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）

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：

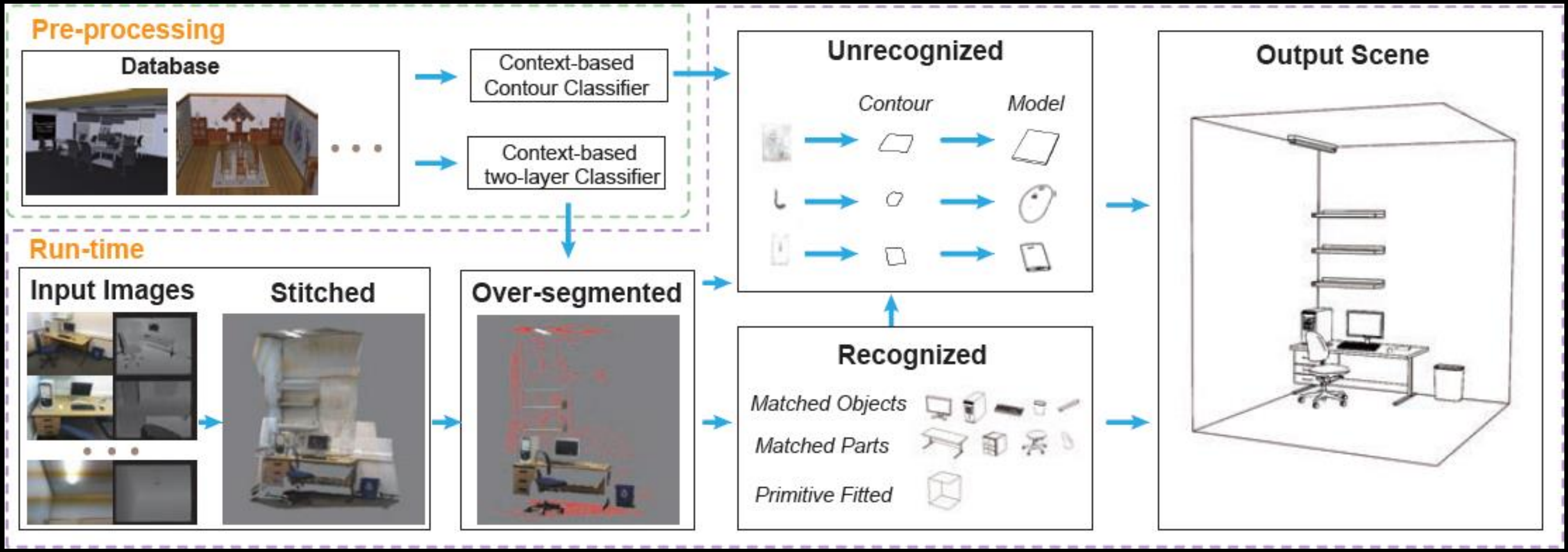
- 室内设计
- 智能家居
- 游戏设计
- 虚拟现实
- 机器人
- … …

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*

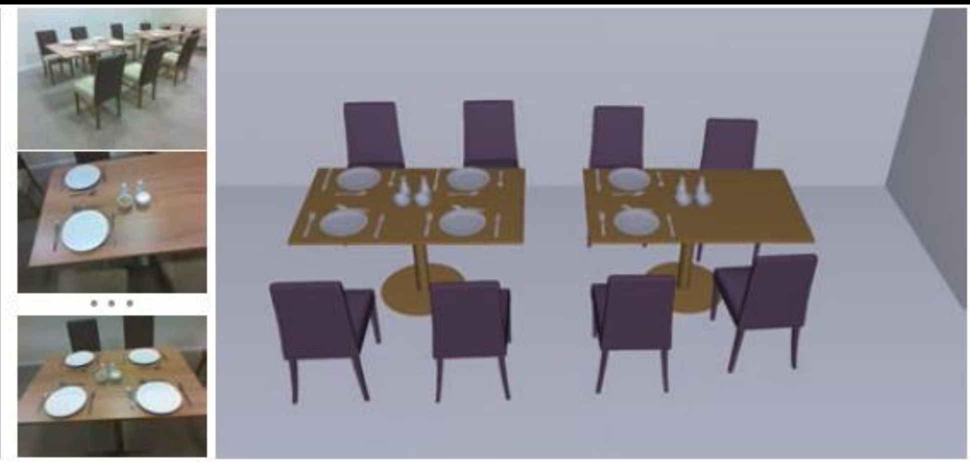
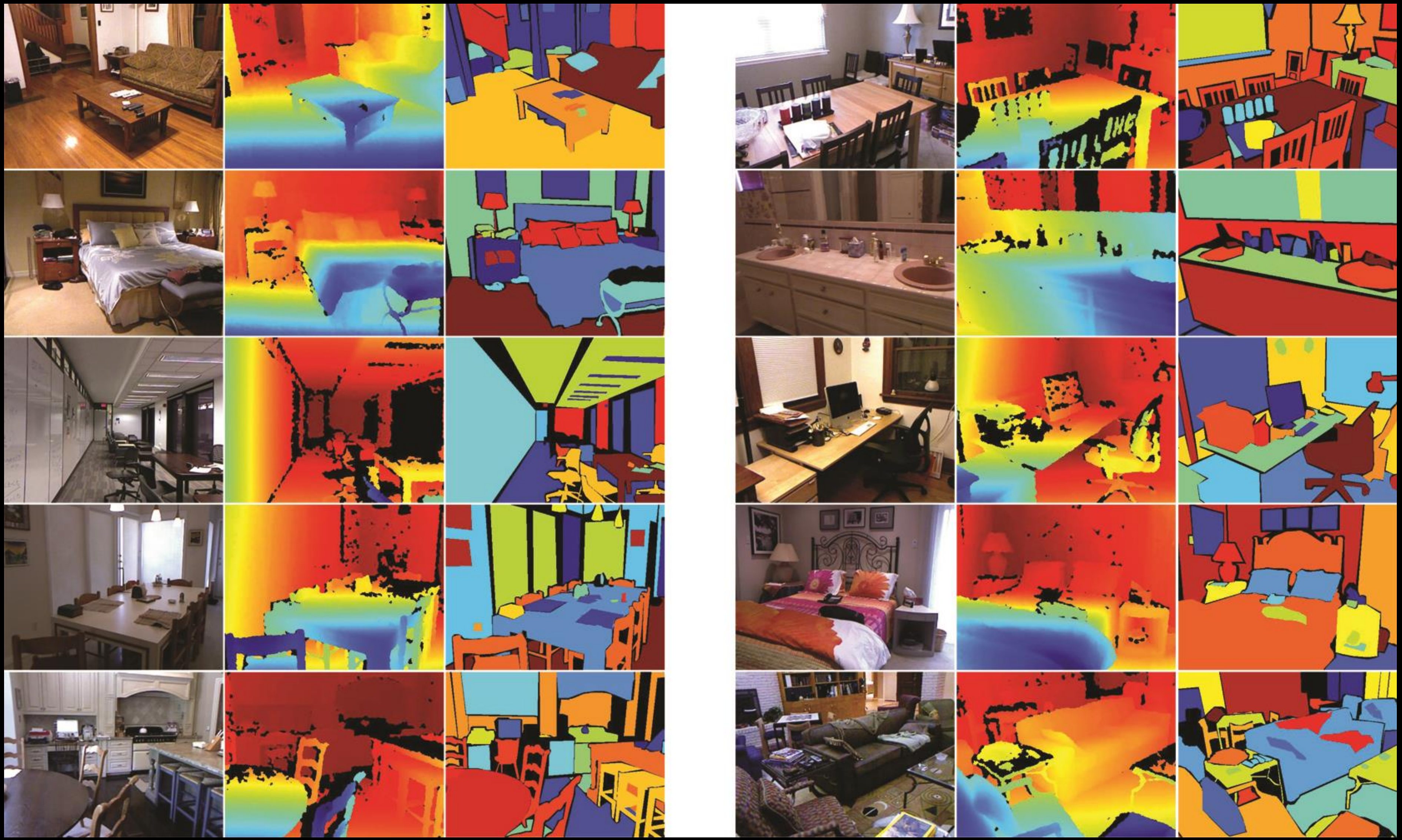


