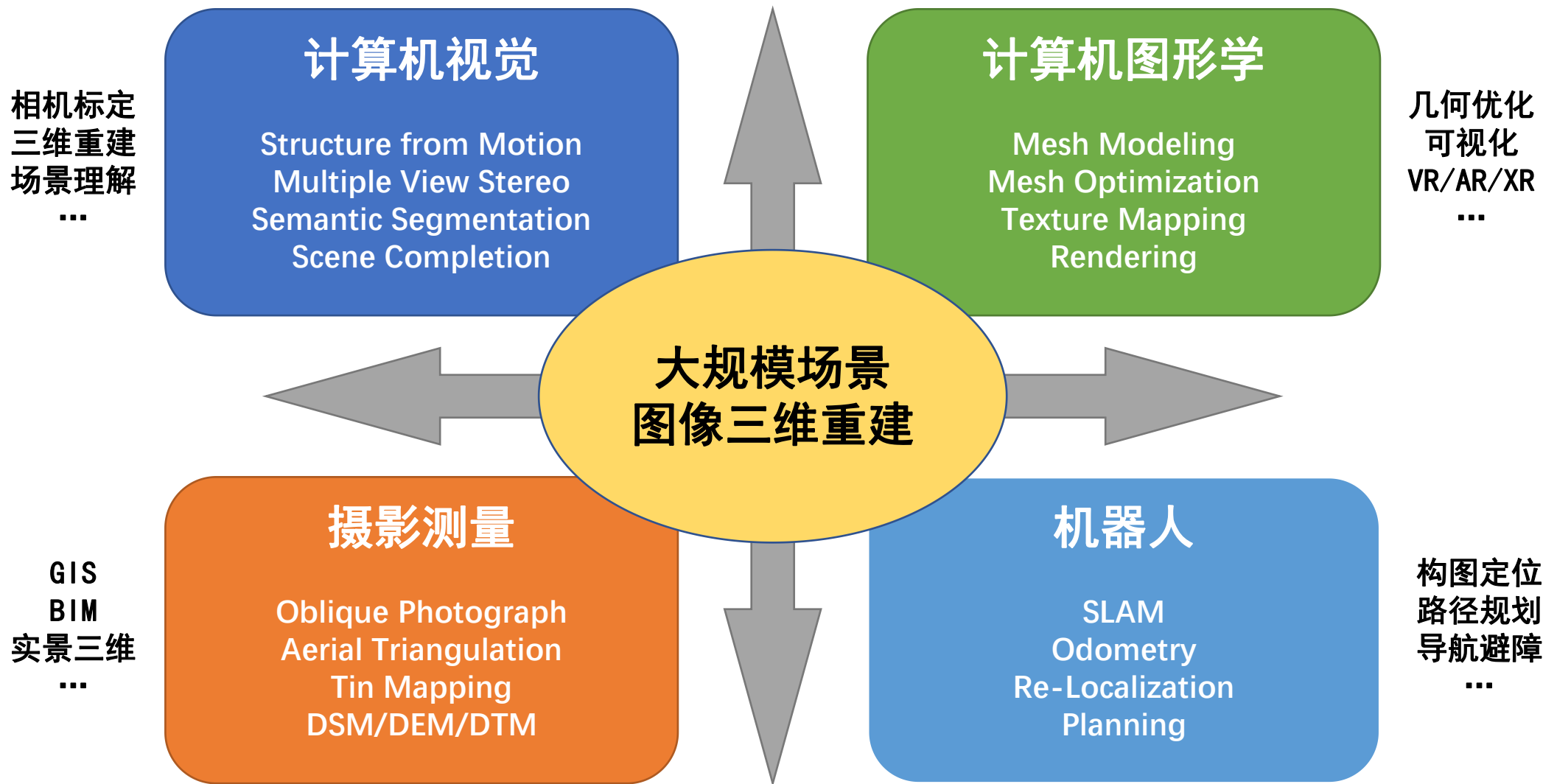


图像三维重建研究中的关键问题

申抒含

中国科学院自动化研究所

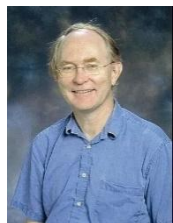
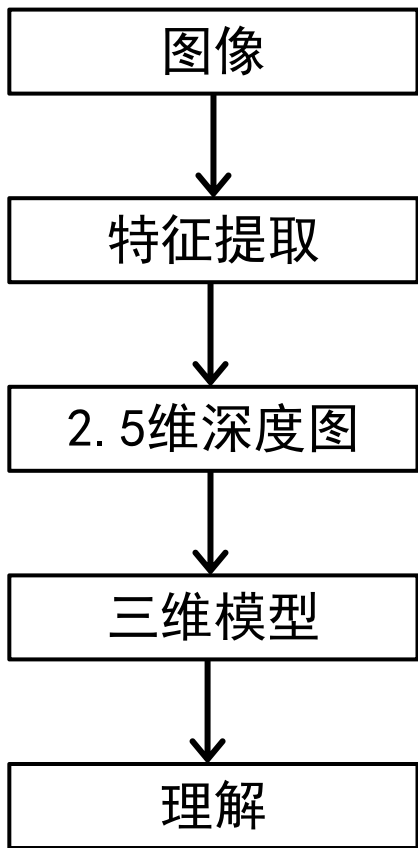
大规模场景图像三维重建



图像三维重建研究历程



David Marr
(MIT)



R. Hartley
(ANU)



A. Zisserman
(Oxford)



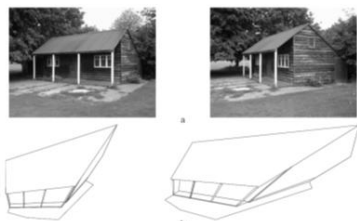
O. Faugeras
(INRIA)



L. Van Gool
(KU Leuven)

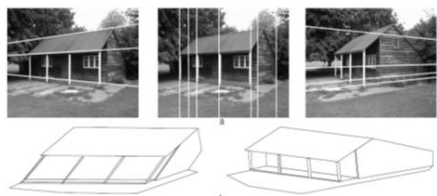


M. Pollefeys
(ETHz)



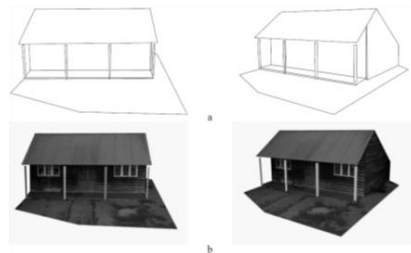
射影重建 (11个未知数)

确定投影矩阵



仿射重建 (3个未知数)

确定无穷远平面

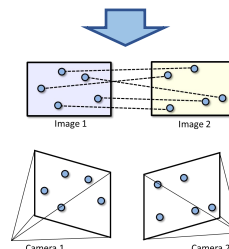


度量重建 (5个未知数)

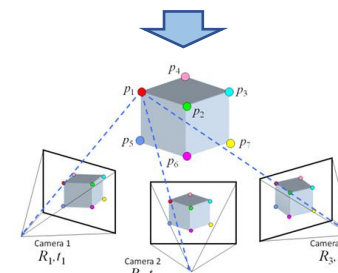
确定相机内参 (自标定)



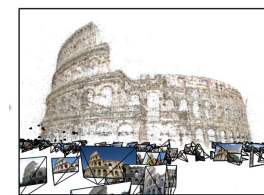
多视角图像 (K已知)



