视觉同步定位与地图构建

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SLAM 起源

同步定位与地图 构建:
Simultaneous Localization and Mapping, SLAM,
Concurrent Mapping and Localization, CML

SLAM问题最早由Randall C. Smith 和Peter Cheeseman等于80年代提出:

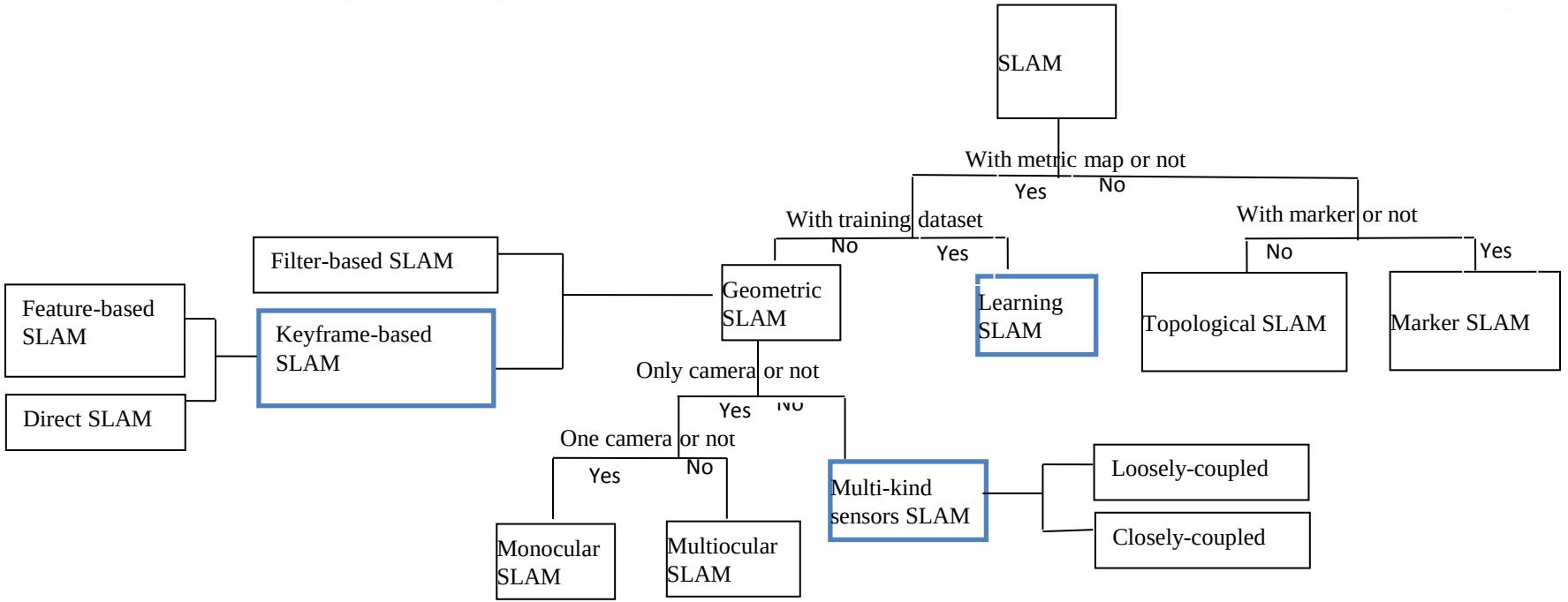
- R.C. Smith and Peter Cheeseman. On the representation and estimation of spatial uncertainty. The International Journal of Robotics Research 5.4 (1986): 56-68.

并于1995 International Symposium on Robotics Research中正式命名:

- H. Durrant-Whyte, D. Rye, and E. Nebot. Localisation of automatic guided vehicles. The 7th International Symposium on Robotics Research (1995): 613–625.

