

基于图像的 室内场景三维建模和模拟

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南京大学计算机科学与技术系 & 计算机软件新技术国家重点实验室

- 双一流学科
- 计算机科学与技术一级重点学科：计算机软件和应用学科均是国家重点学科
- 连续三次科技部评估优秀类国家重点实验室（科技部五年评估一次： 2007、2012、2017）

The screenshot shows the official website of the State Key Laboratory for Novel Software Technology at Nanjing University. The header features the SKL logo and the text "计算机软件新技术国家重点实验室(南京大学)" and "State Key Laboratory for Novel Software Technology at Nanjing University". The navigation bar includes links for 首页 (Home), 实验室概况 (Laboratory Overview), 实验室组织 (Laboratory Organization), 科学研究 (Scientific Research), 人才队伍 (Human Resources), 学术交流 (Academic Exchange), 开放课题 (Open Topics), and 其他 (Others). A banner below the navigation bar displays the text "今天是: 2017年10月1日星期日" (Today is Sunday, October 1, 2017). The main content area is divided into several sections: "实验室公告" (Laboratory Announcements) with news about winning the "Dragon Chip Cup" competition; "学术动态" (Academic Activities) listing reports by faculty members like He Dingsheng, Liu Jun, and Chen Ming; "文件下载" (Document Download) for application forms; and "规章制度" (Regulations and Systems) which includes links to the Ministry of Science and Technology's regulations on laboratory construction and management, and the Ministry of Finance's regulations on specialized management of scientific research funds. A sidebar on the right provides a brief introduction to the laboratory, mentioning its establishment in 1986 and its move to its current location in 1987. It also includes a photograph of the building and contact information: 邮编: 210023, 地址: 江苏省南京市栖霞区仙林大道163号计算机科学与技术楼, 电话: 025—89683467, 传真: 025—89686596, and email: keysoftlab@nju.edu.cn.

报告内容

- 室内场景三维建模和模拟
 - 基于单张图像的室内场景三维建模
 - 基于机器学习的室内场景自动着色
 - 物体表面材质几何和光照属性的扫描获取
- 室外（城市）场景的三维建模
- 本组研究工作介绍

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室外场景三维建模

主要应用：

- 数字城市
- 数字资产
- 游戏设计
- 虚拟现实
- 无人驾驶
-



室内场景三维建模

主要应用：

- 室内设计
- 智能家居
- 游戏设计
- 虚拟现实
- 机器人
-



室内场景三维建模和模拟

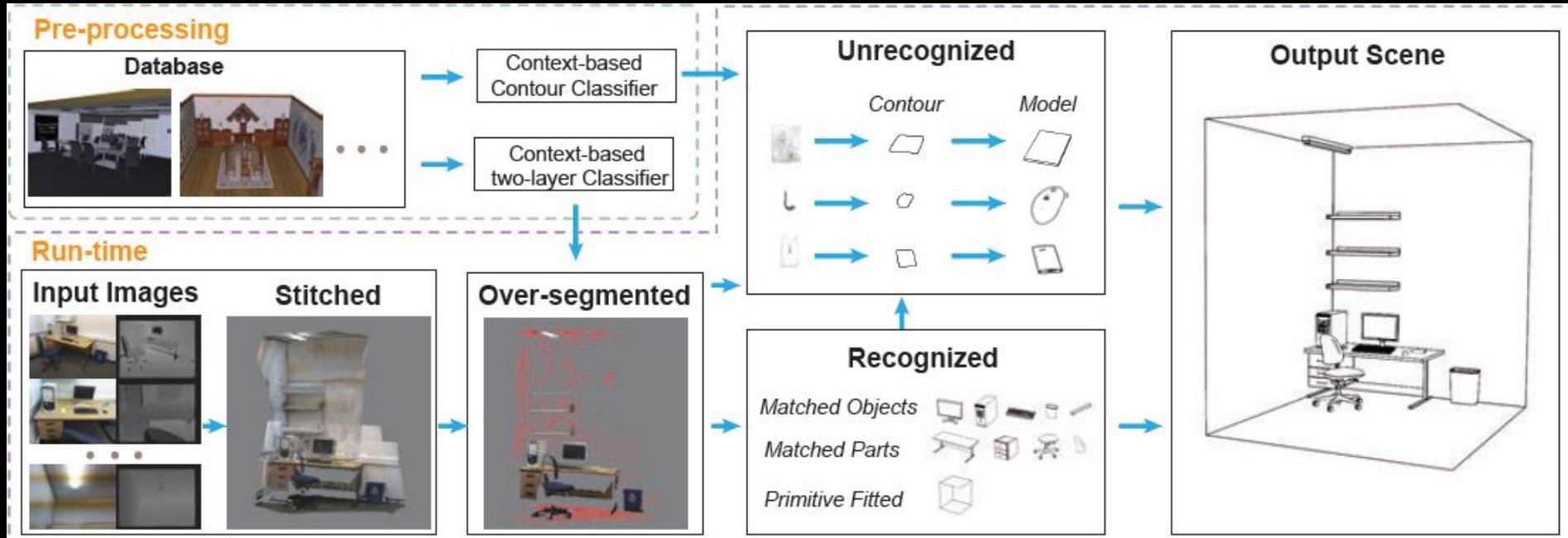
从单张图像重建三维场景



● The Visual Computer 2017,

● IEEE Transactions on Visualization & Computer Graphics (Under Review)

Related Work



Automatic Semantic Modeling of Indoor Scenes from Low-quality RGB-D Data using Contextual Information, ACM Siggraph Asia 2013.