Figure 10: *Semantic modeling result: dining room*

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

A First Step – Scene Understanding



Pipeline

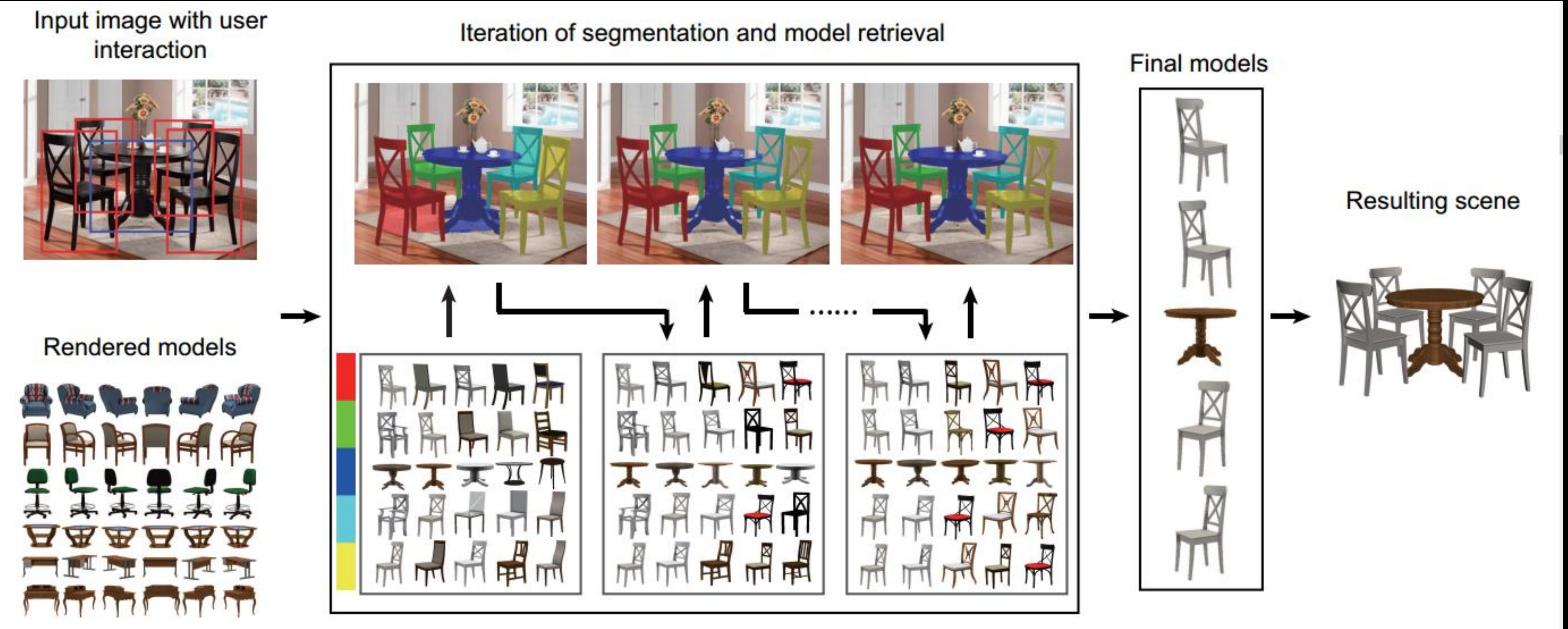


Fig. 1. The pipeline of our framework. The user first drags a few semantic boxes surrounding the objects of interest . We then conduct object segmentation and 3D model retrieval iteratively, yielding the optimal models with rough poses. Finally, we estimate the layout of the scene and refine the poses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