5点法两视图重建

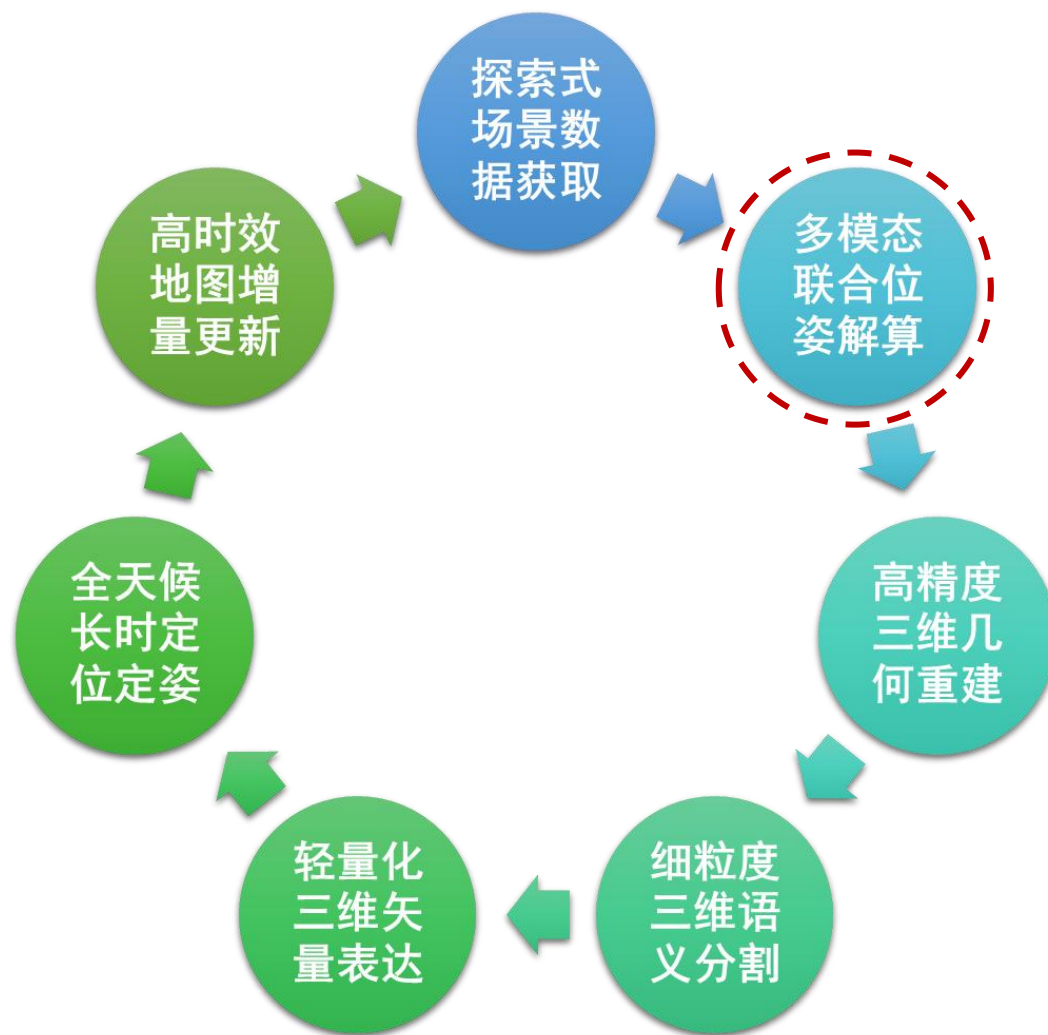


Triangulation,
PnP、Averaging

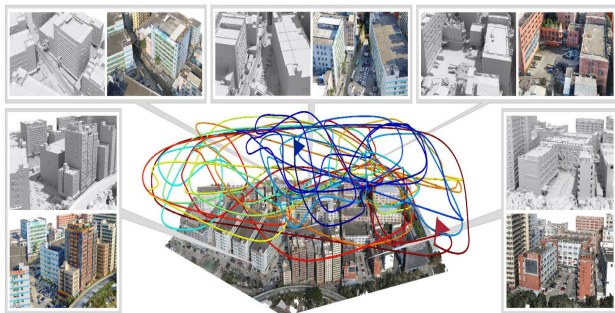


非线性最小二乘优化
Bundle Adjustment

大规模场景图像三维重建完整系统

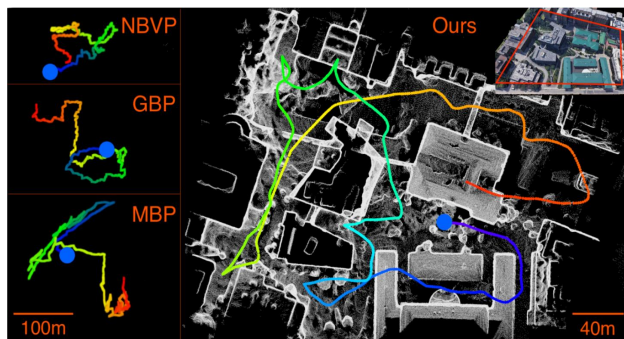


大规模场景图像三维重建完整系统

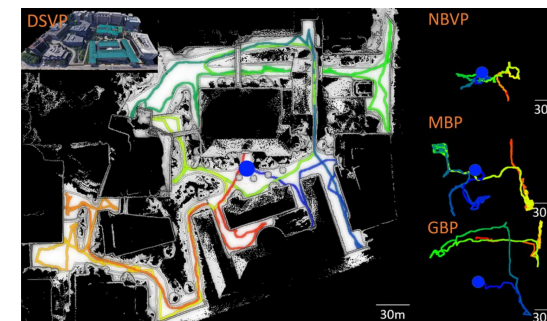
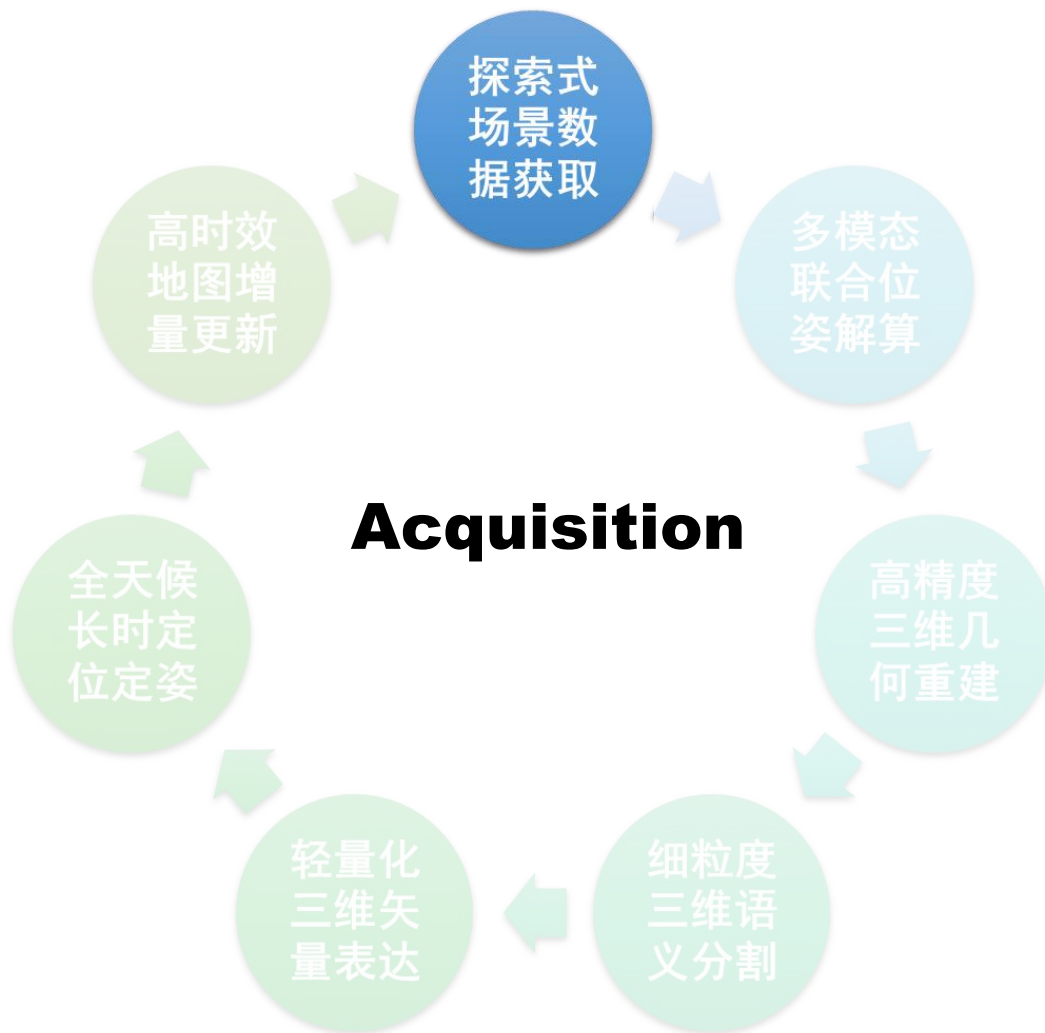


Zhang et.al. SIGGRAPH ASIA 2021

Geometry based

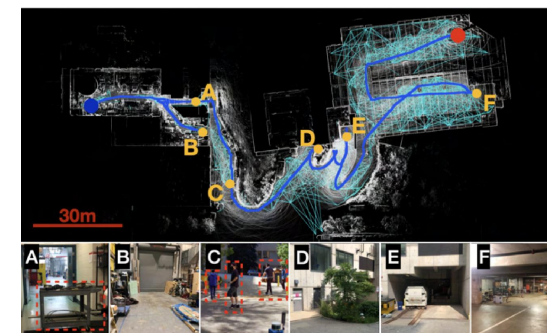


Cao et.al. RSS 2021



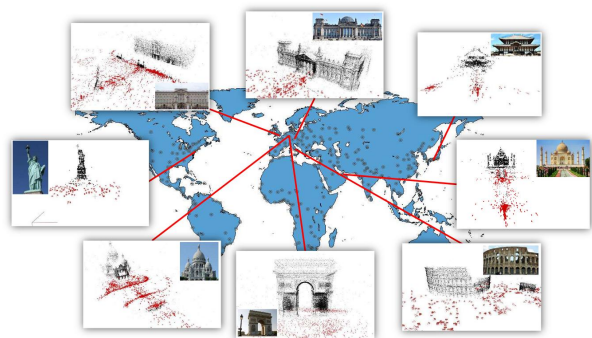
Zhu et.al. ICRA 2021

Geometry based



Yang et.al. IROS 2022

大规模场景图像三维重建完整系统

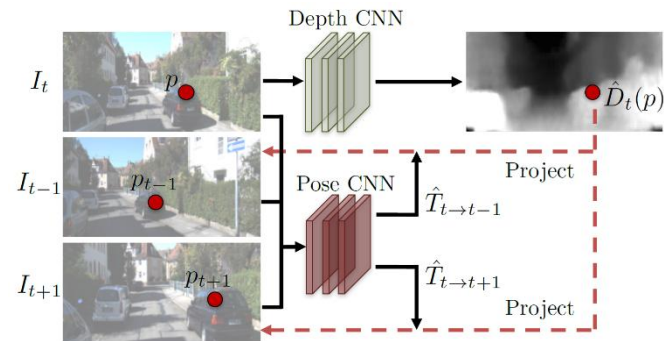
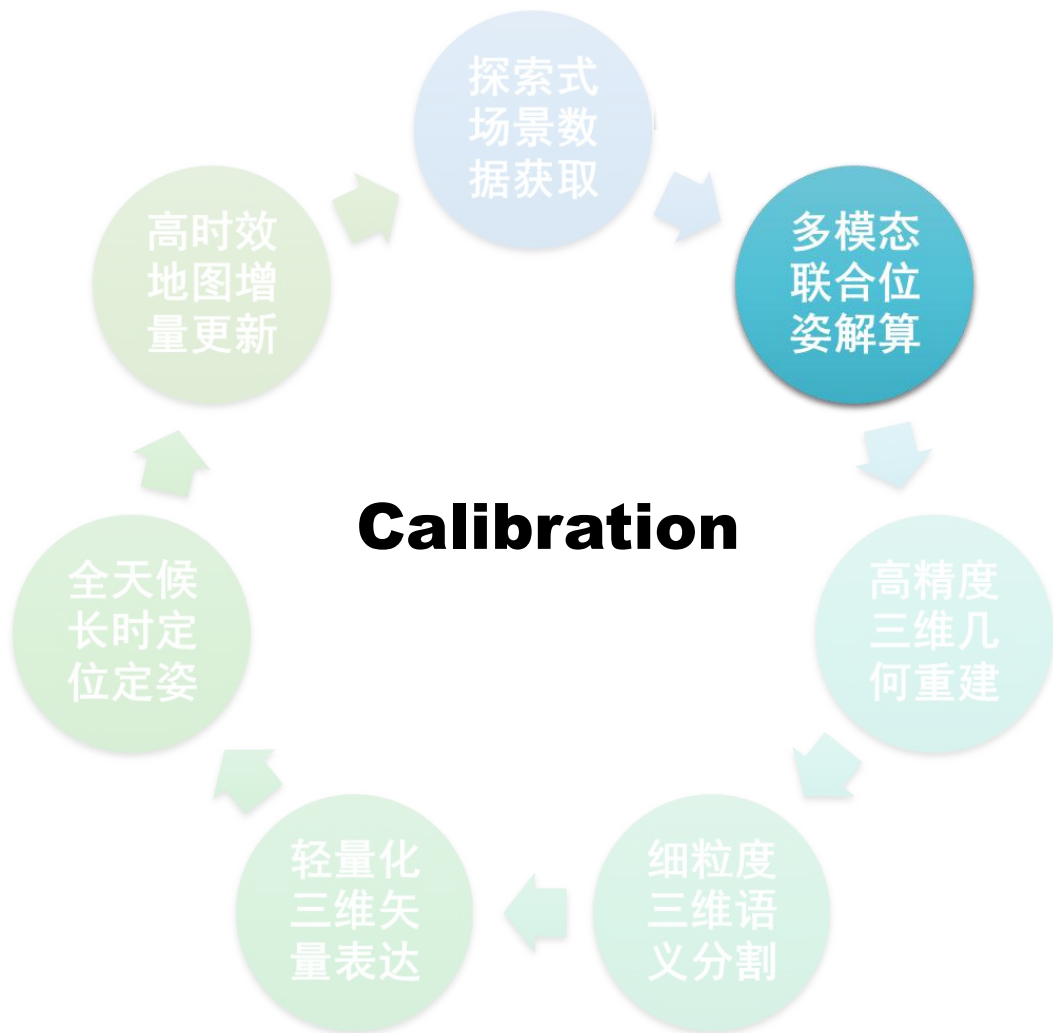