Related Work



Figure 9: Semantic modeling result: living room

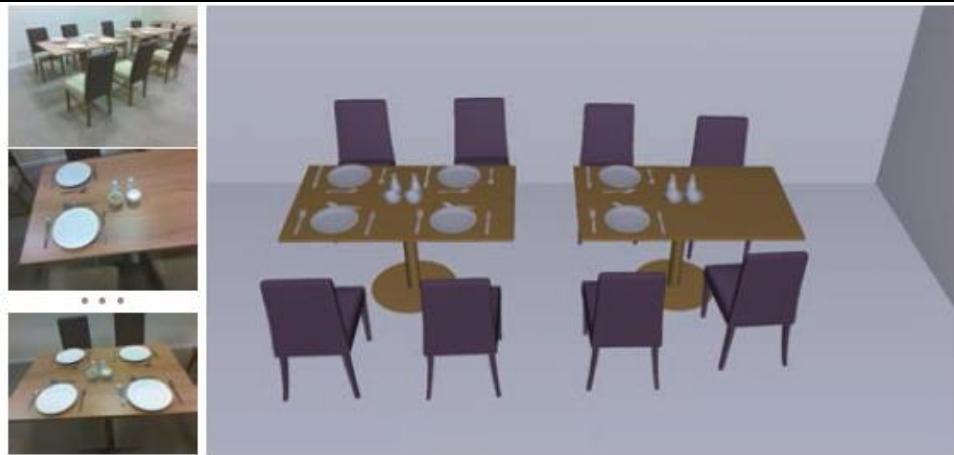
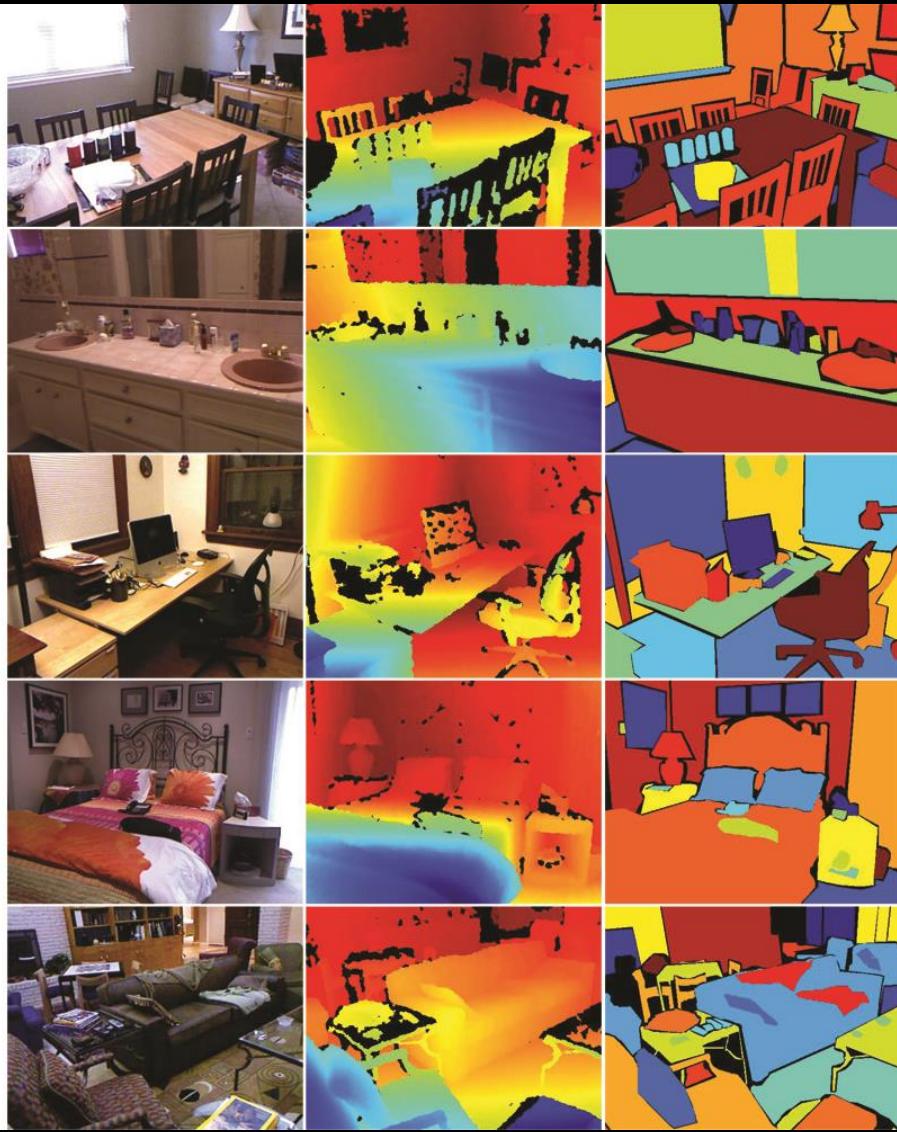
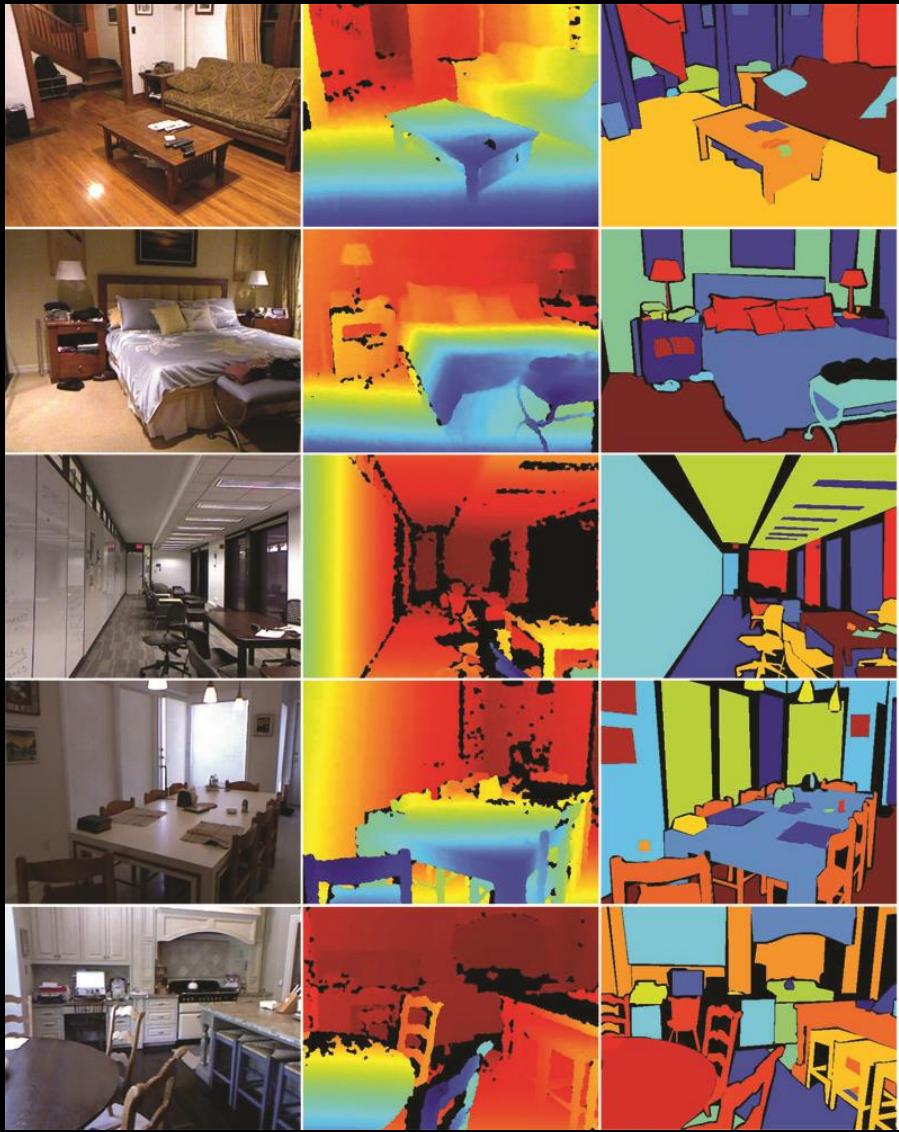