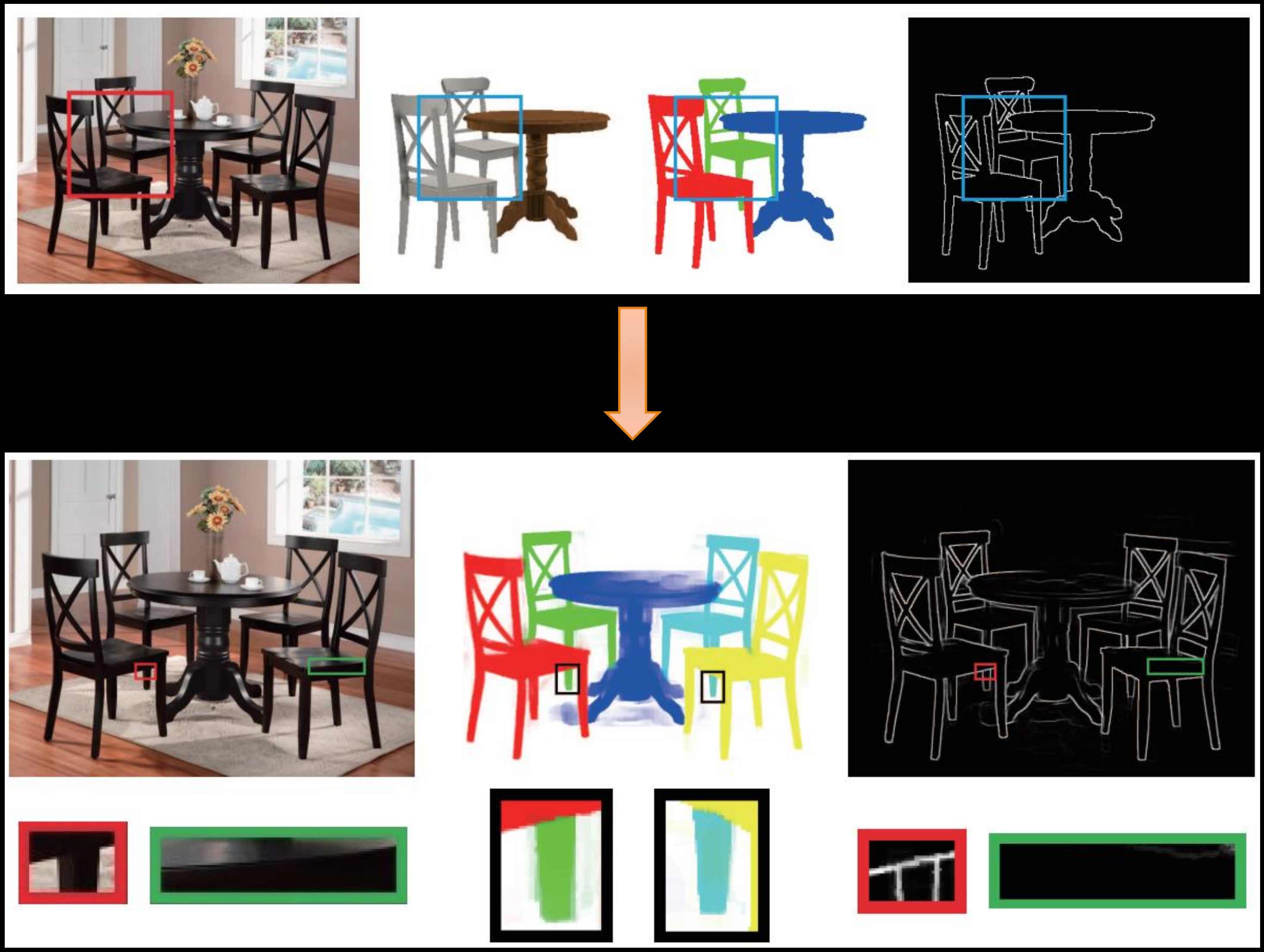
$$P(F|U) = \frac{P(U|F)P(F)}{P(U)}$$

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

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

solved by Graph Cut Algorithm

Object Segmentation with Model Images



Model Retrieval

- The matching score is calculated as:

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

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.

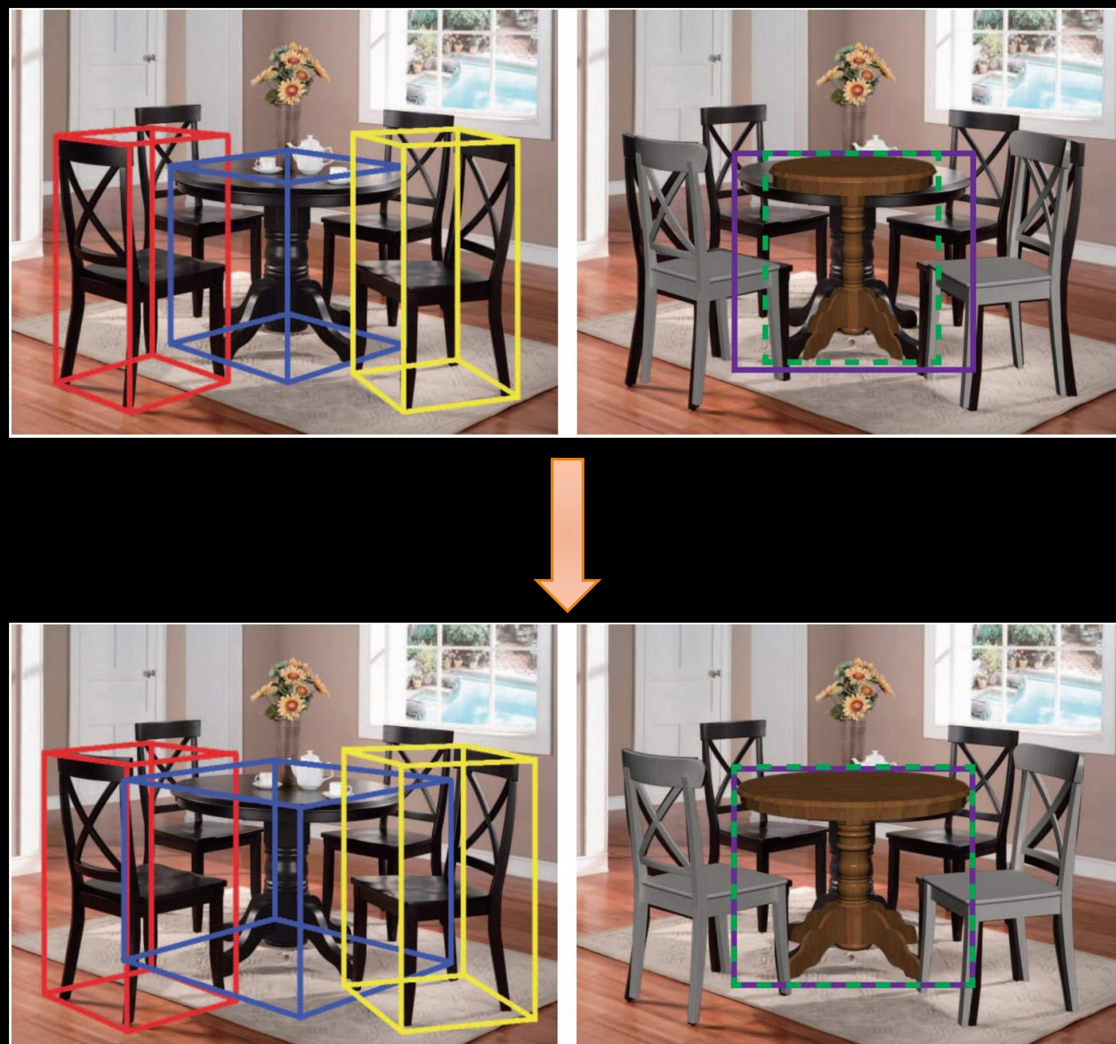
Segmentation reduces the influence brought by severe occlusion.

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.

