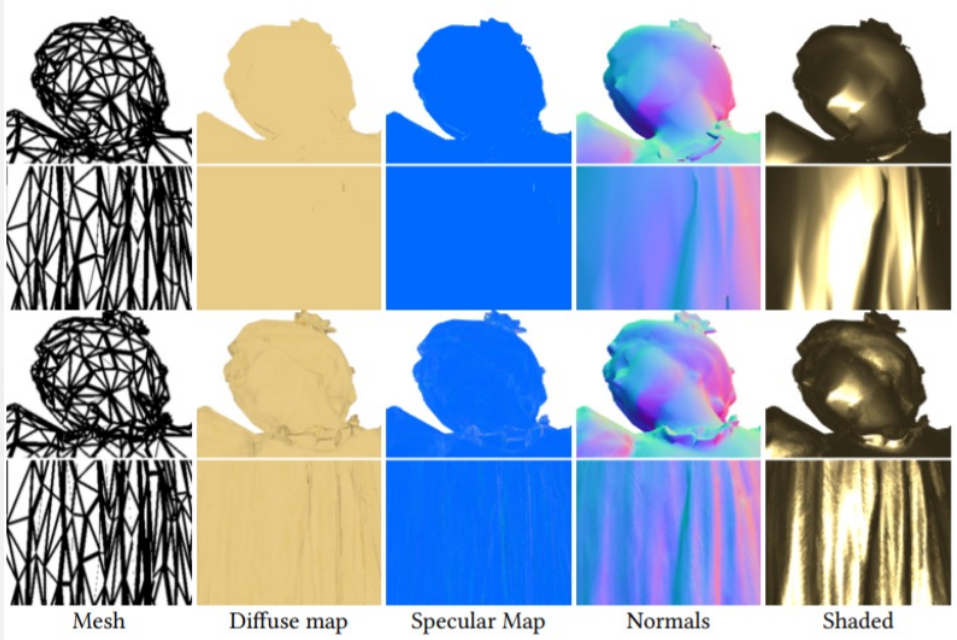
不保纹理的减面算法 – 纹理烘焙



[Ray Casting]



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- **Alain Galvan and Jeff Russell, “A Ray Casting Technique for Baked Texture Generation,” GPU Zen 2, Chapter baked texture generation, 2019**
- **Jon Hasselgren, Jacob Munkberg, Jaakko Lehtinen, Miika Aittala and Samuli Laine, “Appearance-Driven Automatic 3D Model Simplification”, Eurographics Symposium on Rendering 2021**

腾讯实习生招聘

部门名称：光子游戏工作室群-技术中心

工作地点：北美/中国/远程，视工作身份与现居地而定

招聘对象：实习生
1、计算机图形学算法实习生

职位描述：参与计算机图形学相关课题的算法设计与研发，包括几何网格处理，可微渲染，神经网络渲染等相关领域的关键问题

岗位职责和要求：

1.国内外高校在读博士、硕士或高年级本科生，计算机相关专业优先；
2.有良好的数理基础，熟悉计算机图形学、几何处理基础知识；
3.代码基础扎实，能够熟练使用C++/python进行编程；
4.有在图形学相关领域发表学术论文经验优先
5.积极主动、热爱技术，具备良好的沟通能力和团队合作精神

联系方式：xifgao@global.tencent.com