A New Approach to SLAM: Flow-based Learning Paradigm

Hongbin Zha
Key Laboratory of Machine Perception (MOE)
Peking University
zha@cis.pku.edu.cn

Localization and Mapping

◆ Localization

Odometry of sensors or robot systems

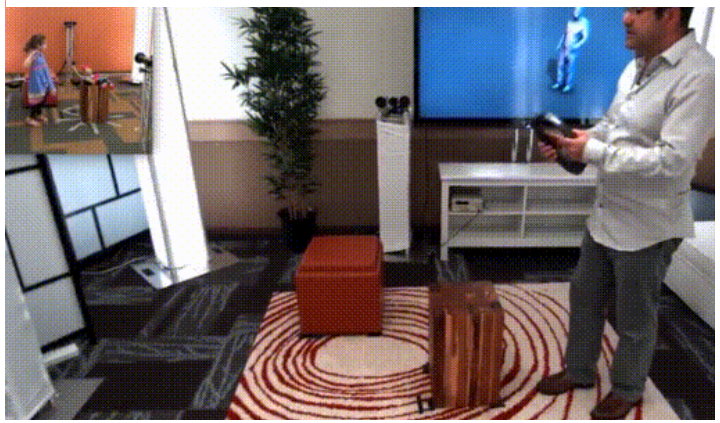
Amazon warehouse robot

Google autonomous driving car

◆ Mapping

3D reconstruction of environments

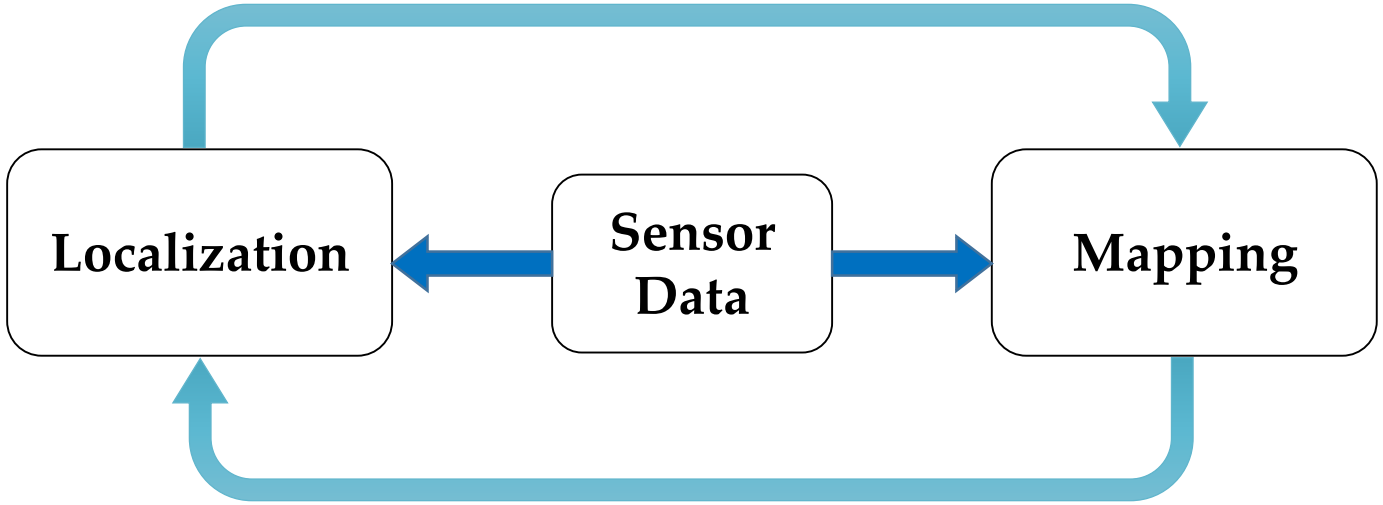
Google earth



Microsoft Holoportation

SLAM: Simultaneous Localization And Mapping

- Tight coupling of **localization** and **mapping**

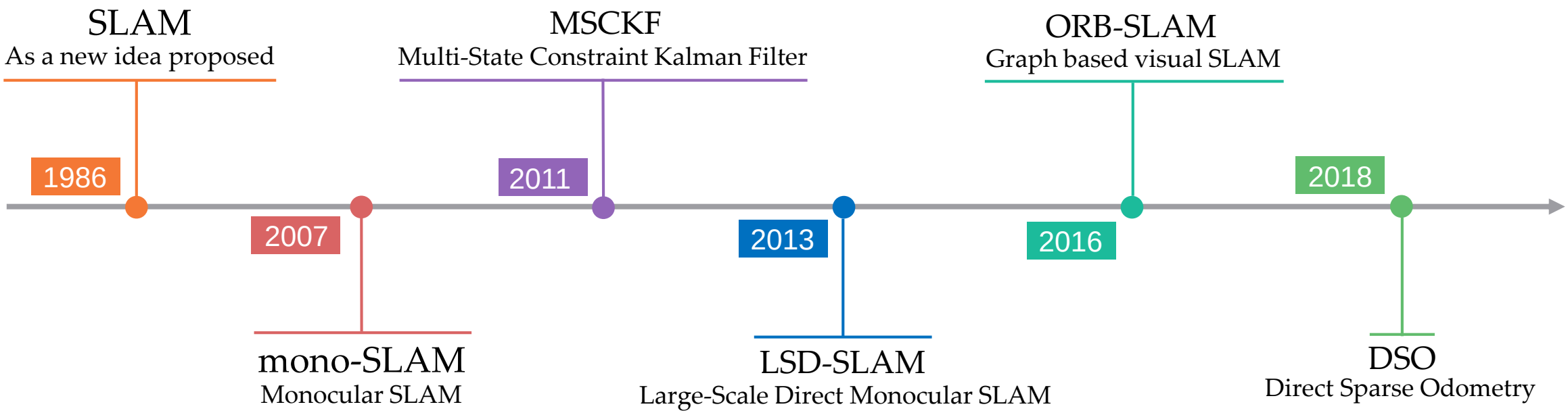


LSD-SLAM

A fundamental function of mobile vision systems as for human

History of SLAM Research

ORB: Oriented FAST and Rotated BRIEF