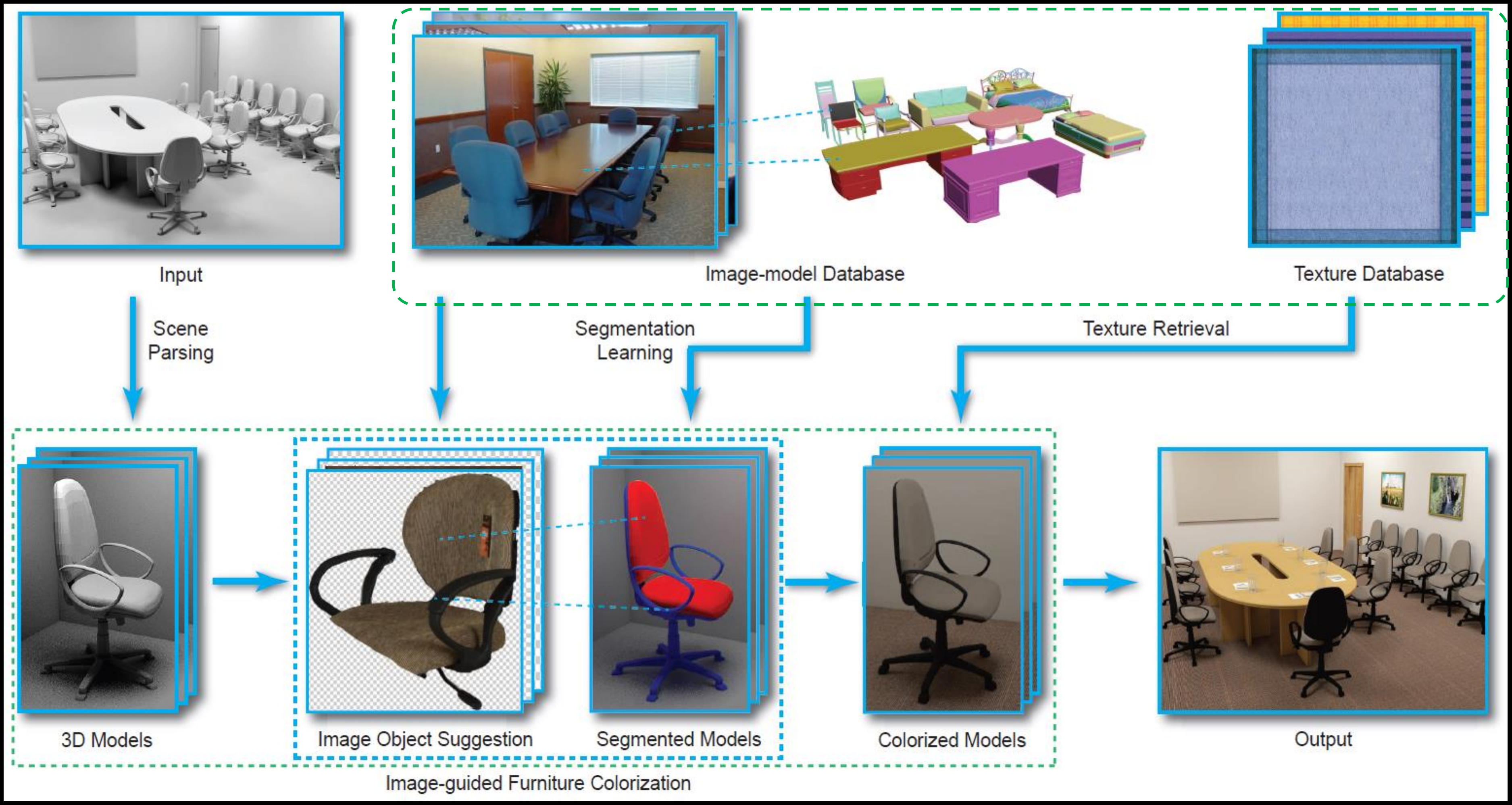
室内场景三维建模和模拟

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

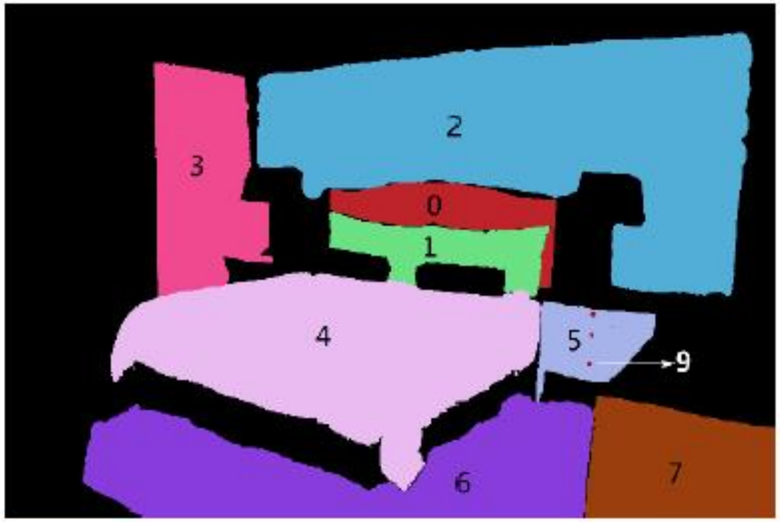


Photo	Name	Number	Texture
bedroom10013.jpg	Bed_frame	0	Wood
bedroom10013.jpg	Bed_pillow	1	Fabric
bedroom10013.jpg	Wall	2	Fabric
bedroom10013.jpg	Curtain	3	Fabric
bedroom10013.jpg	Bed_clothes	4	Fabric
bedroom10013.jpg	Cabinet_surface	5	Wood
bedroom10013.jpg	Floor	6	Fabric
bedroom10013.jpg	Cabinet	7	Wood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