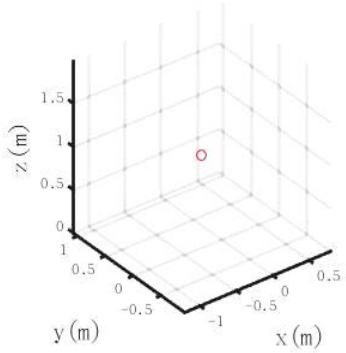
机器人SLAM问题主要研究机器人在未知环境中，从一个位置出发，如何利用自身传感器对环境进行观测，同时建立环境地图，并确定自己在地图中的位置。SLAM技术具有重要的理论价值和应用价值，被许多学者认为是移动机器人实现真正自主的关键，甚至称其为自主移动机器人界的“圣杯（Holy Grail）”！

视觉SLAM分类

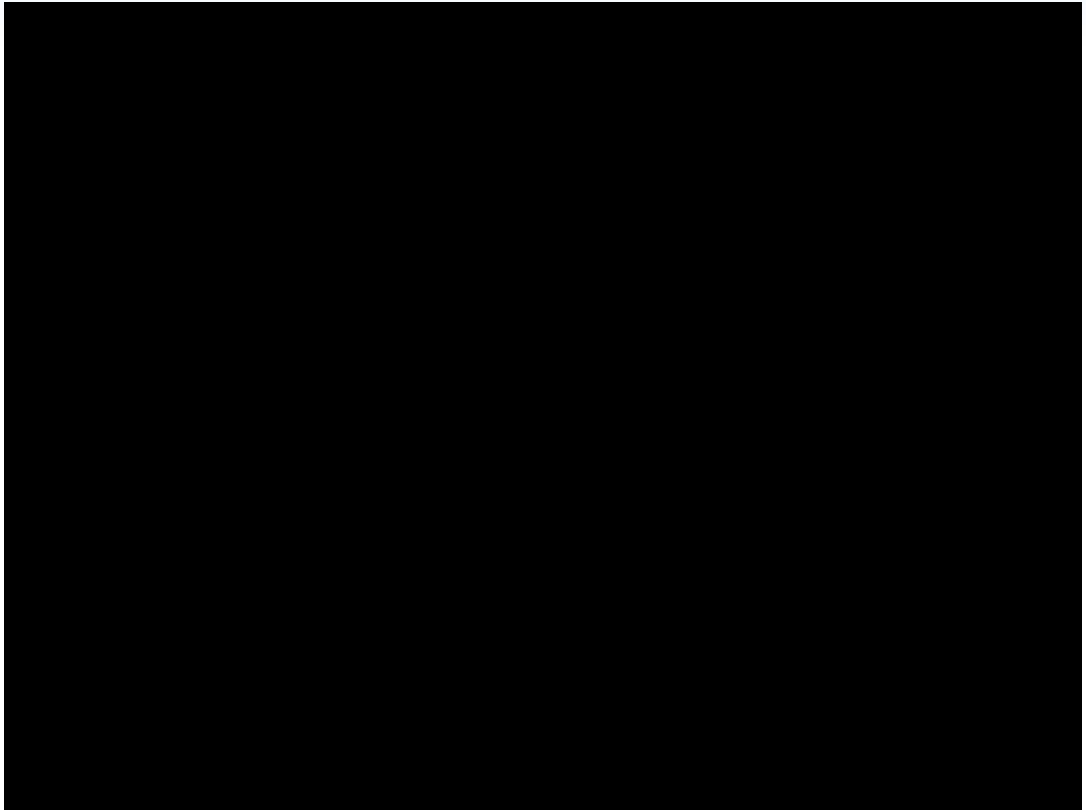

SLAM
With metric map or not
Yes
No
With training dataset
No
Yes
With marker or not
No
Yes
Filter-based SLAM
Feature-based SLAM
Keyframe-based SLAM
Direct SLAM
Geometric SLAM
Learning SLAM
Topological SLAM
Marker SLAM
Only camera or not
Yes
No
One camera or not
Yes
No
Monocular SLAM
Multiocular SLAM
Multi-kind sensors SLAM
Loosely-coupled
Closely-coupled