Figure 10: Semantic modeling result: dining room



Figure 11: Two example scenes reconstructed using RGB-D images from the NYU Depth Dataset.

A First Step – Scene Understanding

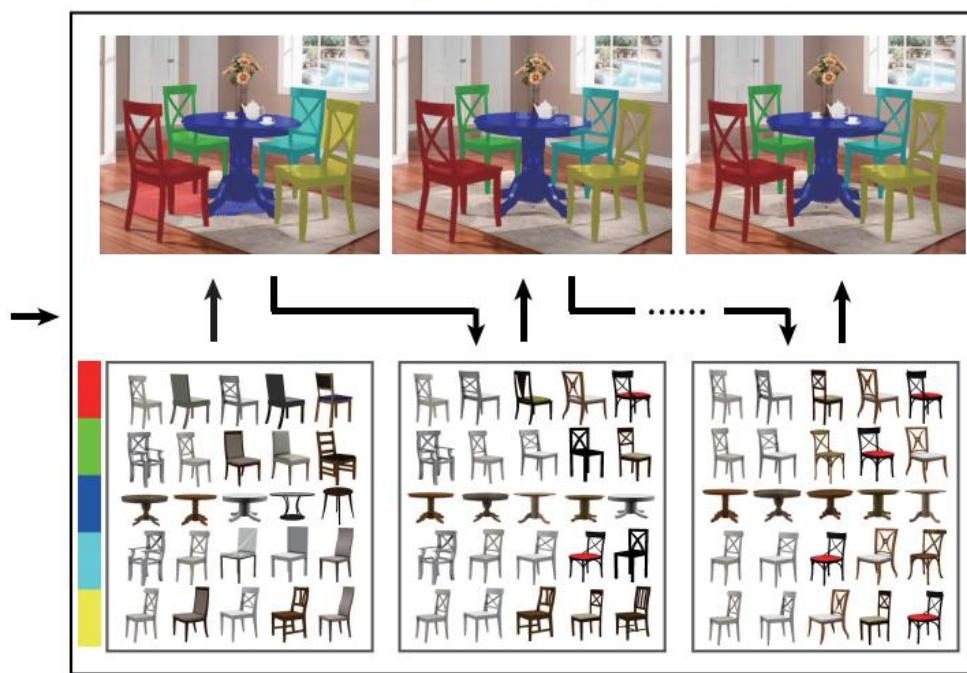


Pipeline

Input image with user interaction



Iteration of segmentation and model retrieval



Final models

Resulting scene



Rendered models



Fig. 1. The pipeline of our framework. The user first drags a few semantic boxes surrounding the objects of interest . We then conduct object segmentation and 3D model retrieval iteratively, yielding the optimal models with rough poses. Finally, we estimate the layout of the scene and refine the poses of all the objects under a unified framework. The 3D models are composed together to obtain the resulting scene.