The

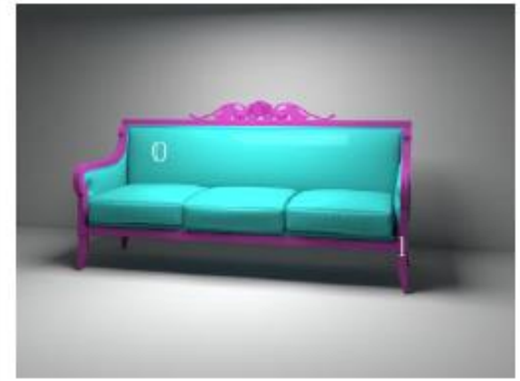
Database

-

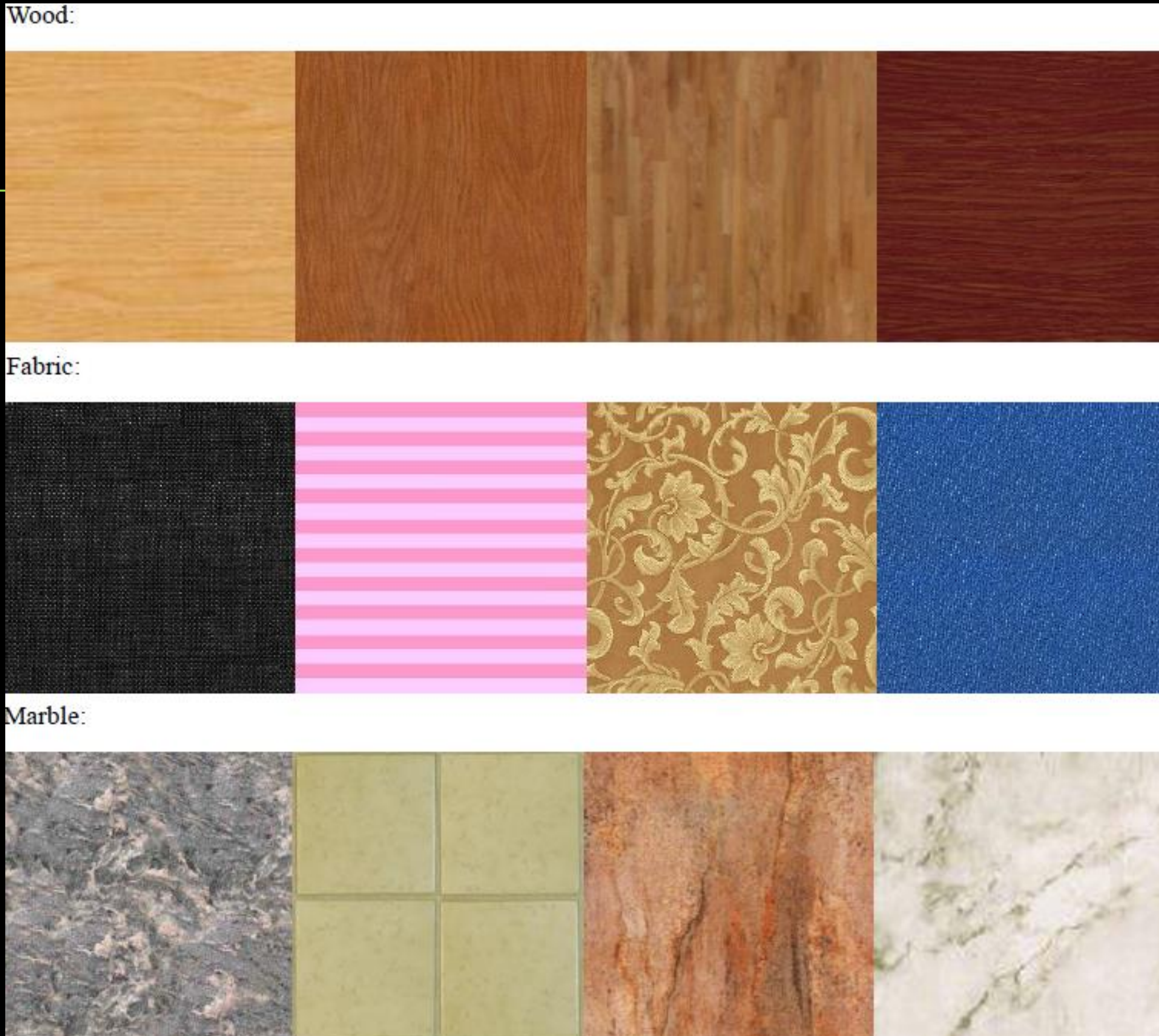
200

Furniture

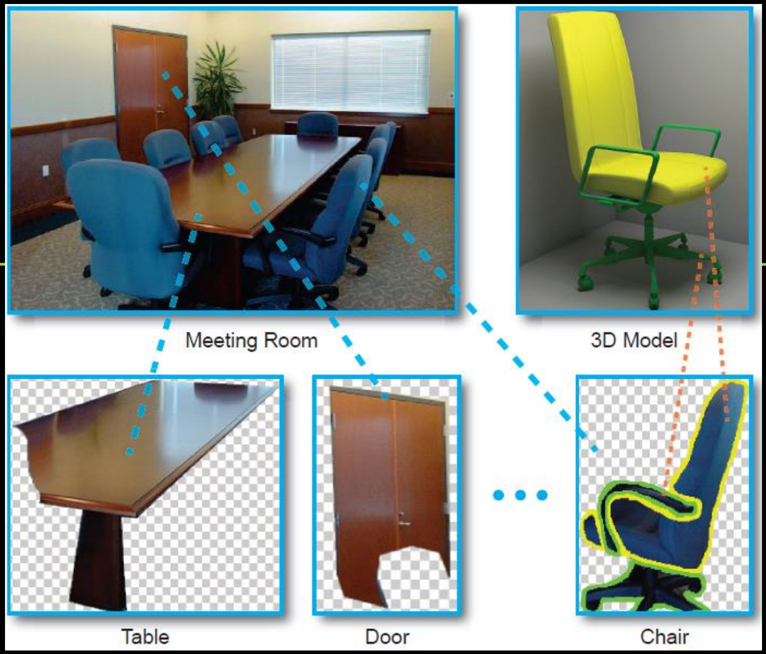
Models

Wooden sofa			
Chair			
Bed			

The Database - 2650 Texture Images

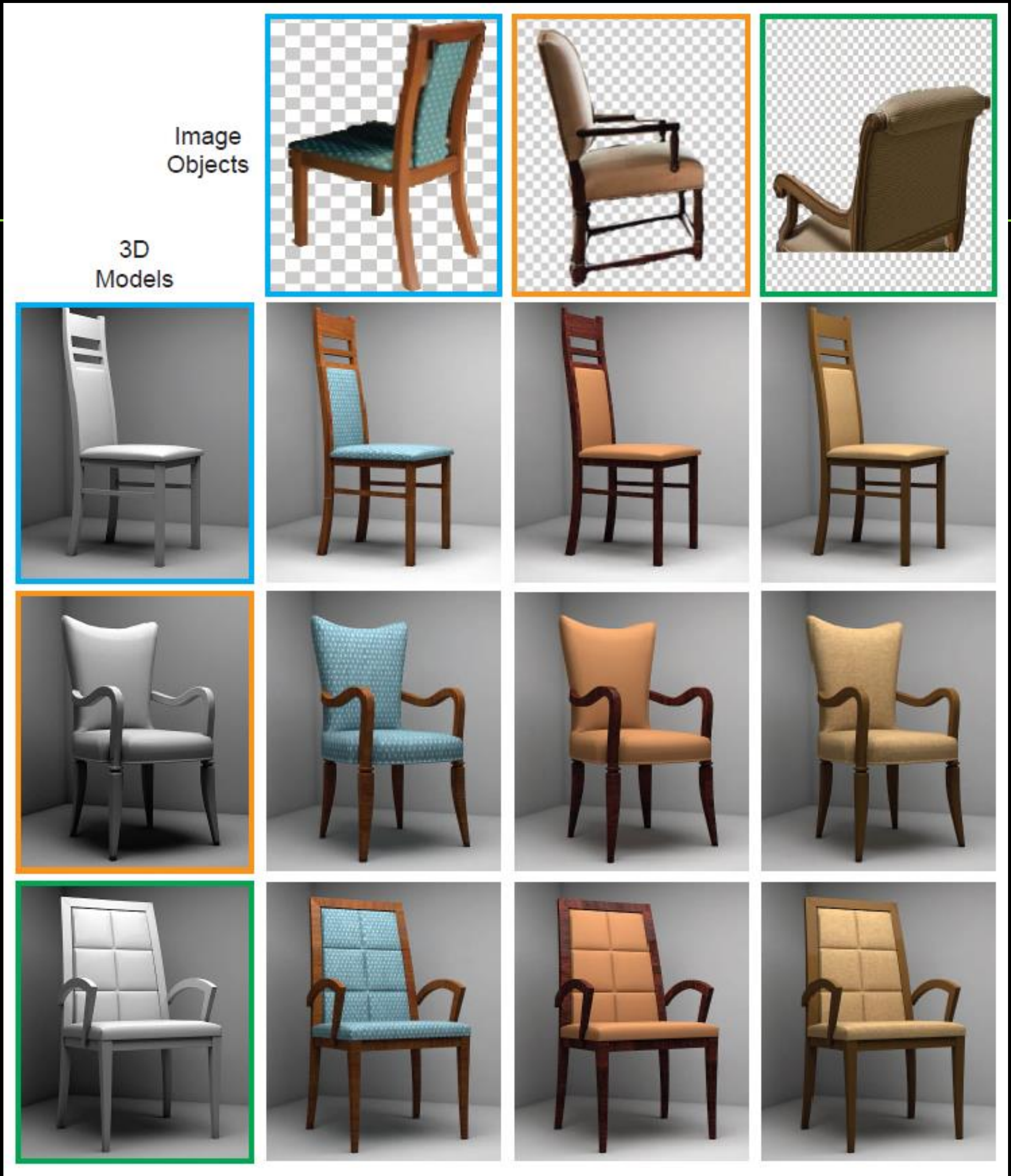