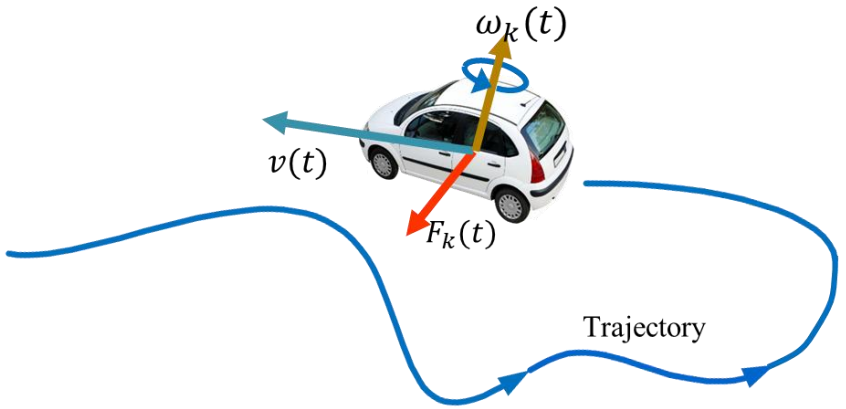


- Make good use of explicit geometrical relationships between consecutive frames
- Enhance the performance by fusing different kinds of sensors
- Work well in limited environments for specific tasks

Is Current SLAM Good Enough?

◆ Pay Little Attention to Temporal Continuity

- Look down upon spatial-temporal consistency inherent in SLAM
- A big source of accumulated error
- Low robustness for feature tracking



◆ Rely Too Strongly on Pixel Correspondence

- Structural features: line, edge, super-pixels,…
- Unable to use structural constraints
- Poor performance on texture-less scenes
- Difficult to transform 3D maps to structural descriptions