Object Segmentation

- A Markov Random Field Multi-labeling Problem

The energy function:

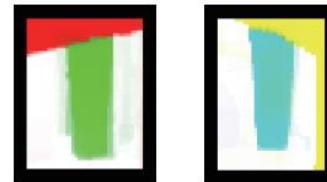
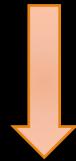
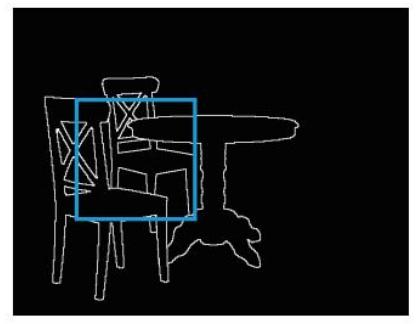
$$P(F|U) = \frac{P(U|F)P(F)}{P(U)}$$

Likelihood term: $P(U|F) = \prod_{s \in S} \exp(-\varphi(s, f_s, U))$

Prior term: $P(F) = \prod_{(s,t) \in N} \exp(-\lambda(\rho(s, t) + \alpha b(s, t))\delta(f_s, f_t))$

solved by Graph Cut Algorithm

Object Segmentation with Model Images



Model Retrieval

- The matching score is calculated as:

$$S_O = (S_F + S_B) \exp\left(\frac{-\rho(1 - S_M)^2}{(S_M^m - S_M^a)^2}\right)$$

S_F : forward matching score

S_B : backward matching score

S_M : mask similarity

S_M^m : maximum mask similarity

S_M^a : average mask similarity

Model Retrieval with Object Segmentation



Segmentation eliminates the negative influence of cluttered background.

Segmentation reduces the influence brought by severe occlusion.

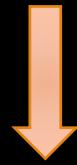
Mask information helps to improve the retrieval.

Results – Model Retrieval



Fig. 14. Top five retrieved models obtained by [18] and our method. Left: The input images with specified target objects. Right: The top five retrieved models, in which for each group the first row is the results by [18], and the second is ours.

Pose Refinement



Results – Scene Reconstruction



Fig. 13. Comparison of model retrieval and scene reconstruction. (a): Input images. (b): HOG results. (c): Results by [17]. (d): Our results without pose refinement. (e): Our results with pose refinement. (f): Our final rendering results.

Results – Scene Reconstruction



Fig. 13. Comparison of model retrieval and scene reconstruction. (a): Input images. (b): HOG results. (c): Results by [17]. (d): Our results without pose refinement. (e): Our results with pose refinement. (f): Our final rendering results.

Results – Segmentation



Fig. 18. Comparison of segmentation results. (a): Input images. (b): PSPNet [41]. (c): GrabCut [32]. (d): Our method. (e): Ground truth.

室内场景三维建模和模拟

三维室内场景自动着色

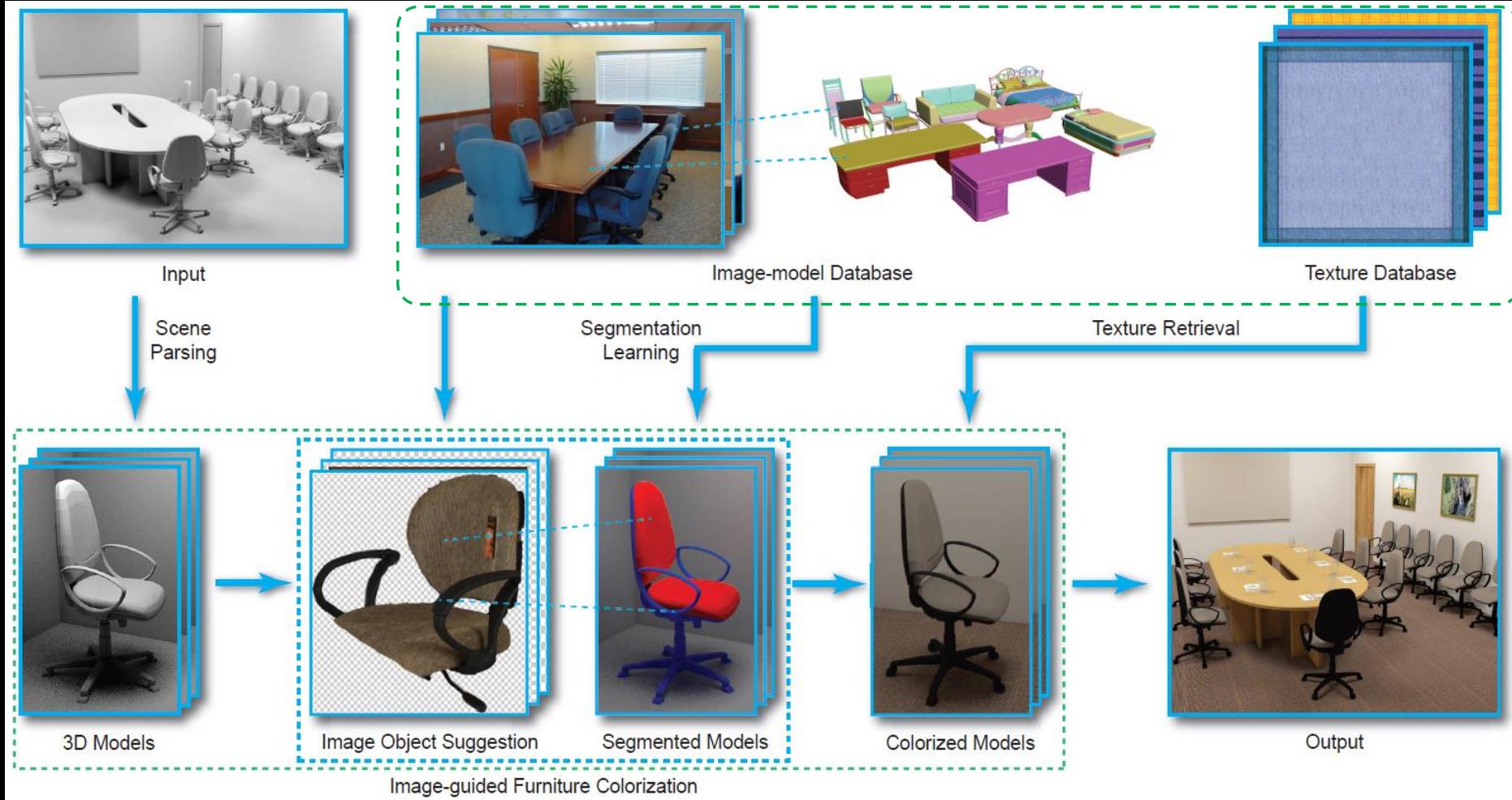


Motivation

- Increasing needs for non-designers to decorate their houses
- Assigning materials using 3D modeling software is time-consuming and requires professional skills