Furniture Colorization



- 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:

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

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

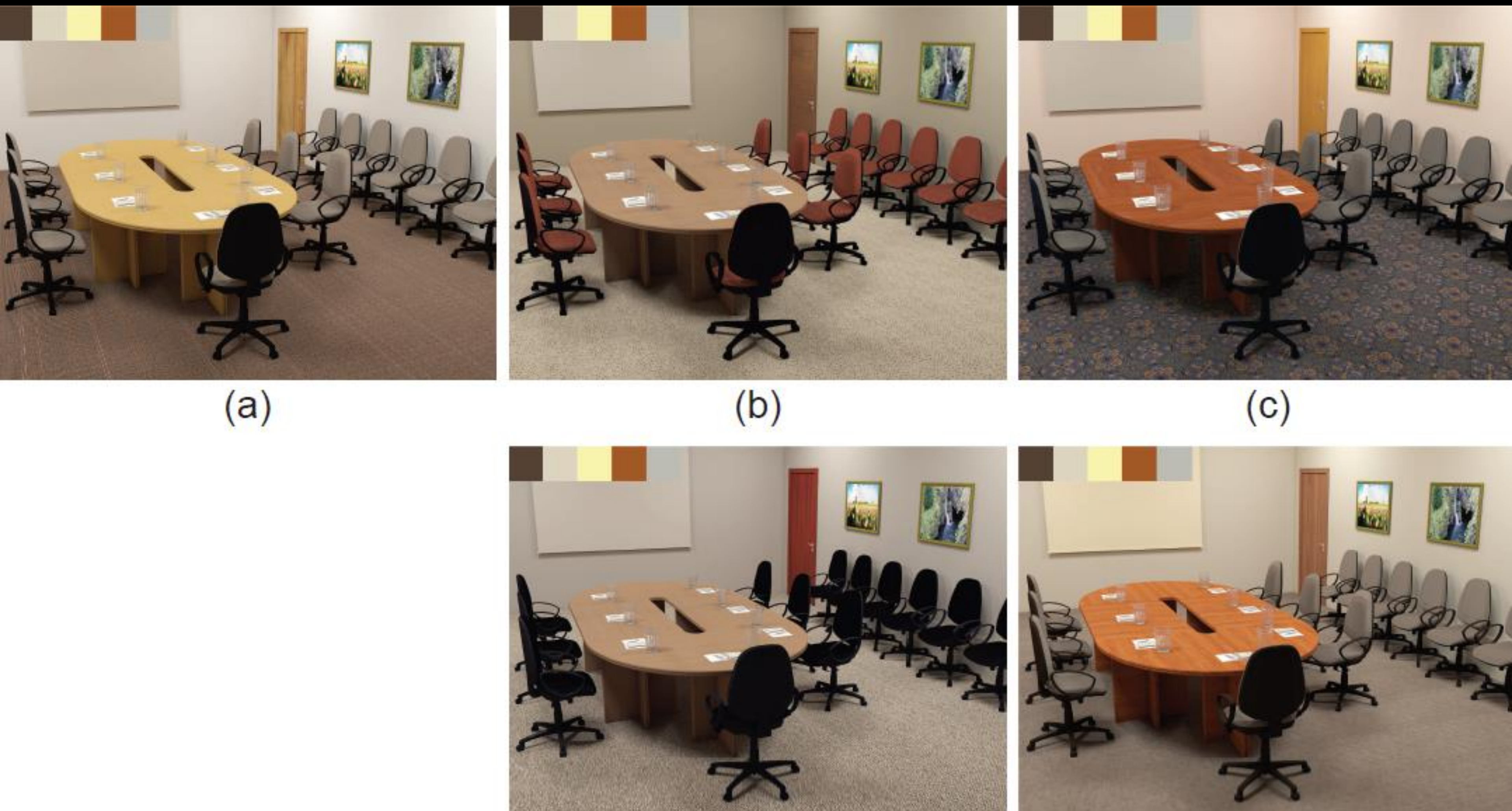
$$Smoothness\ term:\ E_S = \sum_{ij} \log(G(C_{M_i}, C_{M_j}))$$