Heinly et.al. CVPR 2015

Geometry based

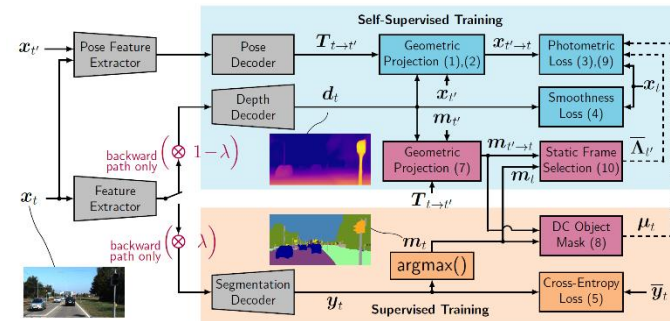


Schonberger et.al. CVPR 2016



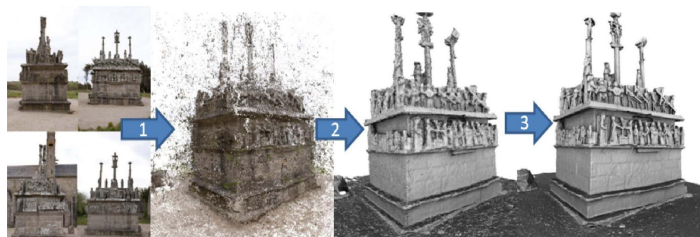
Zhou et.al. CVPR 2017

Learning based



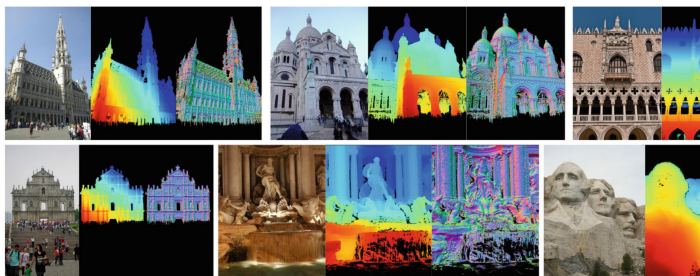
Klingner et.al. ECCV 2020

大规模场景图像三维重建完整系统

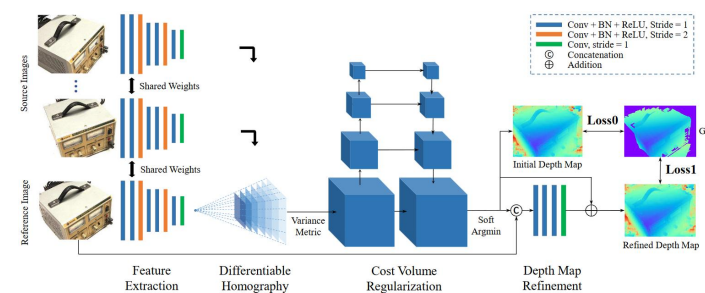
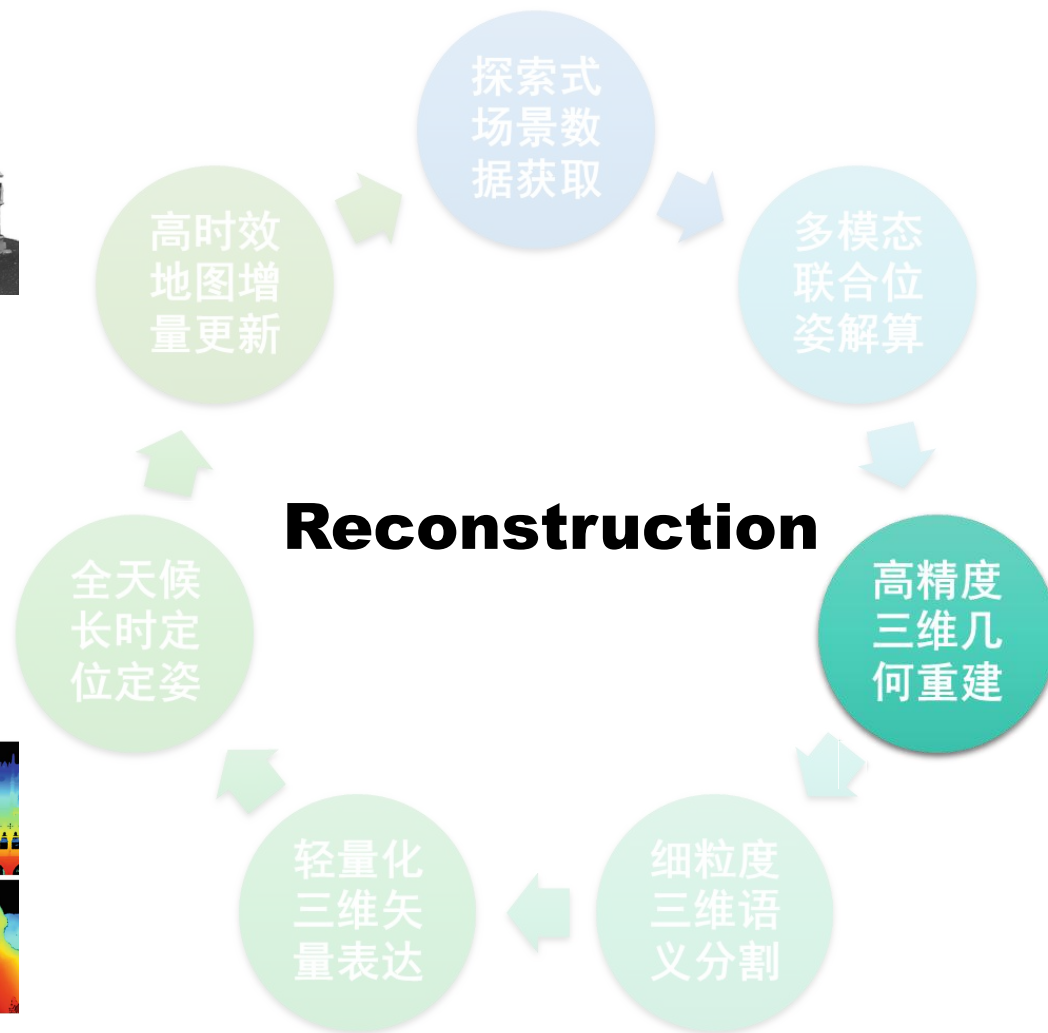


Vu et.al. IEEE TPAMI 2012

Geometry based

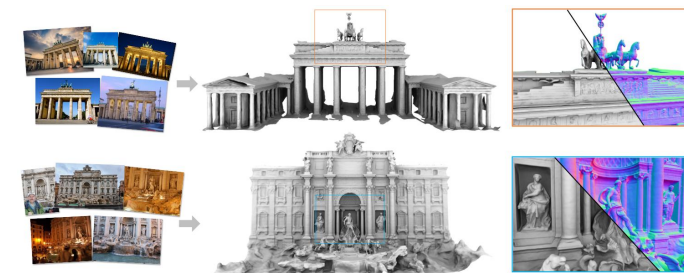


Schonberger et.al. ECCV 2016



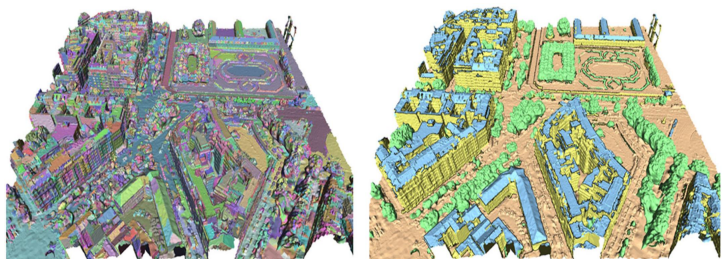
Yao et.al. ECCV 2018

Learning based



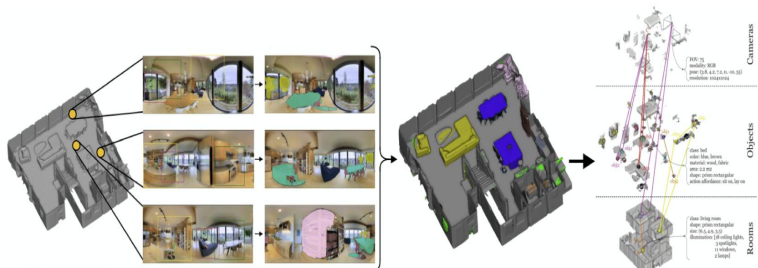
Sun et.al. SIGGRAPH 2022

大规模场景图像三维重建完整系统

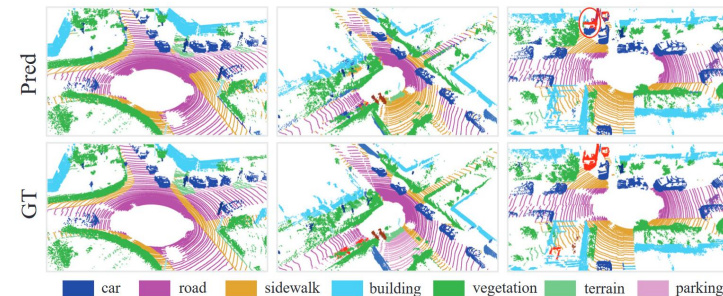
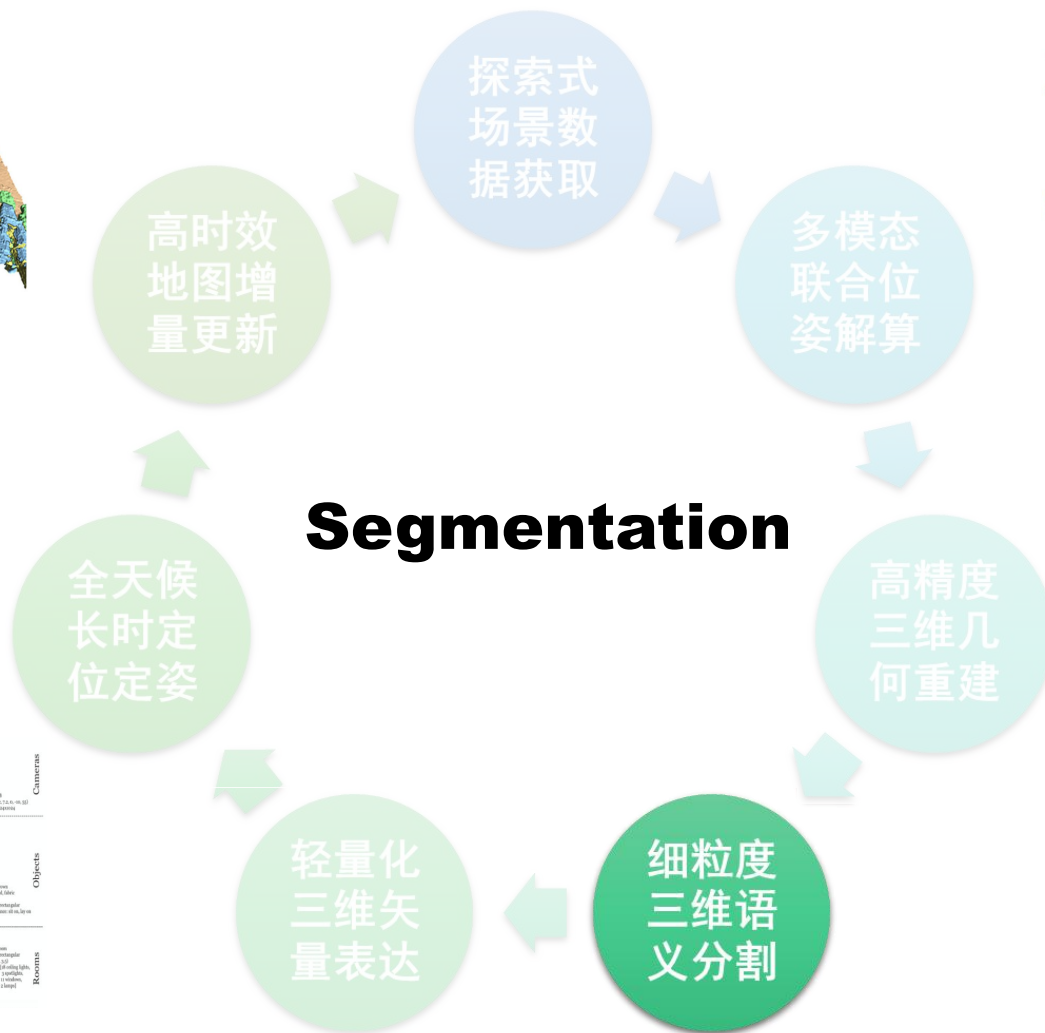