Marker SLAM

通常的marker SLAM，是设计一些特殊的标志物，提取图像特征，进行空间点与图像点的匹配，利用PnP来进行定位。



无需匹配的marker SLAM



学习 SLAM

1. K. Tateno, F. Tombari, et al. CNN-SLAM: Real-time Dense Monocular SLAM with Learned Depth Prediction. CVPR 2017.
2. B. Ummenhofer, H. Z. Zhou, et al. DeMoN: Depth and Motion Network for Learning Monocular Stereo. CVPR 2017.
3. T. H. Zhou, M. Brown, N. Snavely, D.G. Lowe. Unsupervised Learning of Depth and Ego-Motion from video. CVPR 2017.
4. Michael Bloesch, Jan Czarnowski, Ronald Clark, et al. CodeSLAM — Learning a Compact, Optimisable Representation for Dense Visual SLAM. CVPR 2018. (**Honorable Mention**)
5. Chaplot, D.S., Gandhi, D., Gupta, S., Gupta, A. and Salakhutdinov, R., 2020. Learning To Explore Using Active Neural SLAM. In International Conference on Learning Representations. 2020.(Winner of the CVPR 2019 Habitat Navigation Challenge) (https://github.com/devendrachaplot/Neural-SLAM)

拓扑SLAM

- J. Vallvé, J. Solà, J. Andrade-Cetto. Graph SLAM Sparsification with Populated Topologies Using Factor Descent Optimization. IEEE Robotics and Automation Letters, 2018.
- N. Sünderhauf and P. Protzel. Switchable Constraints for Robust Pose Graph SLAM. IROS, pp. 1879-1884, 2012.
- Y. Latif, C. Cadena, J. Neira. Robust Graph SLAM Back-Ends: A Comparative Analysis. IROS, 2014.

几何SLAM

- **滤波SLAM**
- **关键帧SLAM**

- H. Strasdat, J. M. M. Montiel, and A. J. Davison. Real-time monocular SLAM: Why filter?. 2010 IEEE International Conference on Robotics and Automation, 2010, pp. 2657–2664.

- R. Mur-Artal, J. M. M. Montiel, and J. D. Tardós. ORB-SLAM: A Versatile and Accurate Monocular SLAM System. IEEE T-RO, vol. 31, no. 5, pp. 1147–1163, Oct. 2015

Real-time monocular SLAM: Why filter?

Andrew Davison

MonoSLAM，2006

首次实现单目实时SLAM

PTAM， 2007

Real-time monocular SLAM: Why filter?

基本关键概念

- EKF
- SFM
- Keyframe
- Bundle adjustment
- Loop closure detection

Real-time monocular SLAM: Why filter?

- G. Klein and D. W. Murray. Parallel tracking and mapping for small AR workspaces. In *Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR)*, 2007.

- E. Eade and T. Drummond. Monocular SLAM as a graph of coalesced observations. In *Proceedings of the International Conference on Computer Vision (ICCV)*, 2007.

Real-time monocular SLAM: Why filter?

- we can conclude that filter-based SLAM frameworks might be beneficial if a small processing budget is available, but that BA optimization is superior elsewhere.