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

solved by Markov Chain Monte Carlo Sampling

Colorization by Examples

Results



Results



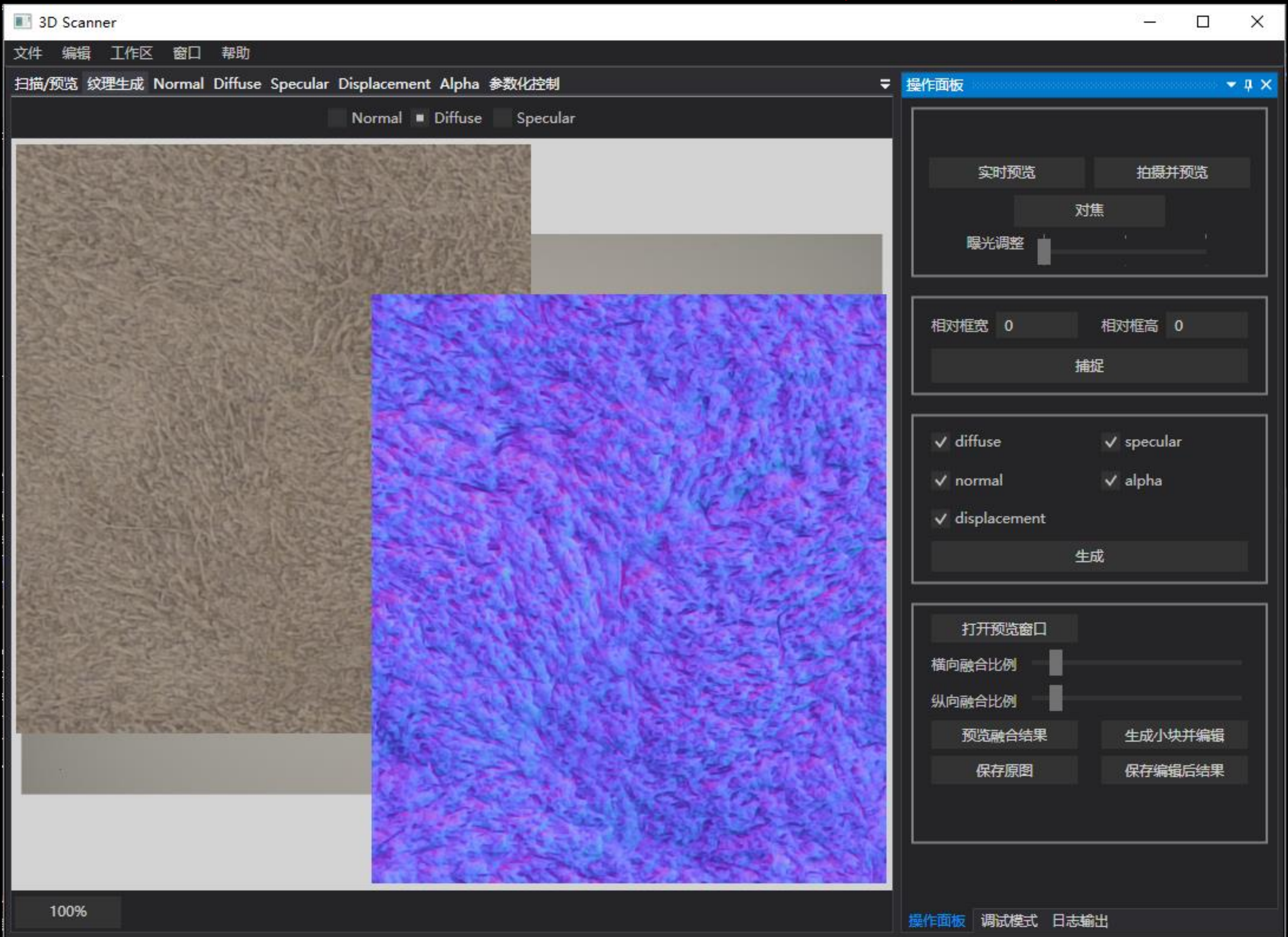
室内场景三维建模和模拟

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

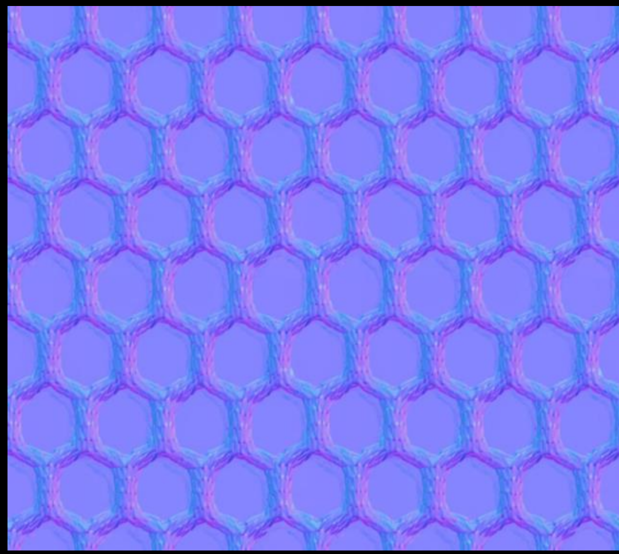
材质物理属性扫描和高端视觉特效



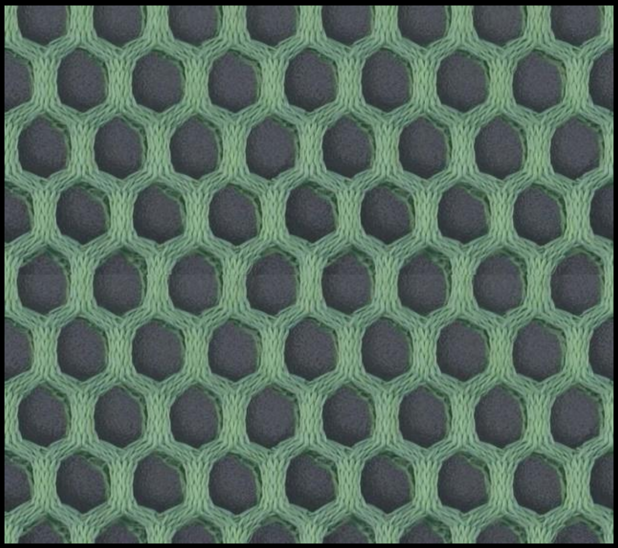
室内场景三维建模和模拟

材质物理属性扫描和高端视觉特效

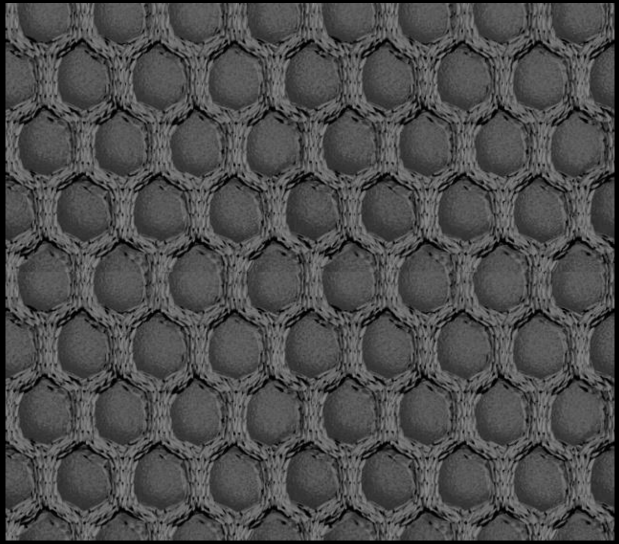
Normal



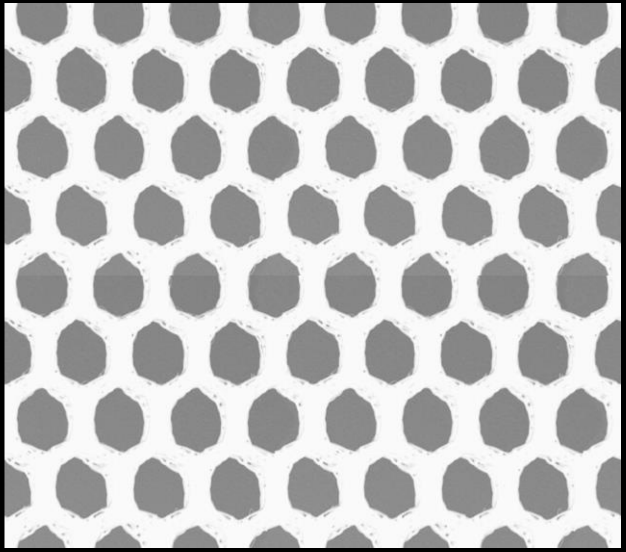
Diffuse



Specular



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

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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