Rouhani et.al. ISPRS JPRS 2017

Geometry based

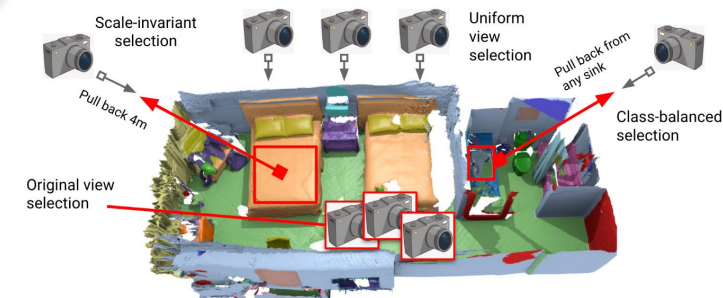


Armeni et.al. ICCV 2019



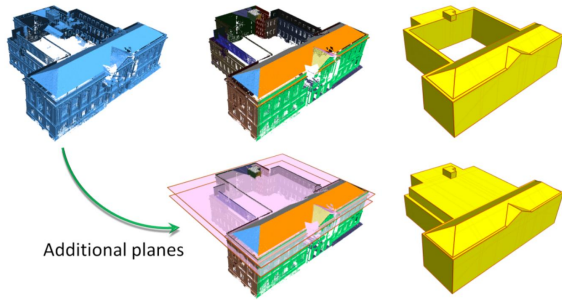
Hu et.al. CVPR 2020

Learning based



Kundu et.al. ECCV 2020

大规模场景图像三维重建完整系统



Additional planes

Nan et.al. ICCV 2017

探索式
场景数
据获取

高时效
地图增
量更新

多模态
联合位
姿解算

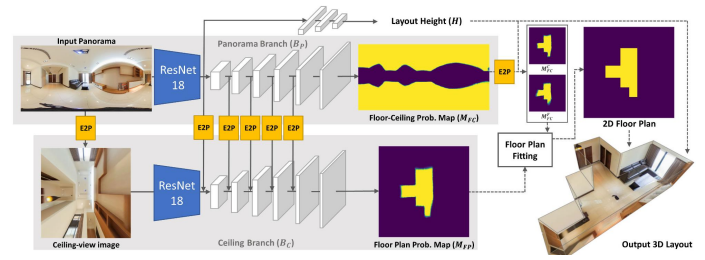
全天候
长时定
位定姿

高精度
三维几
何重建

轻量化
三维矢
量表达

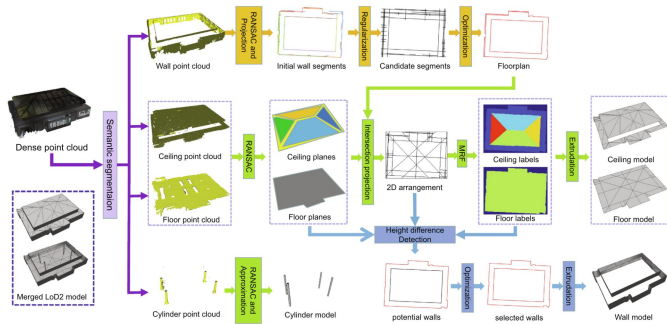
细粒度
三维语
义分割

Representation



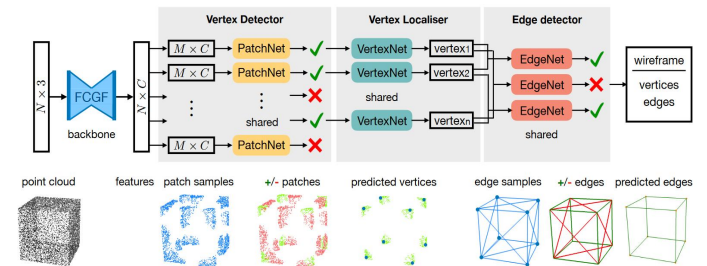
Yang et.al. CVPR 2019

Geometry based



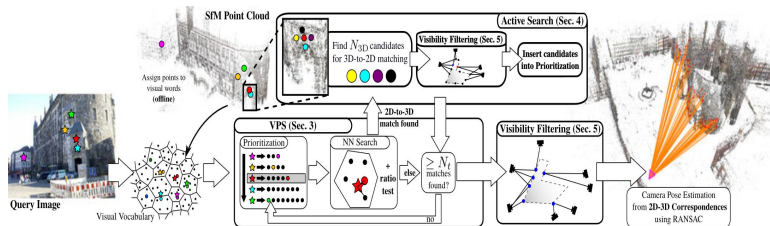
Han et.al. ISPRS JPRS 2021

Learning based



Liu et.al. ICLR 2021

大规模场景图像三维重建完整系统

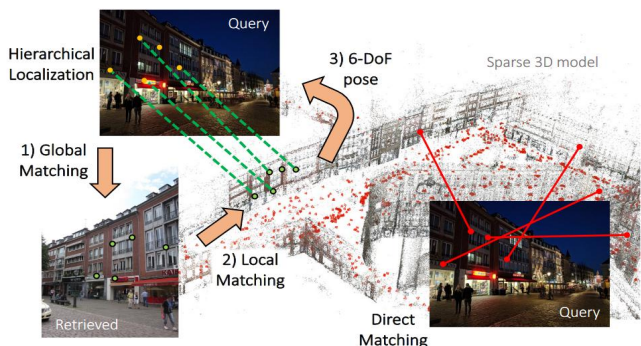


Sattler et.al. IEEE TPAMI 2017