Colorization Pipeline



The
Database
-
1680
Indoor
Images

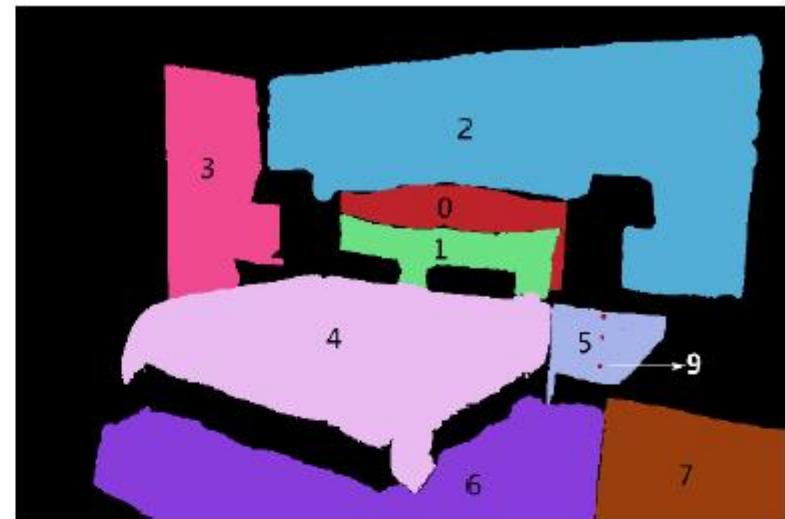


Photo	Name	Number	Texture
bedroom10013.jpg	Bed_frame	0	Wood
bedroom10013.jpg	Bed_pillow	1	Fabric
bedroom10013.jpg	Wall	2	Fabric
bedroom10013.jpg	Curtain	3	Fabric
bedroom10013.jpg	Bed_clothes	4	Fabric
bedroom10013.jpg	Cabinet_surface	5	Wood
bedroom10013.jpg	Floor	6	Fabric
bedroom10013.jpg	Cabinet	7	Wood
bedroom10013.jpg	Bed	8	0_1_4
bedroom10013.jpg	Cabinet_handle	9	Metal
bedroom10013.jpg	Cabinet	10	5_9

The
Database
-
200
Furniture
Models

Wooden sofa			
Chair			
Bed			

Wood:



The
Database

-
2650

Texture
Images

Fabric:

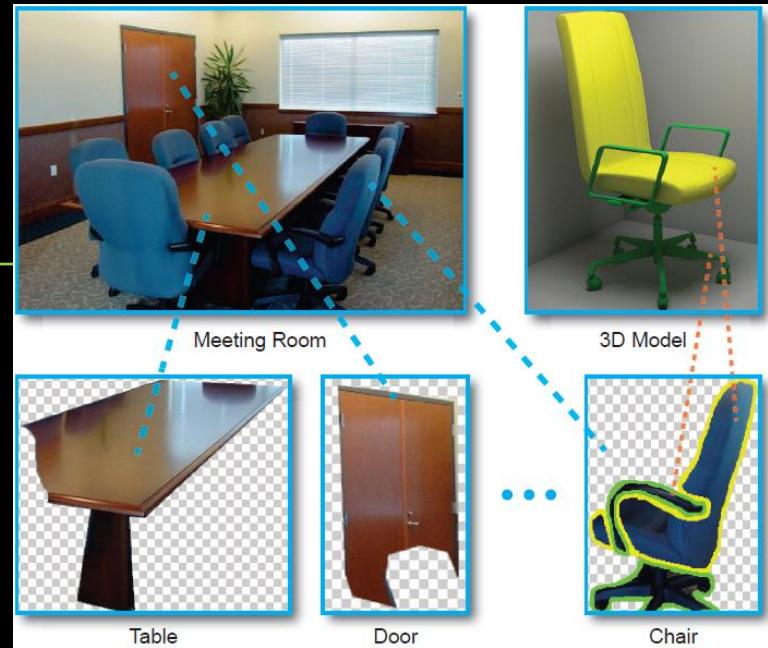


Marble:



Furniture Colorization

- A classification problem



- Features:

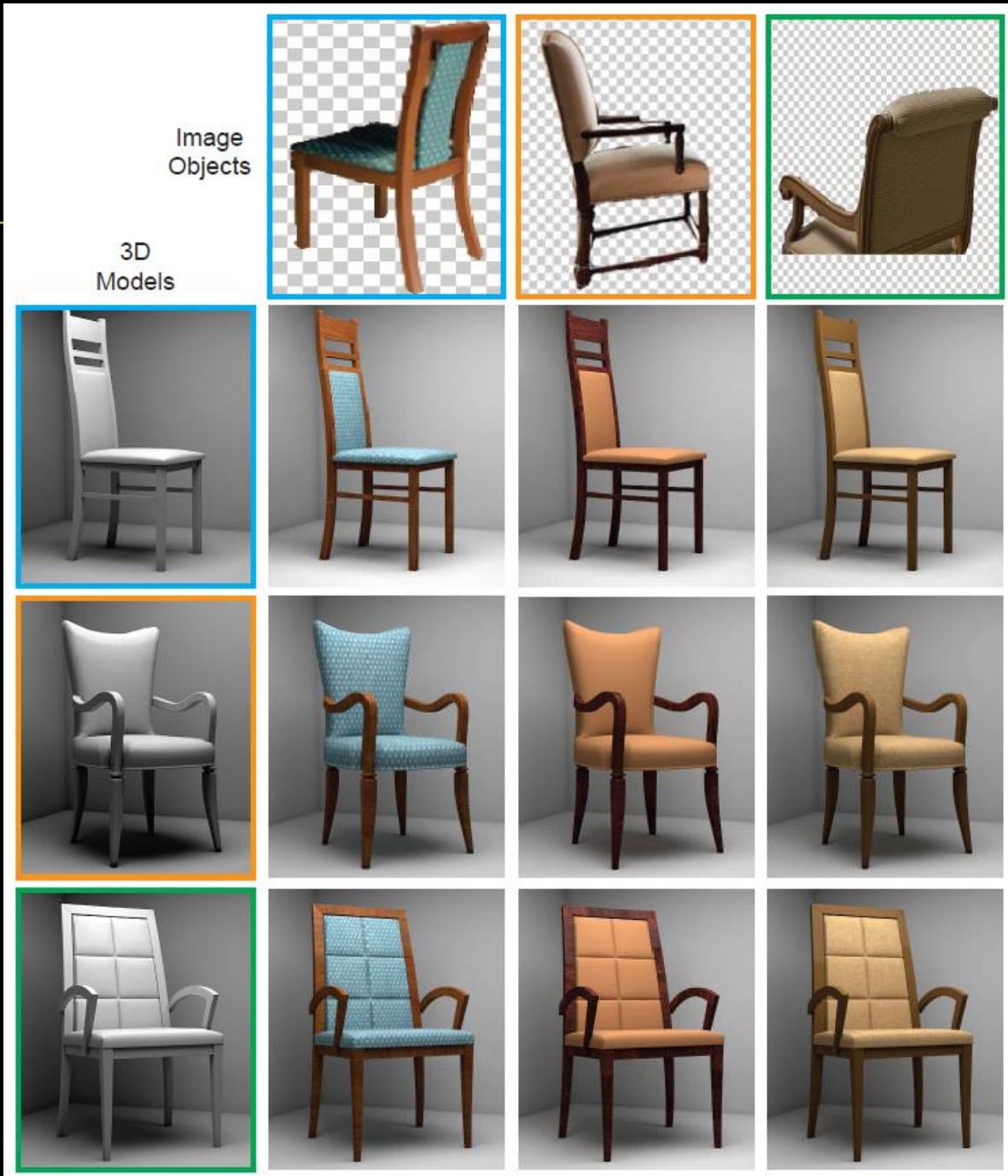
- Local: Curvature, PCA, Shape Diameter Function (SDF), Average Geodesic Distance (AGD), Shape Context and Spin Image
- Global: Histograms of the Gaussian curvature, AGD feature and SDF feature

- Classifier: JointBoost

Furniture

Colorization

Results



Scene Colorization

- A Markov Random Field Framework

The energy function:

$$E = E_D + \alpha E_S + \beta E_C$$

Data term: $E_D = \sum_i \log(G(C_{M_i}))$

Smoothness term: $E_S = \sum_{ij} \log(G(C_{M_i}, C_{M_j}))$

Constraint term: $E_c = -\frac{1}{Z} \sum_i \sum_{k=1}^5 \min_j ||C_{U_k} - C_{M_{ij}}||$

solved by Markov Chain Monte Carlo Sampling

Colorization by Examples



Results



(a)



(b)



(c)