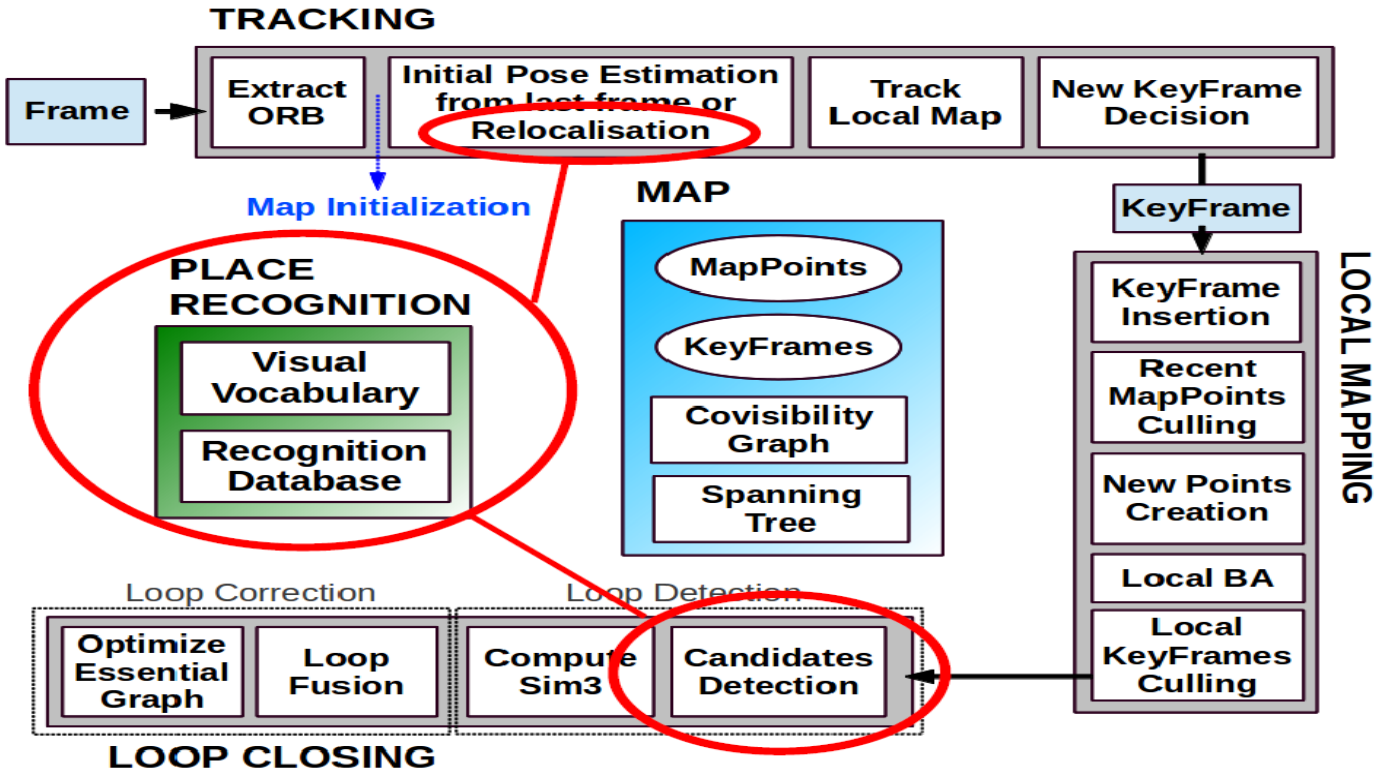
- These results are shown to be remarkably independent of the particular motion and scene setting.

ORB-SLAM: A Versatile and Accurate Monocular SLAM System

基本关键概念：

- fast 角点
- ORB 描述子
- 基本矩阵
- 平面homography
- Graph
- Covisibility graph
- Bundle adjustment
- Loop closure detection

ORB-SLAM: Real-Time Monocular SLAM



Automatic Map Initialization

Model Selection

Homography
(Planar, Low Parallax)

Fundamental Matrix
(General)

Keyframe Selection

Survival of the Fittest
KeyFrame Selection

Fast Keyframe Insertion
(no distance threshold)

Culling of redundant
Keyframes

Relocalization

- Bag of words

ORB descriptors

	ORB-SLAM	PTAM	RGBD-SLAM	LSD-SLAM
fr1_xyz	**0.90**	1.15	1.34	9.00
fr2_xyz	0.30	**0.20**	1.42	2.15
fr1_floor	**2.99**		3.51	38.07
fr1_desk	**1.69**		2.52	10.65
fr2_360 _kidnap	3.81	**2.63**	100.5	
fr2_desk	**0.88**		3.94	4.57
fr3_long _office	**3.45**		-	38.53
fr3_nstr_ tex_near	**1.39**	2.74	-	7.54
fr3_str_ tex_far	**0.77**	0.93	-	7.95
fr3_str_ tex_near	1.58	**1.04**	-	
fr2_desk _person	**0.63**		2.00	31.73
fr3_sit_ xyz	**0.79**	0.83	-	7.73
fr3_sit_ _halfsph	**1.34**		-	5.87
fr3_walk _xyz	**1.24**		-	12.44
fr3_walk _halfsph	**1.74**		-	

TUM RGB-D Benchmark

RMSE (cm)

RGB-D SLAM results taken from the benchmark website

课后作业

了解四足机器人

- 综述

https://mp.weixin.qq.com/s/kVbjZdw6t9wymCd84oXbpA

- 国内外四足机器人团队

https://mp.weixin.qq.com/s/oTELx9nJLDEnqAvdTquhjA

谢 谢

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