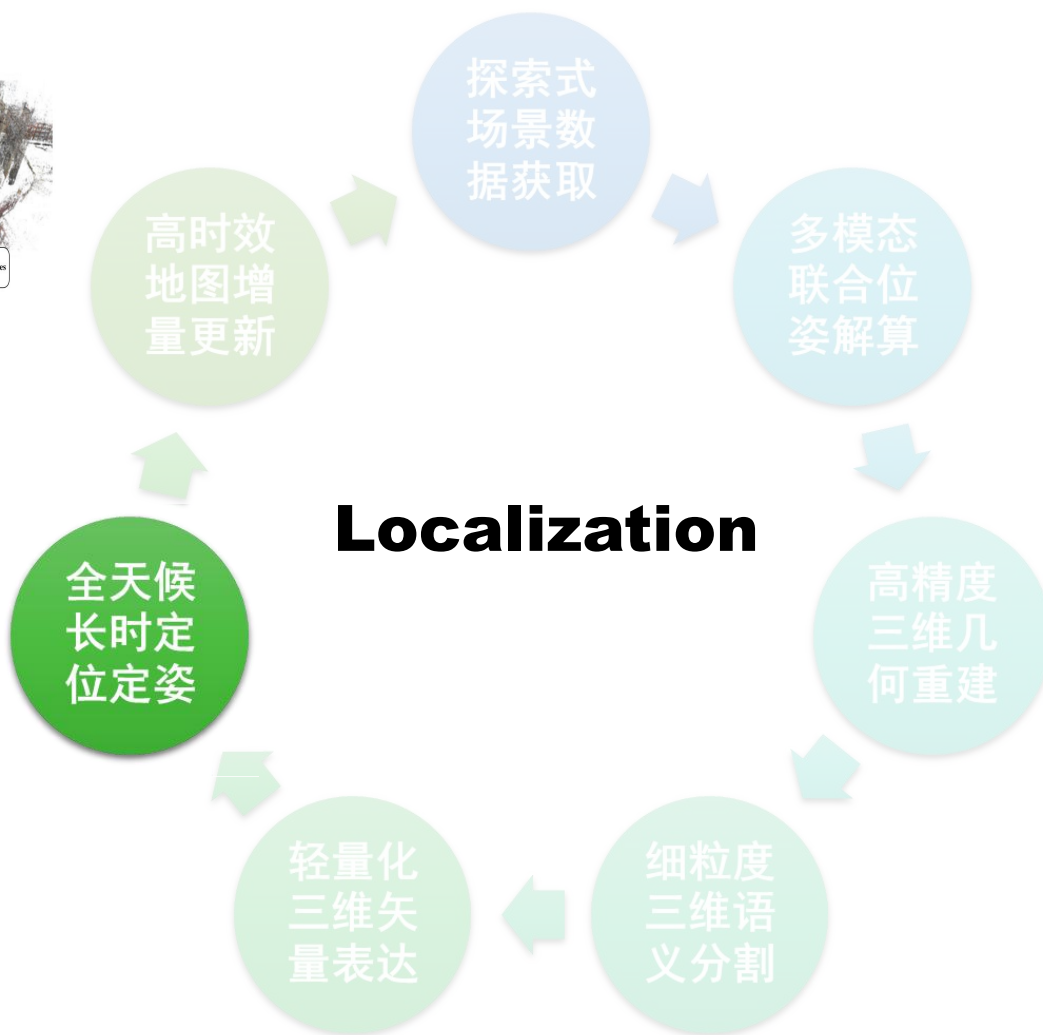
Kendall et.al. CVPR 2015

Geometry based

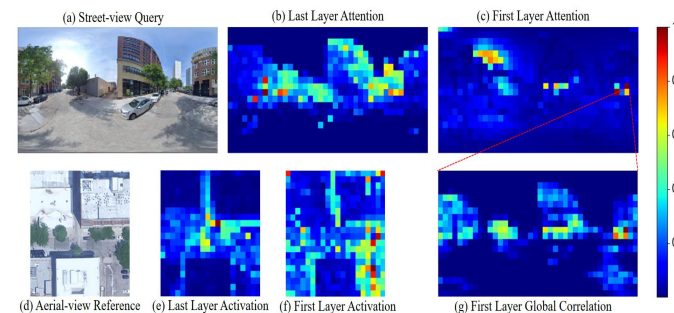


Sarlin et.al. CVPR 2019

Localization

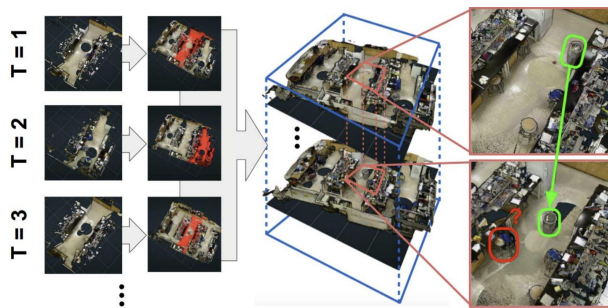


Learning based



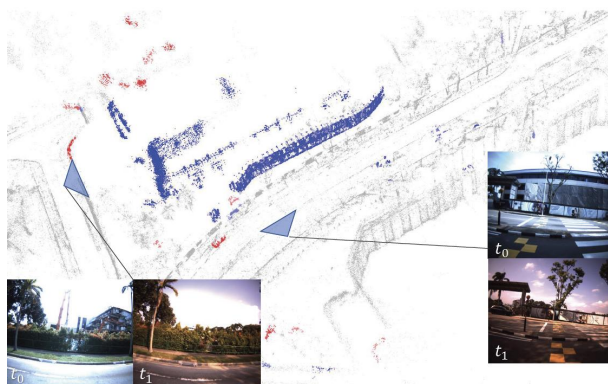
Zhu et.al. CVPR 2022

大规模场景图像三维重建完整系统



Lee et.al. ICCV 2017

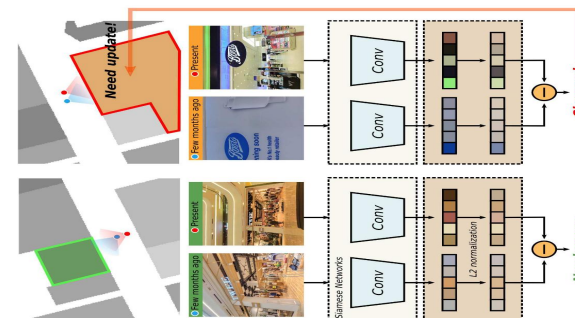
Geometry based



Yew et.al. ICRA 2021

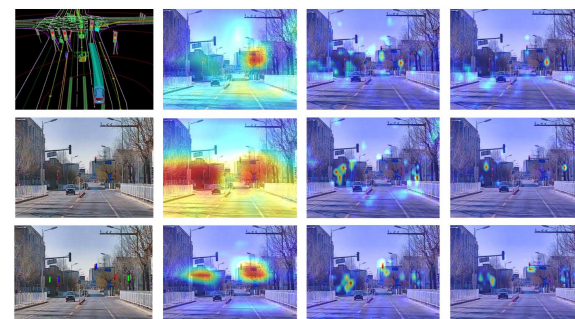


Updating



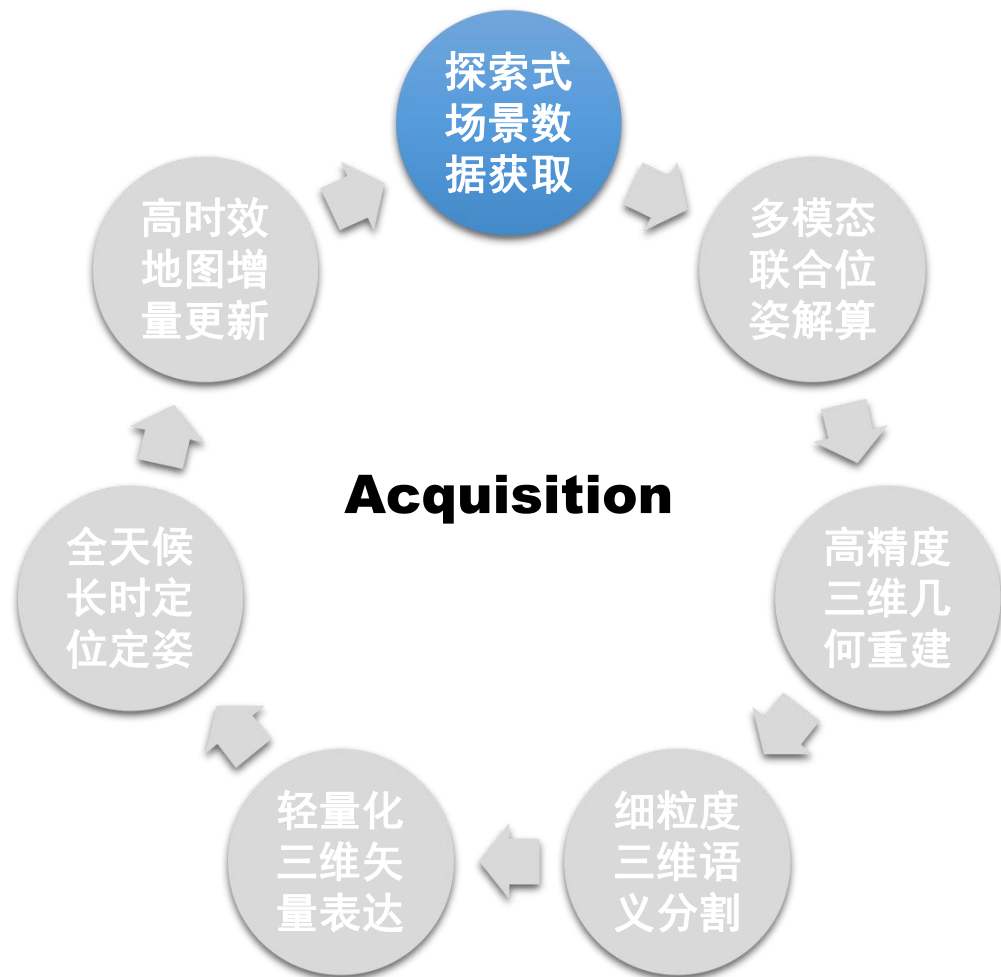
Revaud et.al. CVPR 2019

Learning based



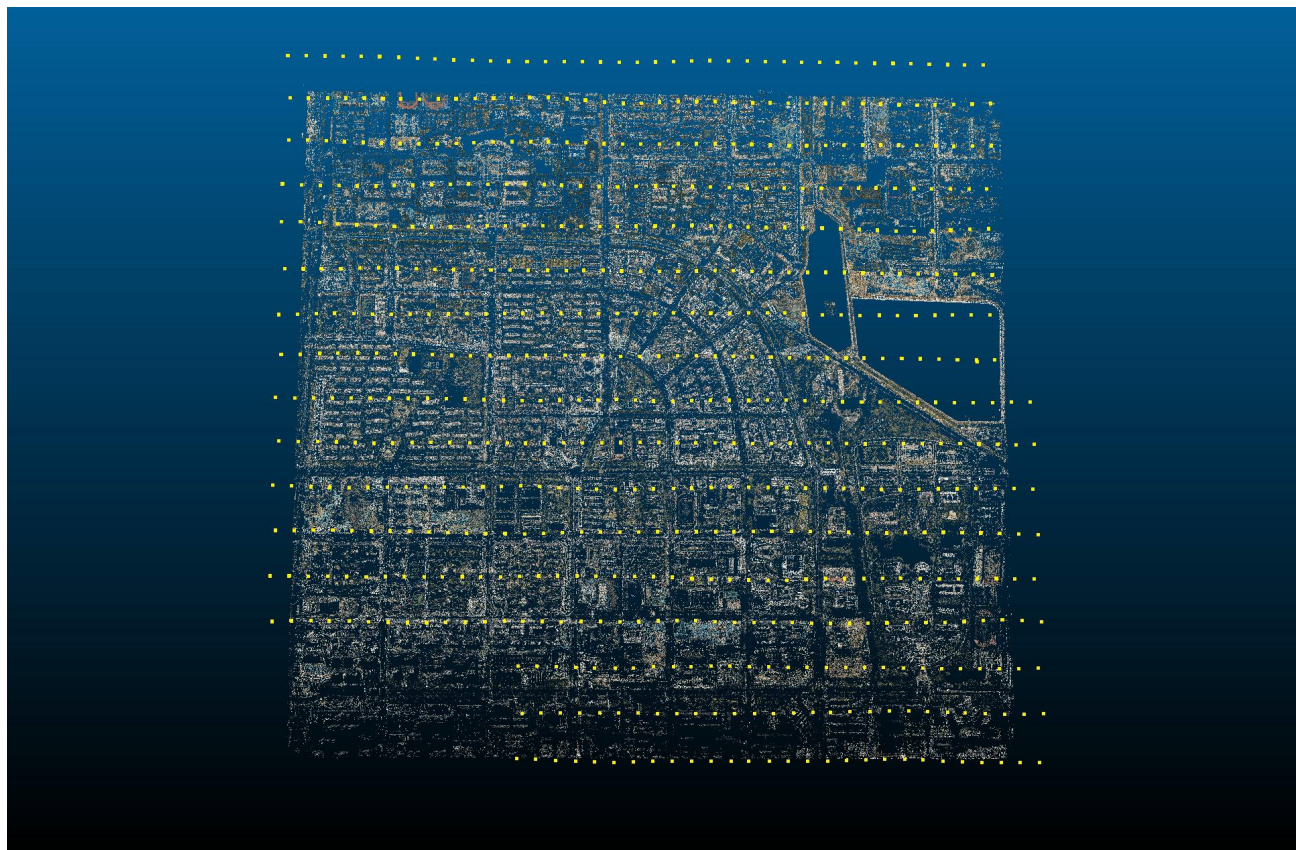
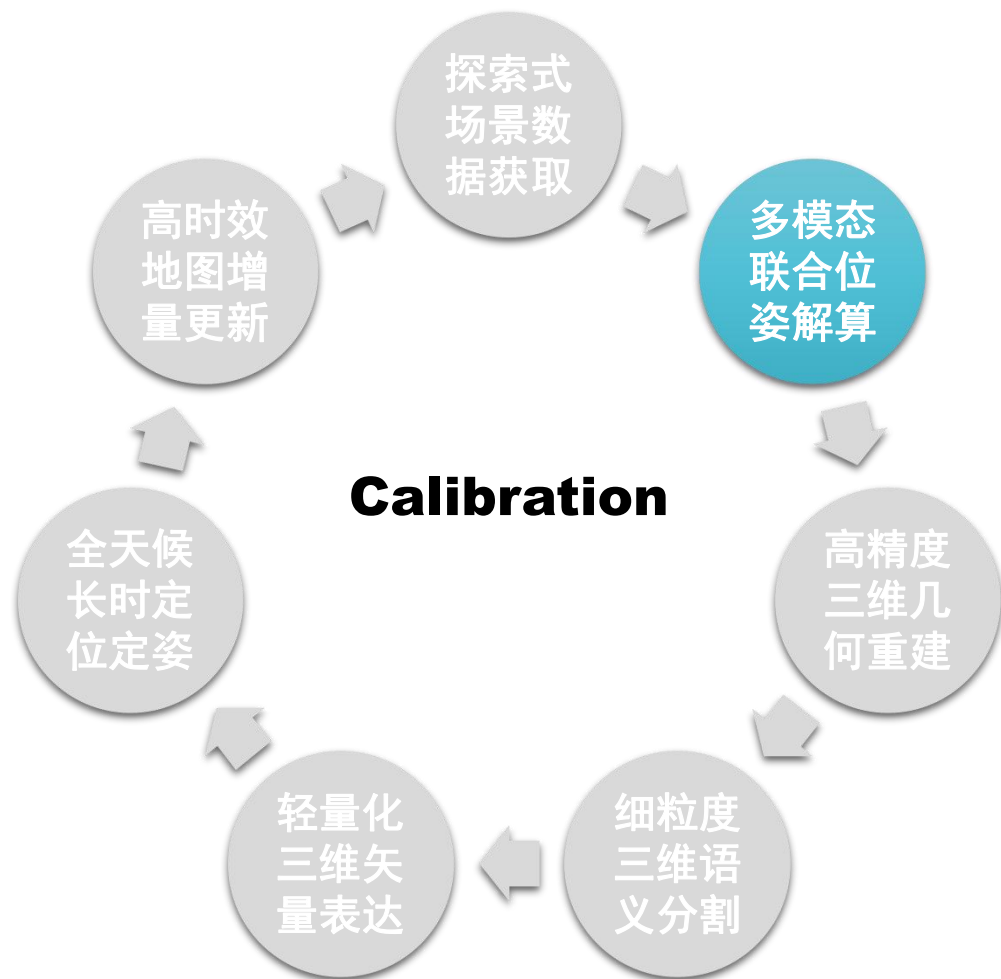
He et.al. ICRA 2022

大规模场景图像三维重建完整系统



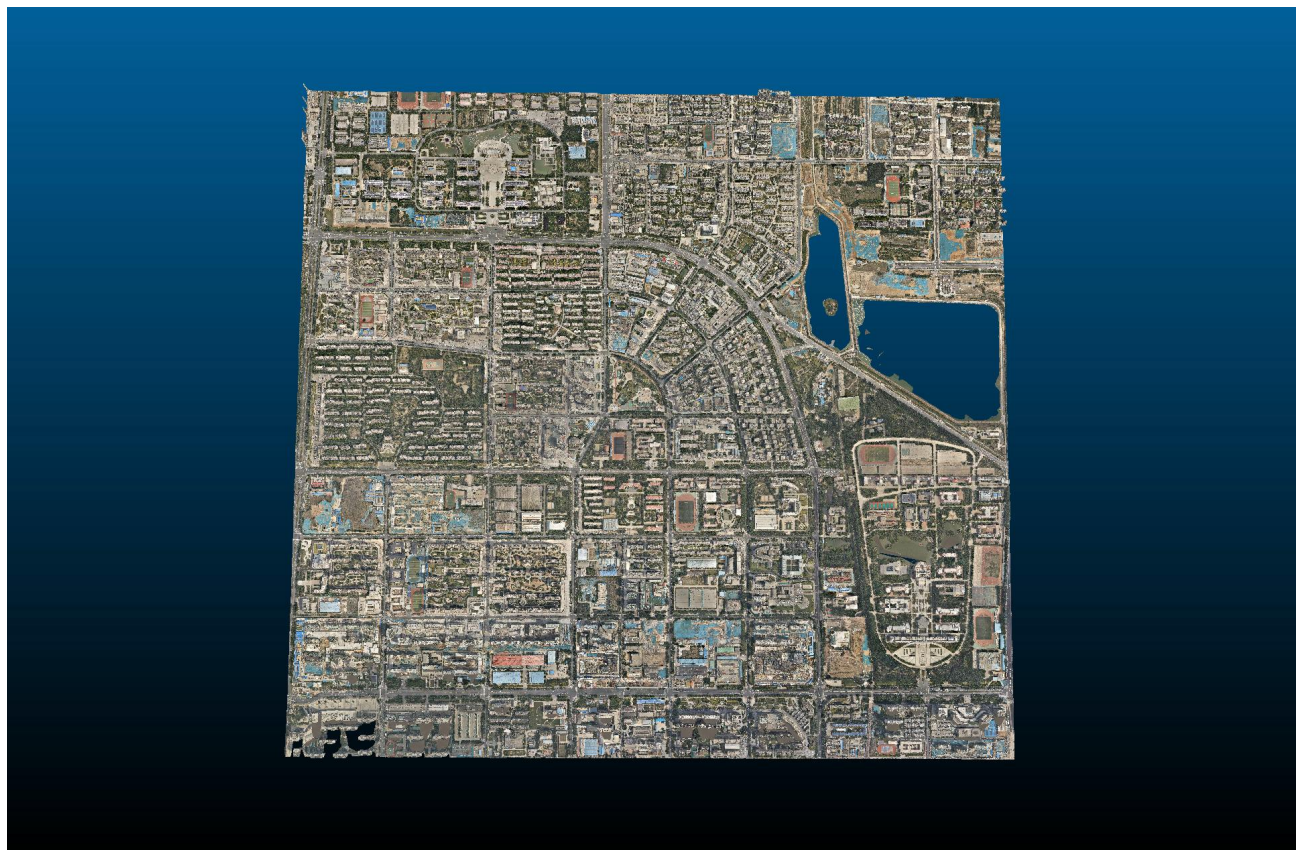
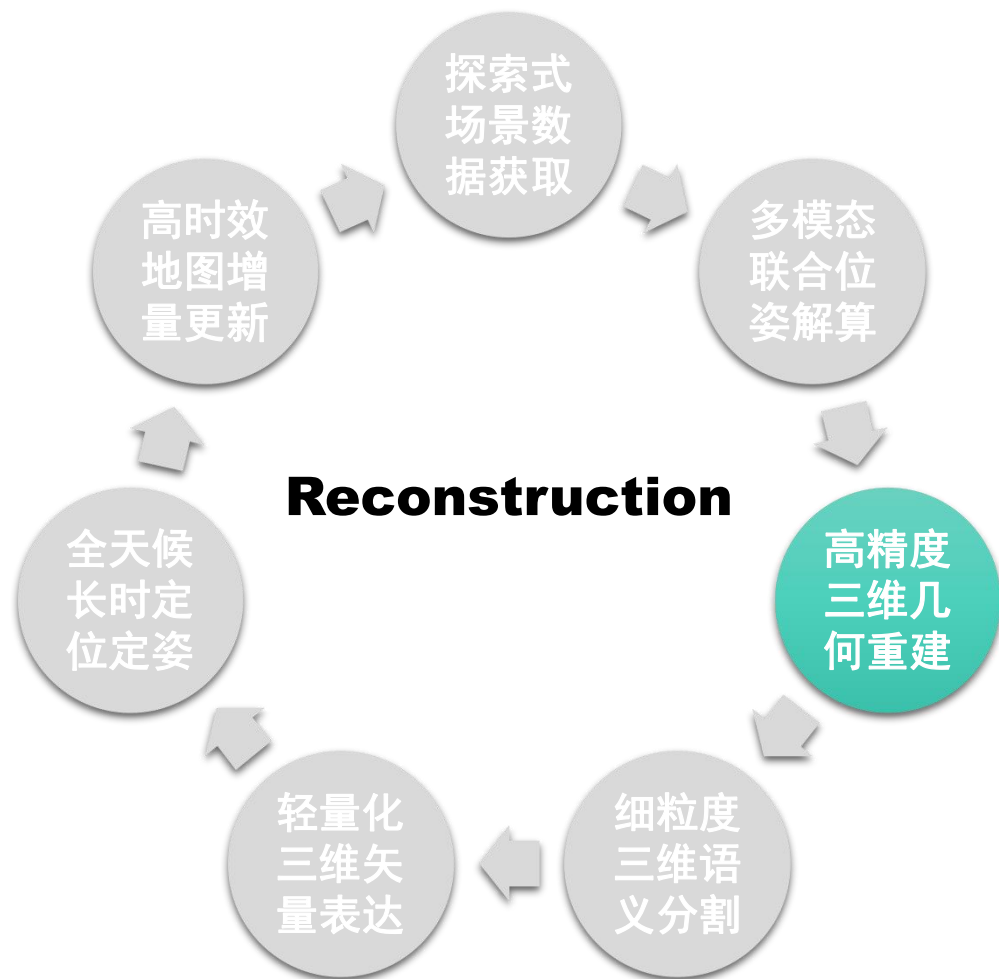
基于全局地图的场景探索式数据获取