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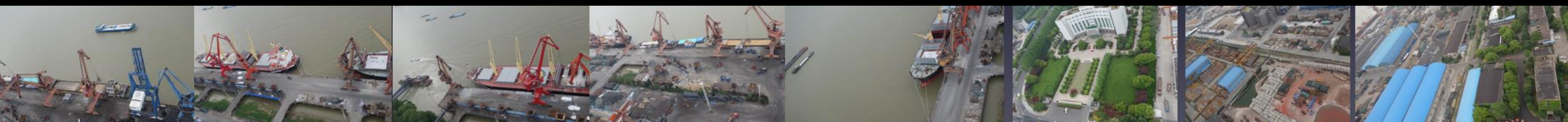
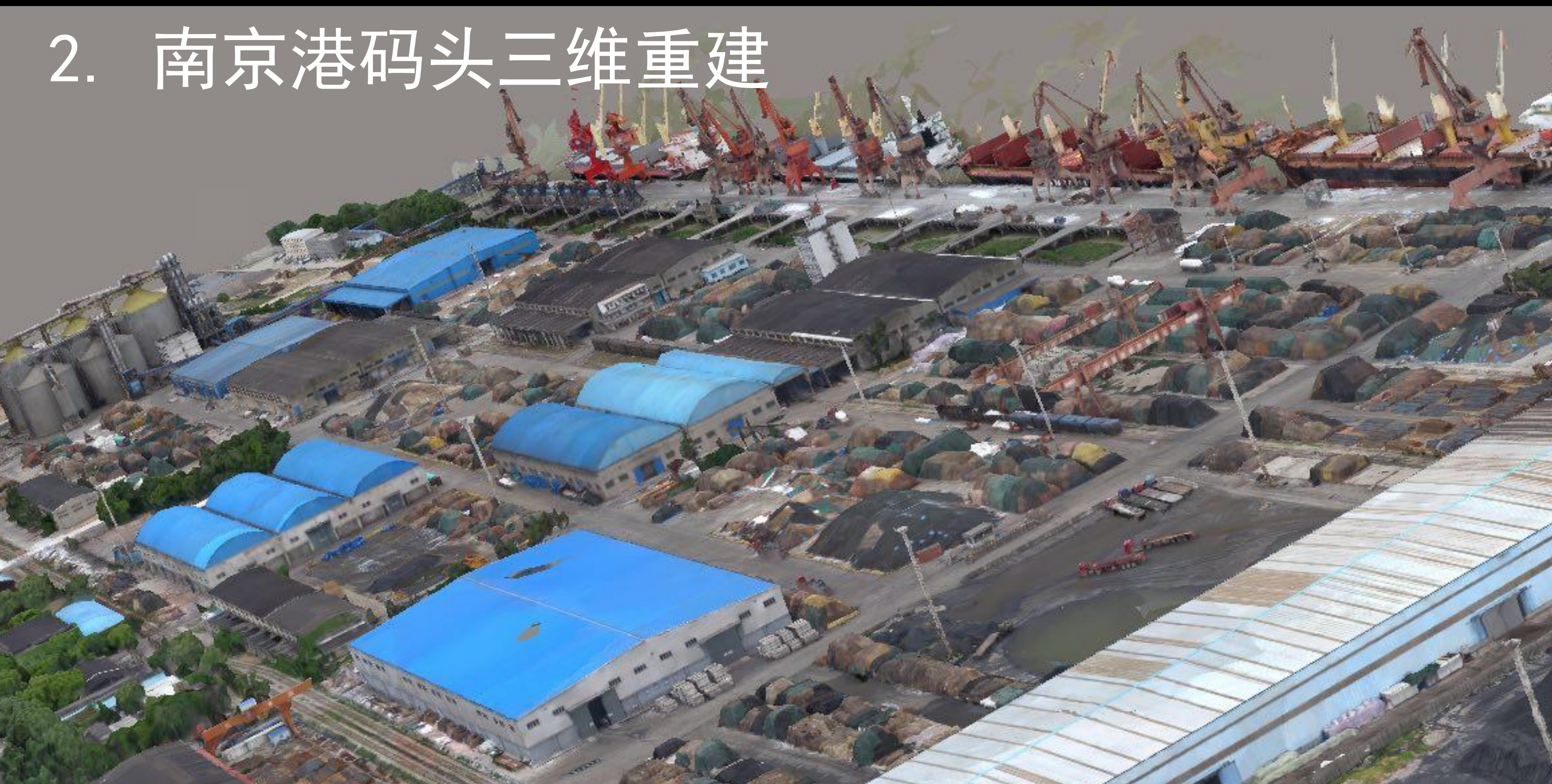


2. 南京港码头三维重建



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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

三维场景
真实感
绘制

基于
机器人、
无人机的
大场景
三维建模

计算机图形
学(CG)&
虚拟现实
(VR)

虚拟现实
和
增强现实

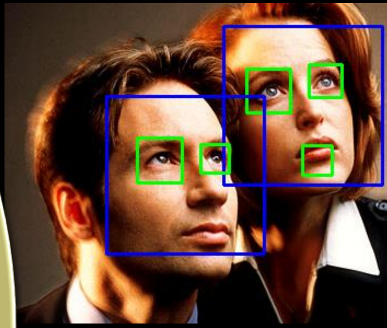
SLAM技术、
室内场景
三维建模
和模拟

建有企业联合实验室

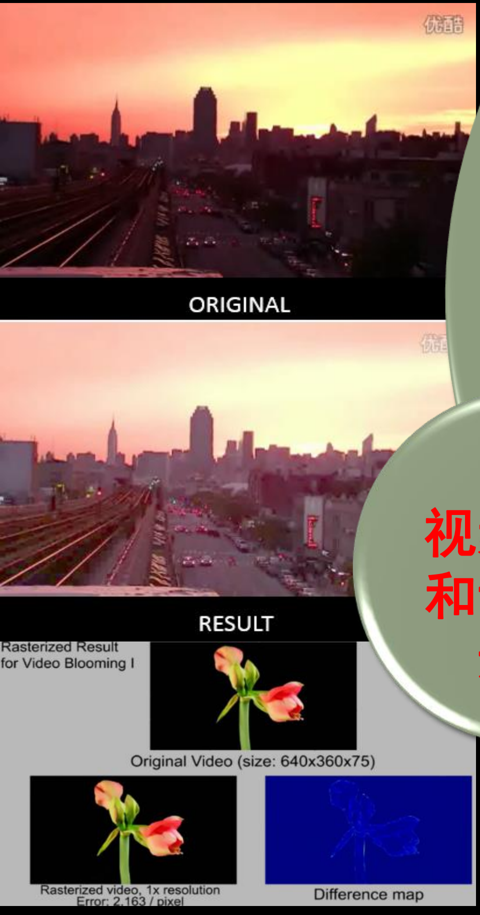
My Group
研究方向2

图像视频分割和处理

图像视频处理 & 计算机视觉(CV)



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.

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谢 谢！

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