Results



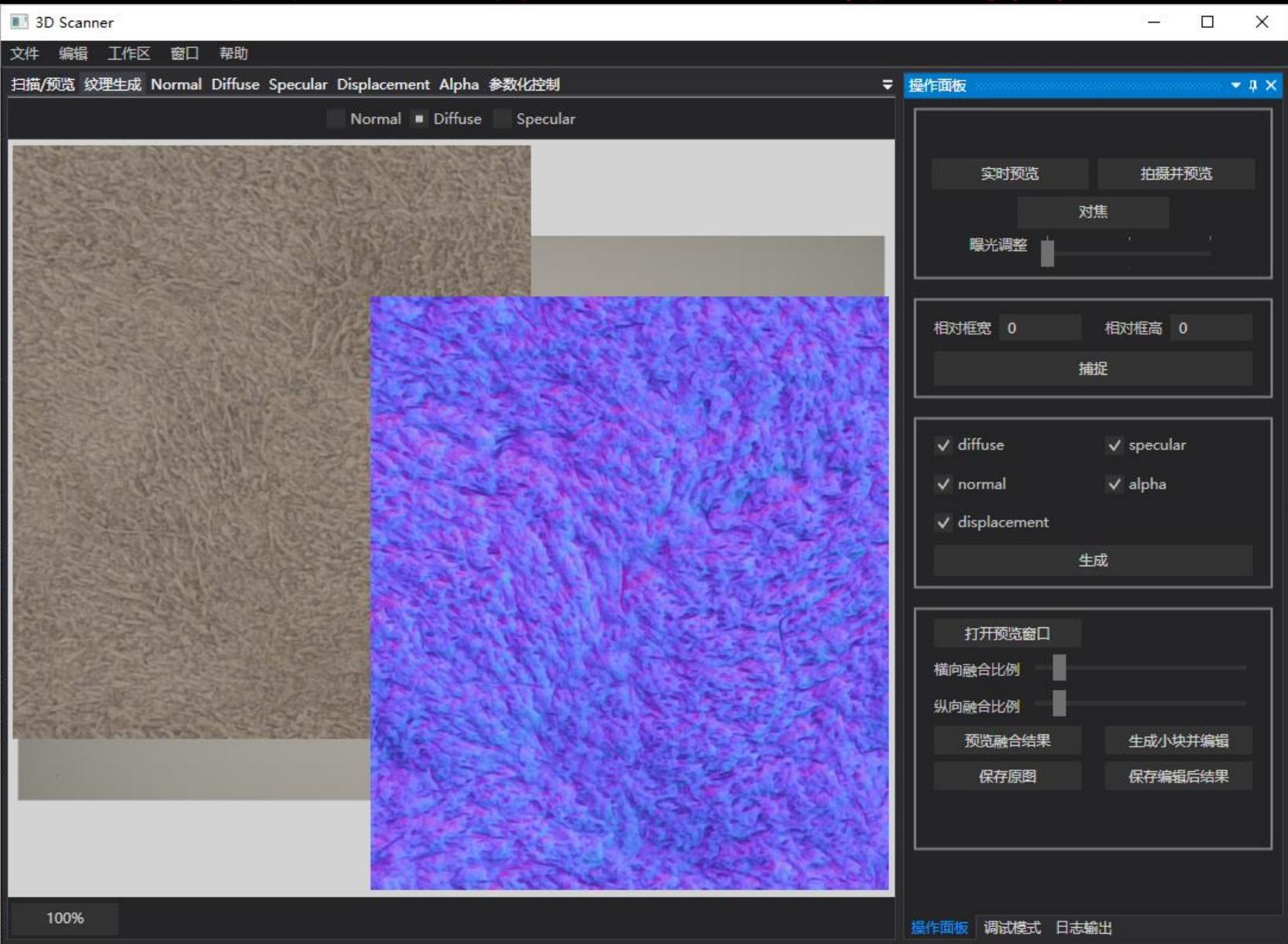
室内场景三维建模和模拟 材质物理属性扫描和高端视觉特效

➤ Large scale geometry can be modeled easily, but small scale geometry is the key to PHOTOREALISTIC RENDERING (工业级应用的照片真实感)



室内场景三维建模和模拟

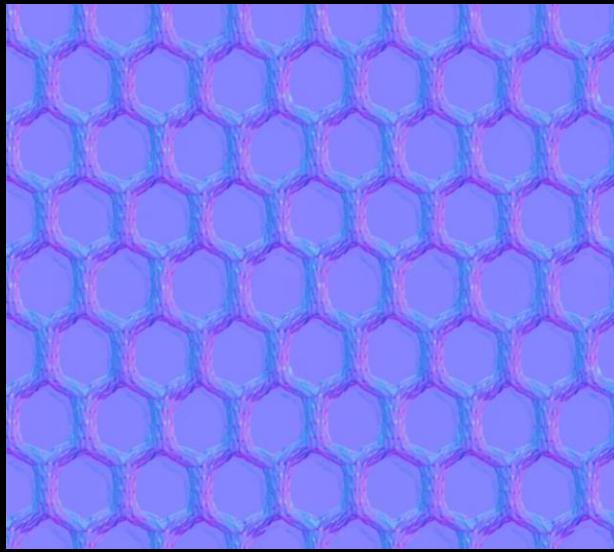
材质物理属性扫描和高端视觉特效



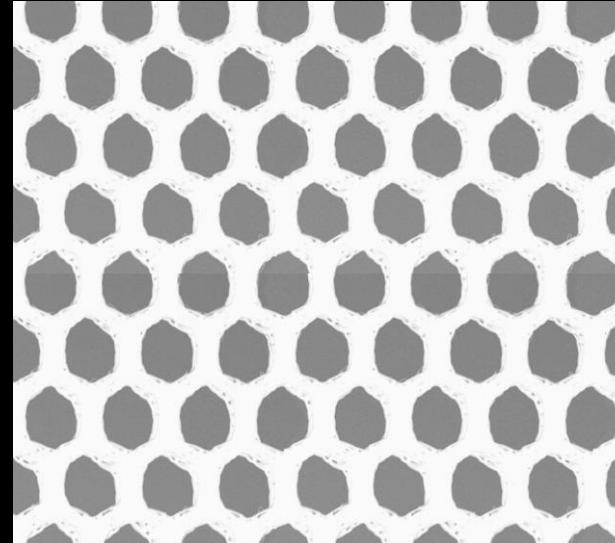
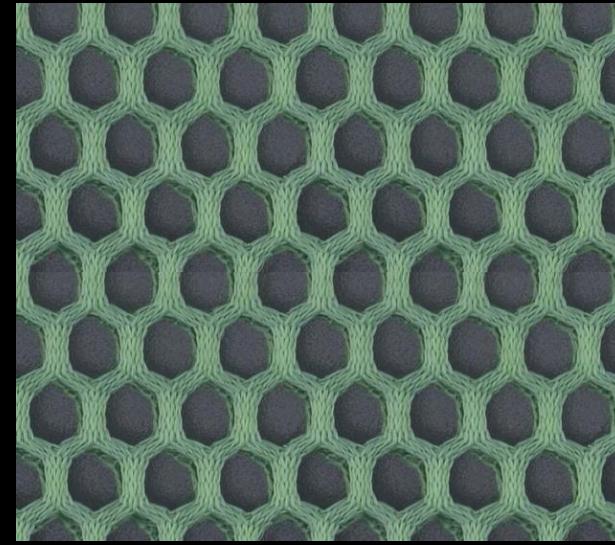
室内场景三维建模和模拟