大规模场景图像三维重建完整系统



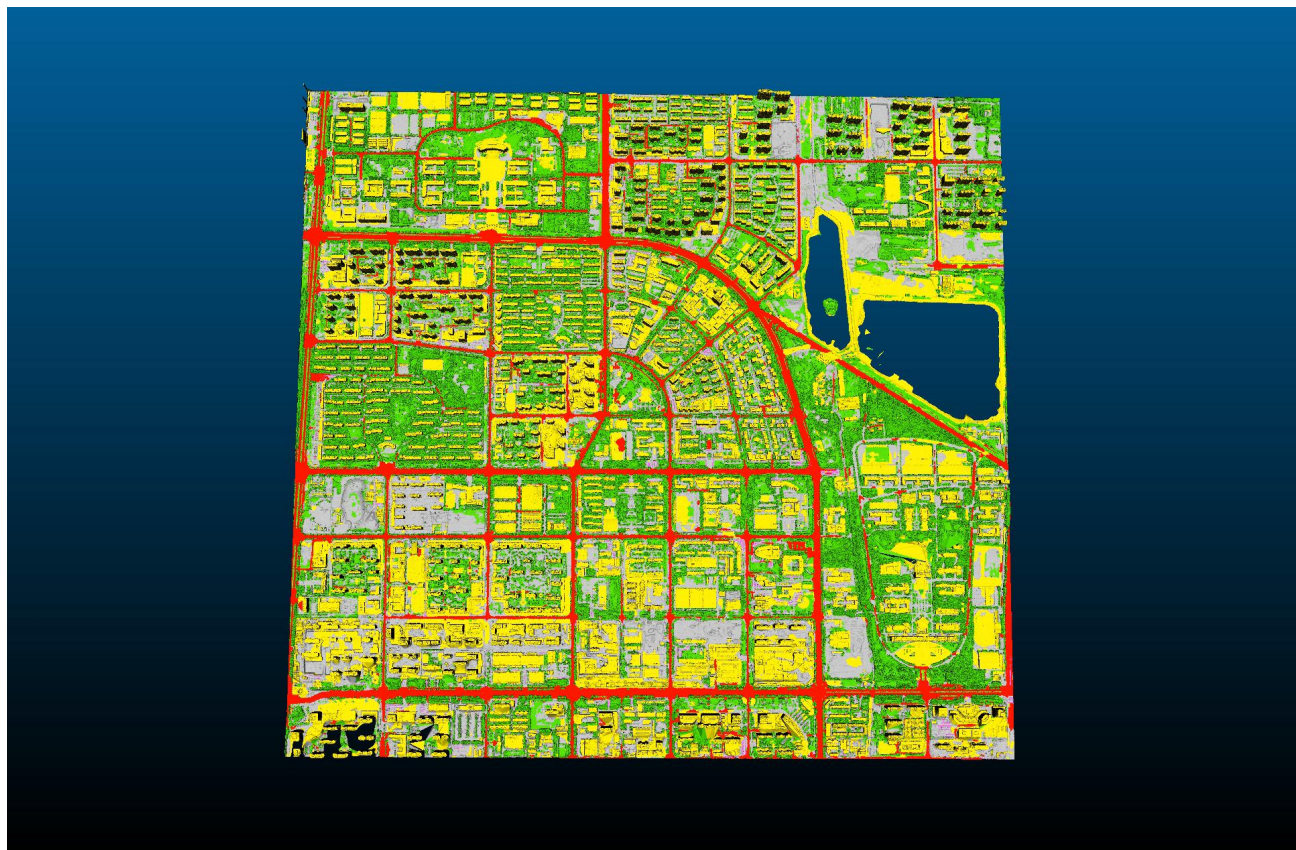
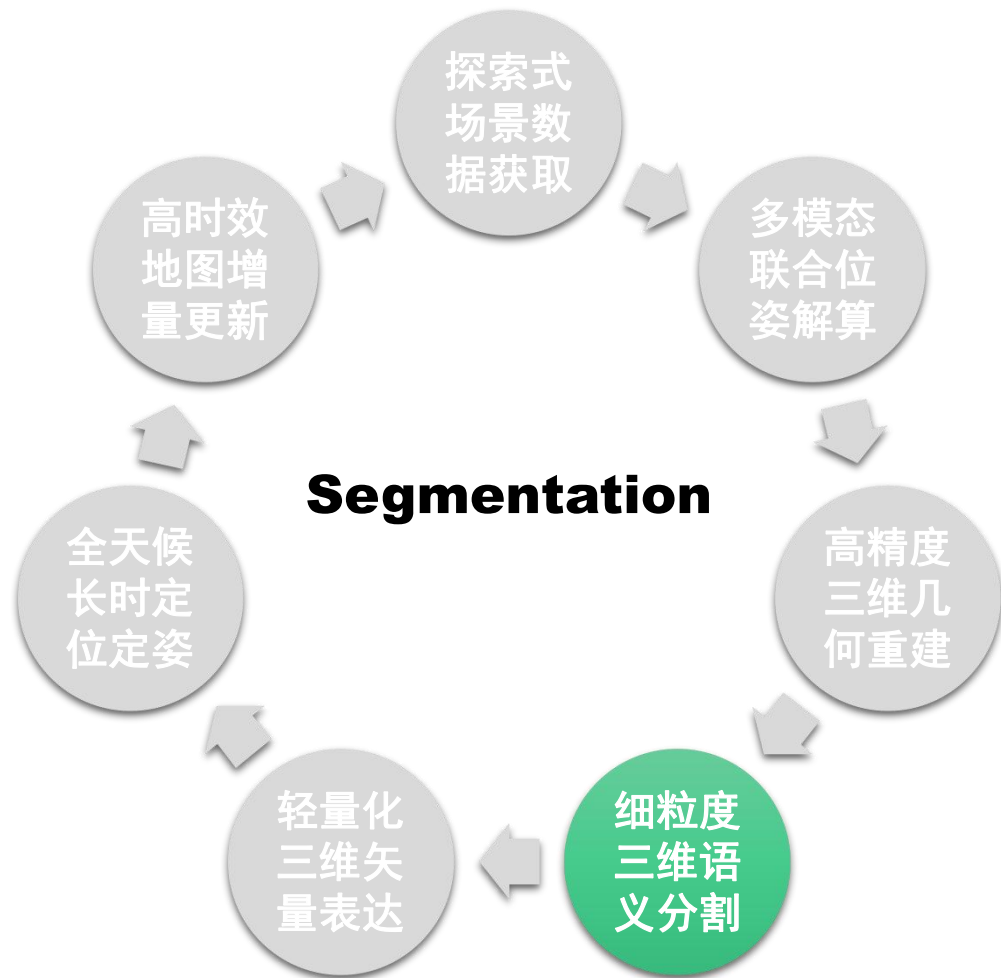
航拍图像相机位姿解算

大规模场景图像三维重建完整系统



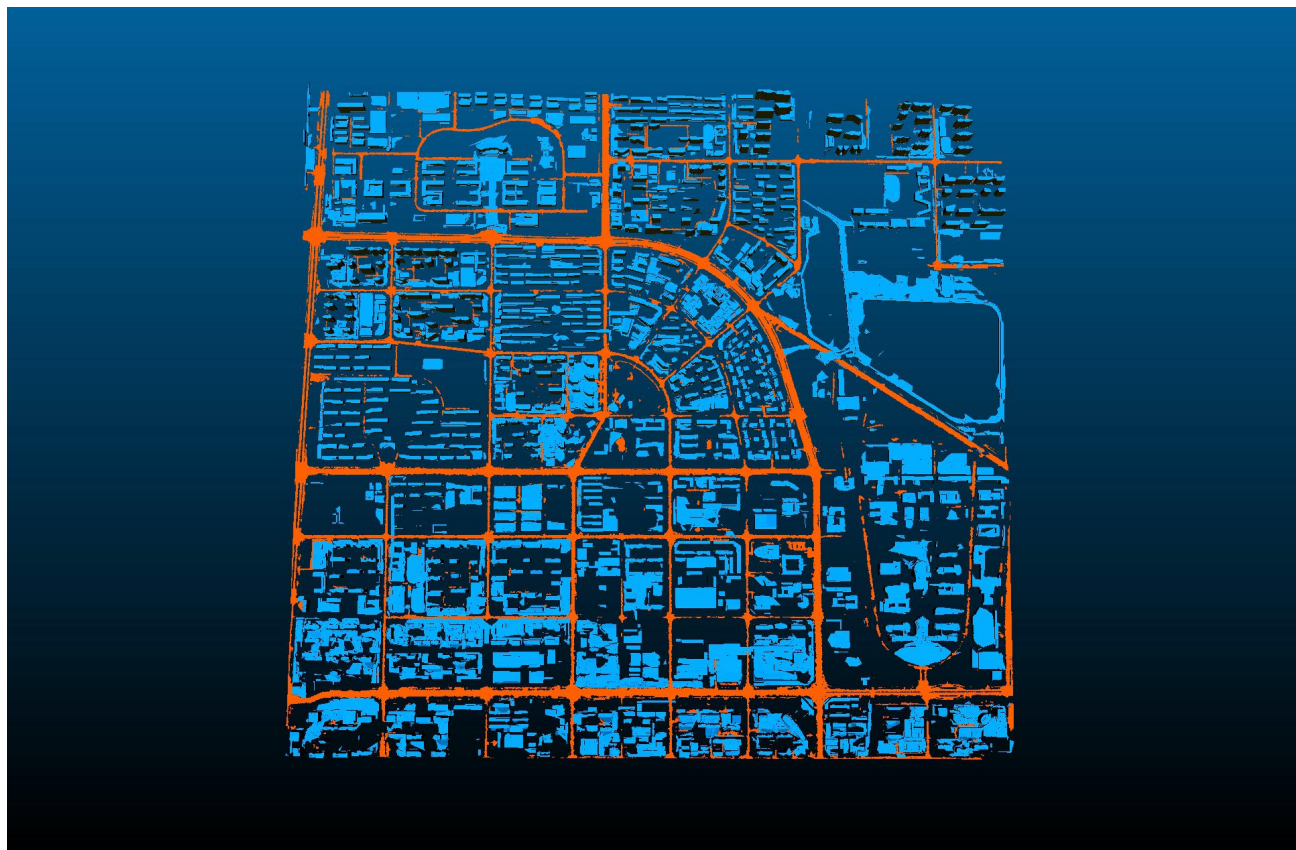
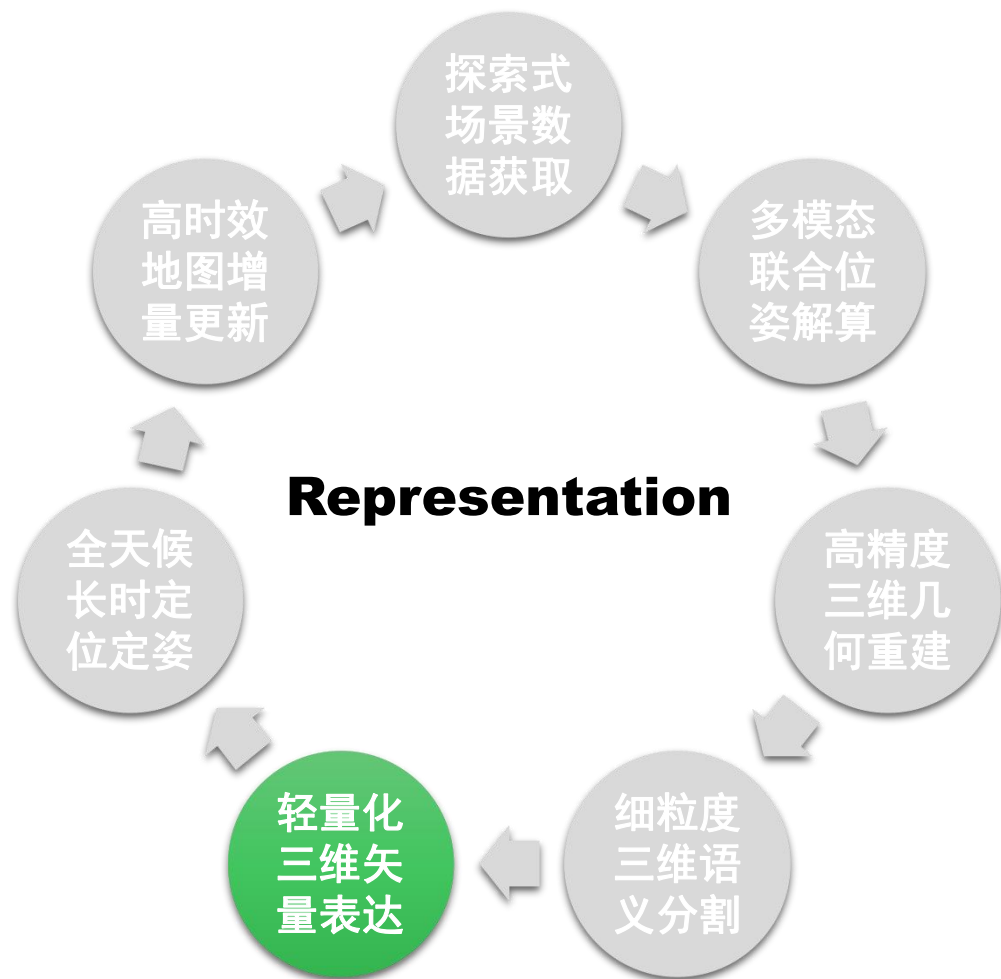
倾斜摄影三维几何重建

大规模场景图像三维重建完整系统



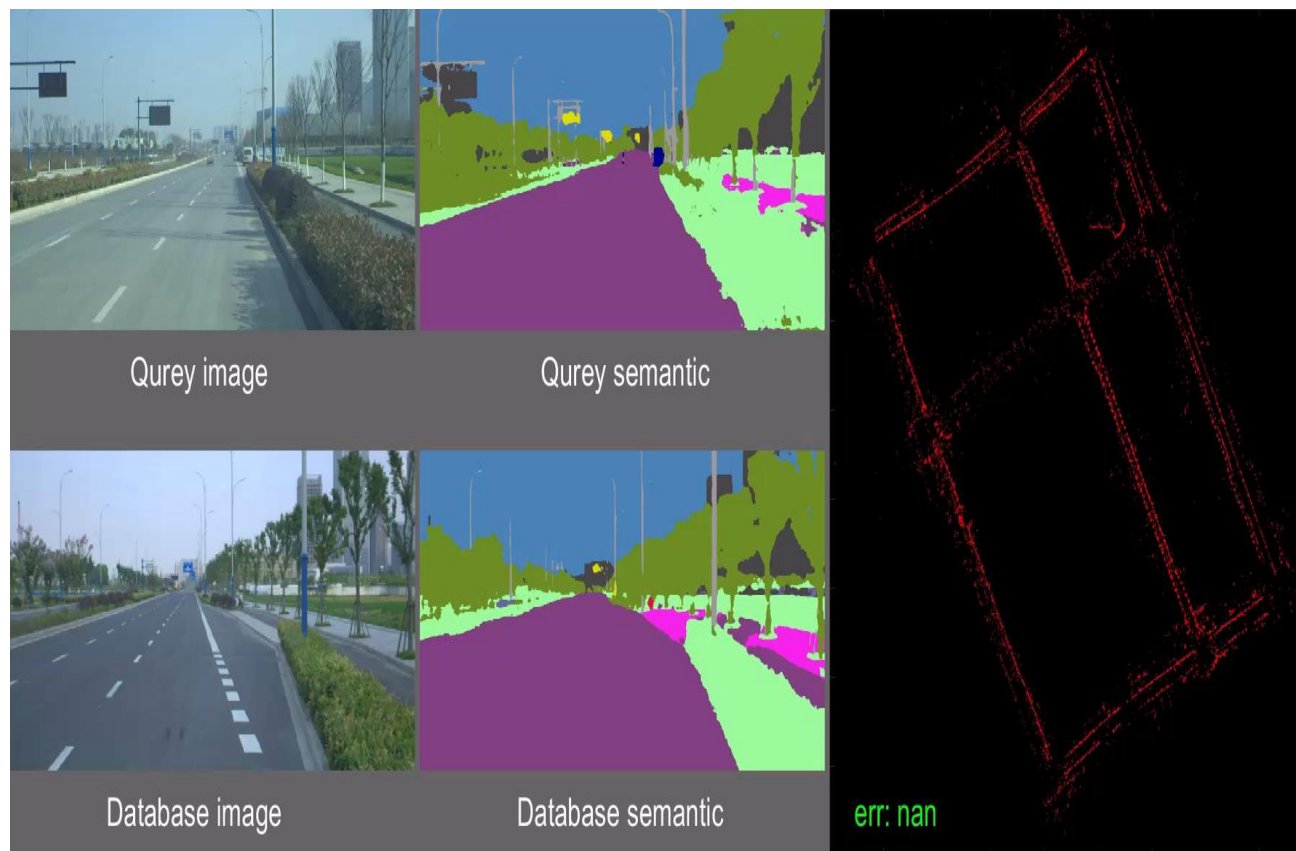
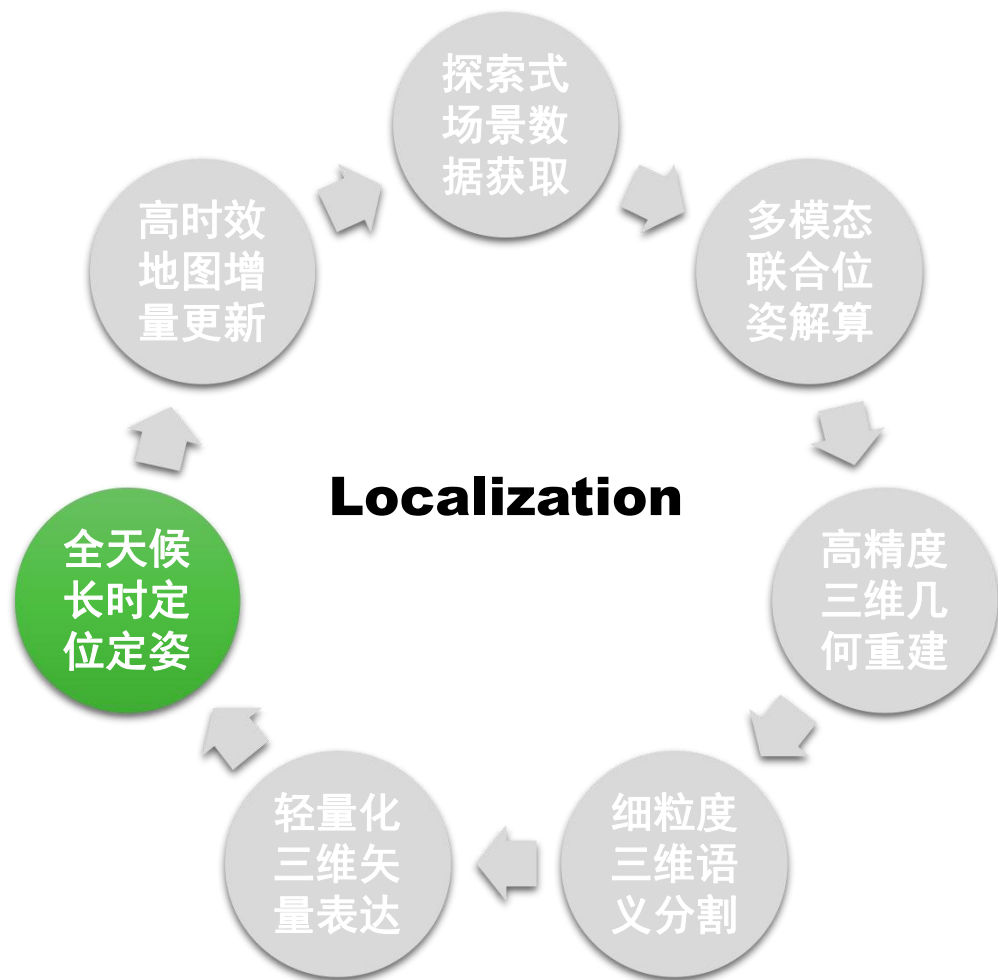
城市场景地物三维语义分割