材质物理属性扫描和高端视觉特效

Normal
Specular



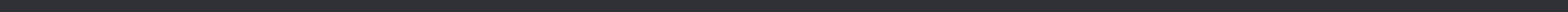
Diffuse
Alpha



室内场景三维建模和模拟 材质物理属性扫描和高端视觉特效



室内场景三维建模和模拟 材质物理属性扫描和高端视觉特效



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室外（城市）大场景三维建模

UAV-based激光雷达、倾斜摄影大场景建模



室外（城市）大场景三维建模

UAV-based激光雷达、倾斜摄影大场景建模

1. 南京紫东科技园区实景三维重建

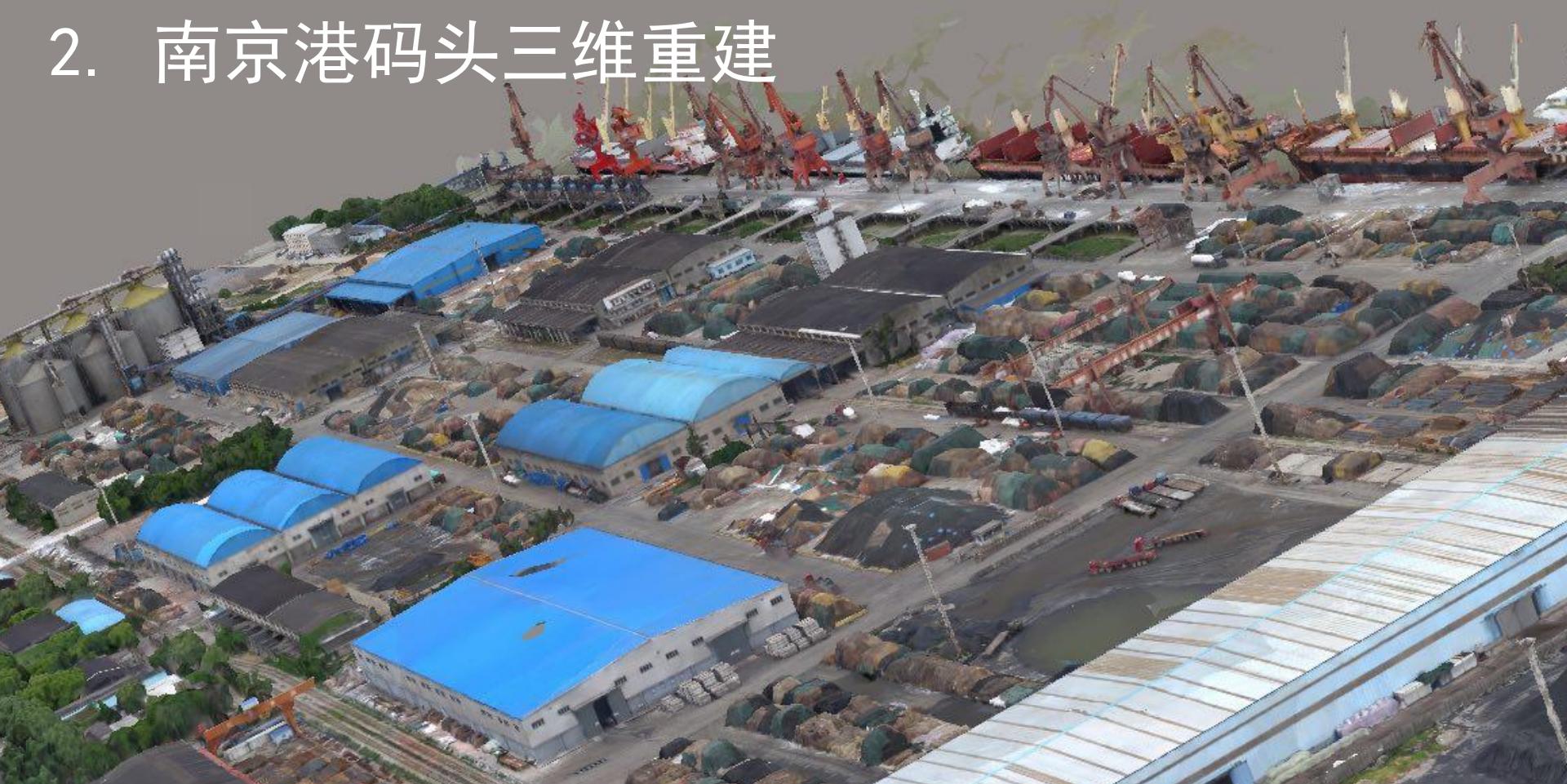


室外（城市）大场景三维建模

UAV-based激光雷达、倾斜摄影大场景建模



2. 南京港码头三维重建



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My Group

研究方向1



拥有自主研发的激光
和摄影测量仪
及多台工业无人机



建有企业联合实验室

My Group

研究方向2

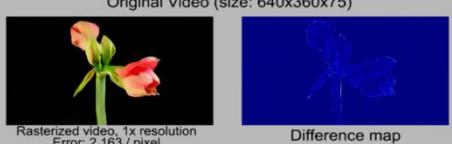


图像视频
处理 &
计算机
视觉 (CV)

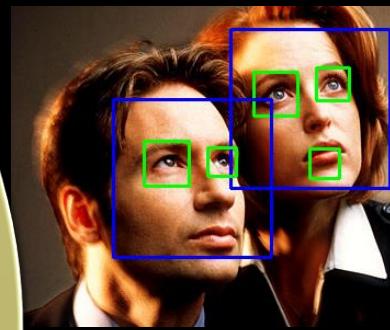
图像
视频分割
和处理



图像
视频增强
和计算摄
影学



内容分析
与处理
(人、车、行
为、事件
检测识别
跟踪)



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参考文献

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- **Jie Zhu**, **Yanwen Guo***, and Han Ma, A Data-driven Approach for Furniture and Indoor Scene Colorization, IEEE Transactions on Visualization and Computer Graphics, 2018, 24(9): 2473-2486.
- **Mingming Liu**, **Yanwen Guo***, Jun Wang, Indoor Scene Modeling from a Single Image Using Normal Inference and Edge Features, The Visual Computer, 2017, 33(10): 1-14.
- **Mingming Liu**, Yunfeng Zhang, Jingwu He, Jie Guo, **Yanwen Guo***, Image-based 3D Model Retrieval for Indoor Scenes by Simulating Scene Context, IEEE ICIP 2018.

谢 谢！

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