大规模场景图像三维重建完整系统



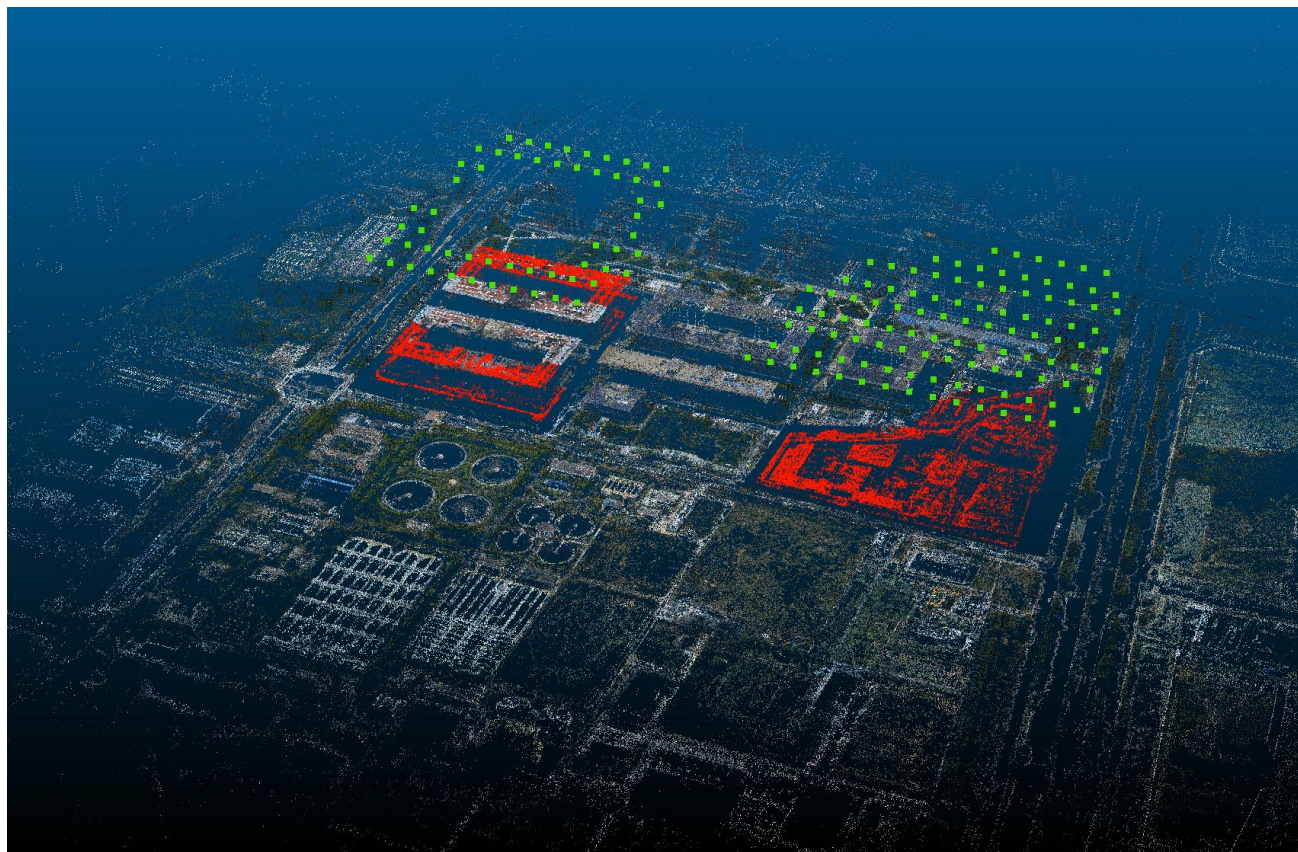
建筑物轻量化三维矢量表达

大规模场景图像三维重建完整系统



基于三维地图的无人车长时定位定姿

大规模场景图像三维重建完整系统



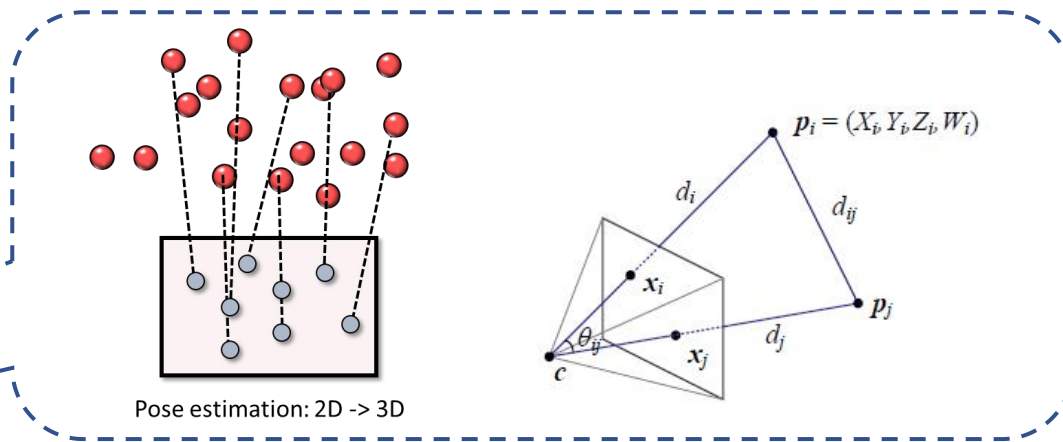
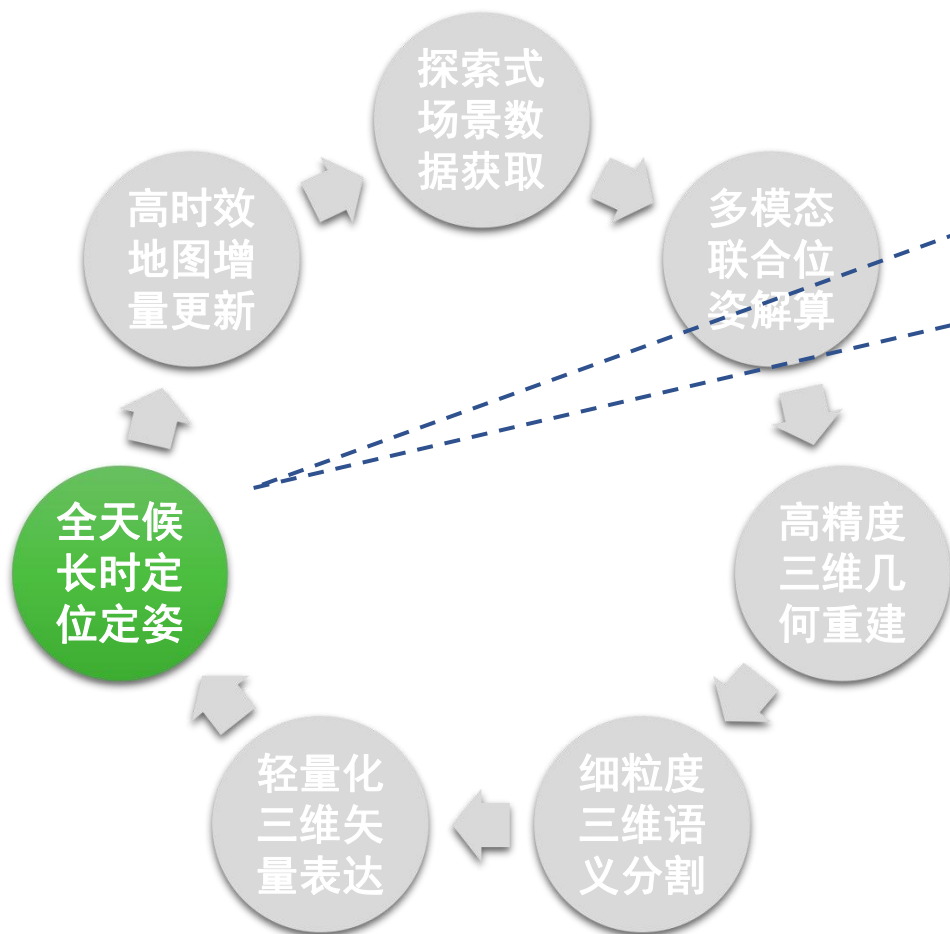
三维场景变化检测与增量更新

大规模场景图像三维重建完整系统

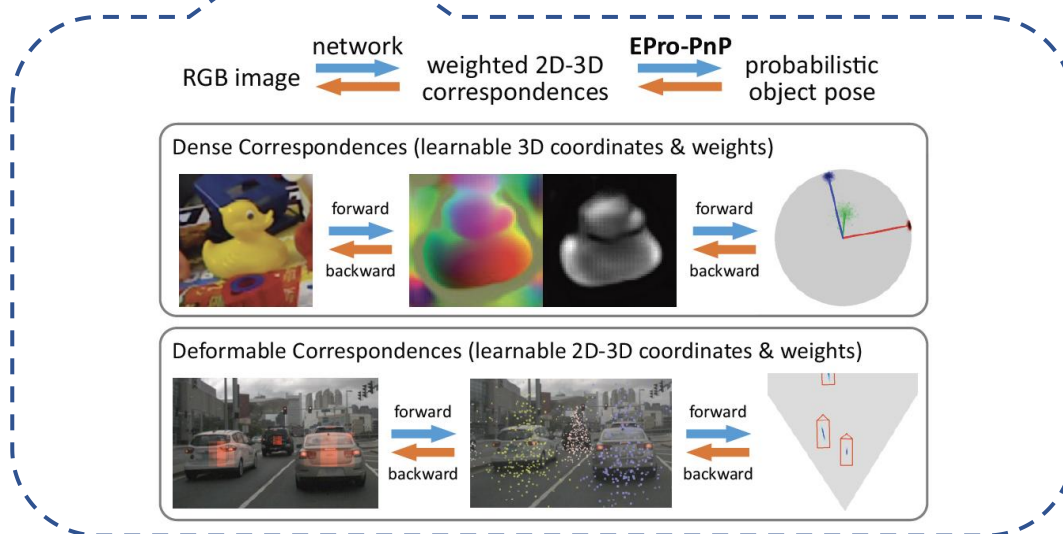


图像三维重建研究中的关键问题

几何视觉与深度学习的融合问题



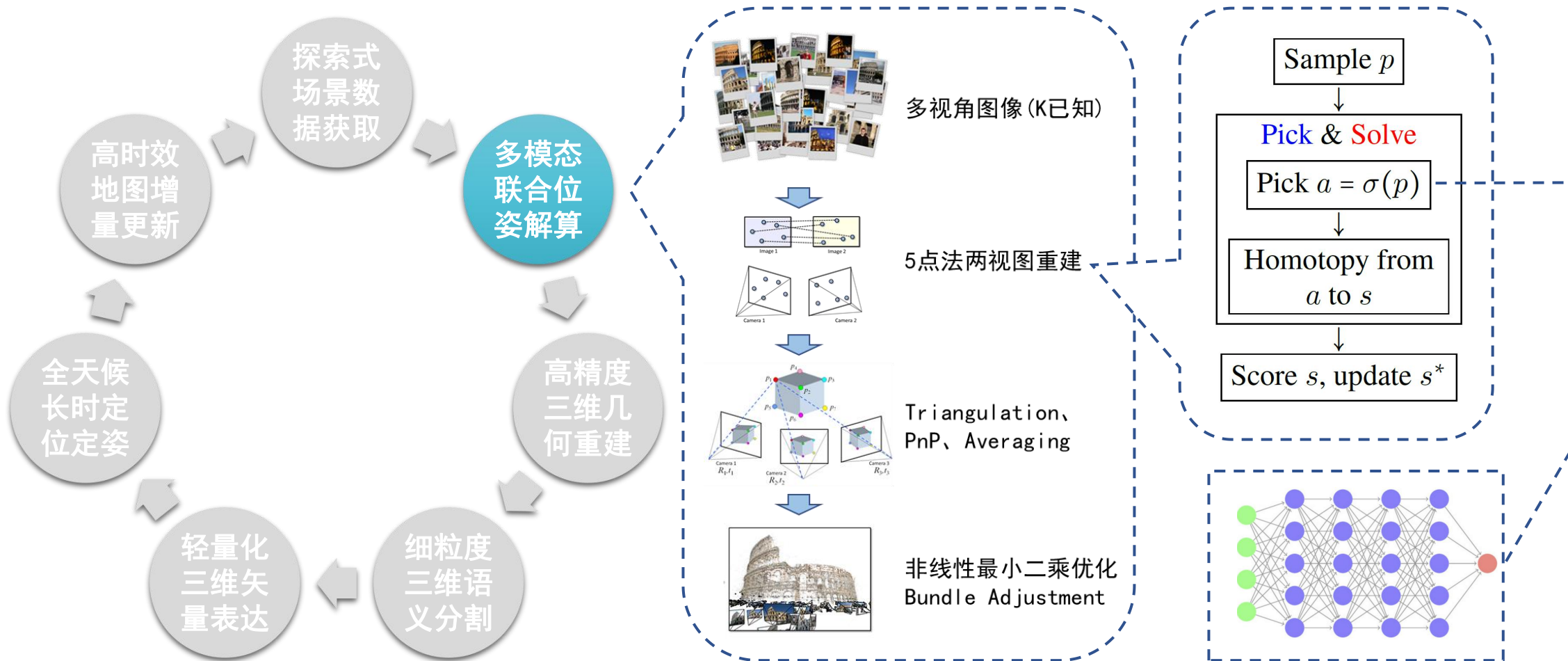
Chen et.al. CVPR 2022 **Best Student Paper**



图像三维重建研究中的关键问题

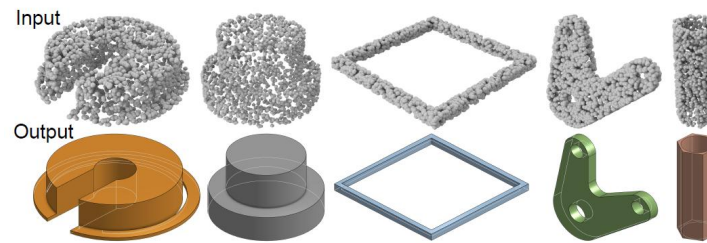
几何视觉与深度学习的融合问题

Hruby et.al. CVPR 2022 **Best Paper**



图像三维重建研究中的关键问题

- 几何视觉与深度学习的融合问题
- 逆向重建与正向重建的融合问题



DeepCAD, Wu et.al. ICCV 2021



逆向重建（多视角图像→三维模型）

Bentley ContexCapture



正向重建（程序化语言→三维模型）

ArcGIS CityEngine

总结

- **行业需求：** 全流程三维重建工具链（实景三维、无人系统、AR/VR、智能制造）
- **关键问题：** 几何视觉与深度学习的融合、逆向重建与正向重建的融合



数字城市



VR内容



高精地图