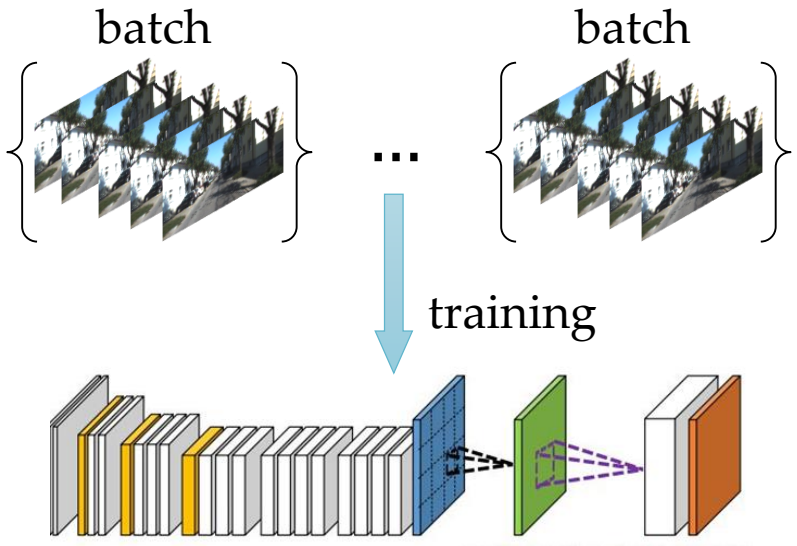
Is Current SLAM Good Enough?

◆ High Computational Cost

- Repetitive and redundant computation
- High demand for hardware
- Limit its real-time applications

◆ Learning Approach and SLAM

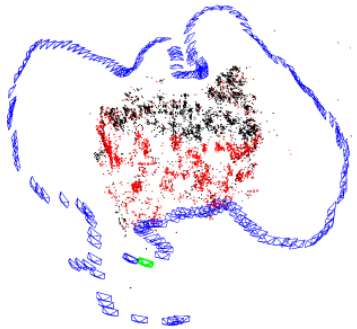
- Off-line batch training instead of online learning
- Supervised learning requires massive labeled data
- Tedious parameter tuning
- Poor generalization ability



Critical Problem

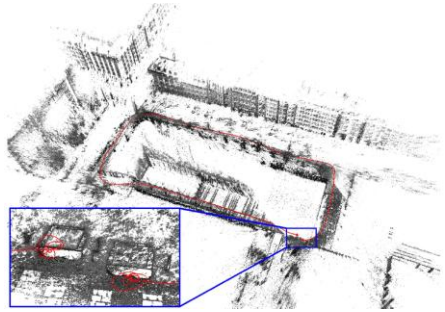
◆ Lack of Systematic Formulation

- Require delicate hand-crafted design and ad hoc strategies
- Various optimizations are proposed for different situations with lots of constraints
- Poor generalization ability to different situations



ORB-SLAM

- ➢ Poor performance on texture-less scenes
- ➢ Extensive computation caused by optimization



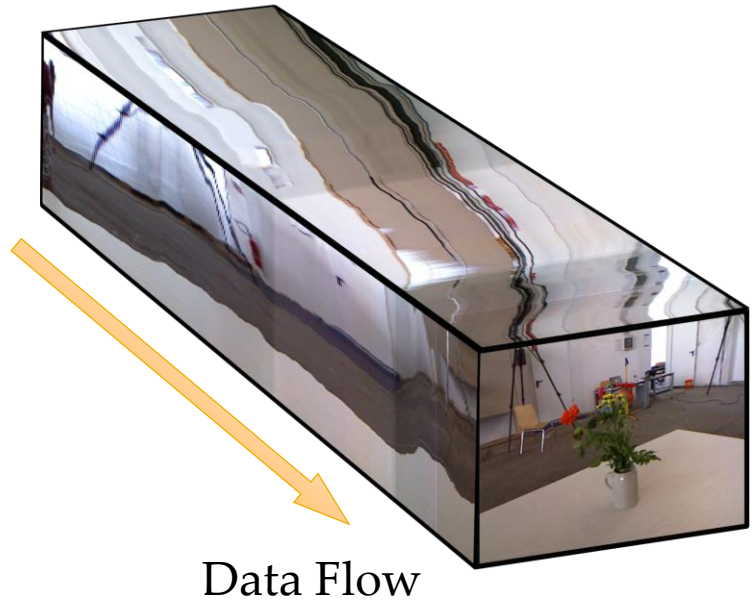
DSO

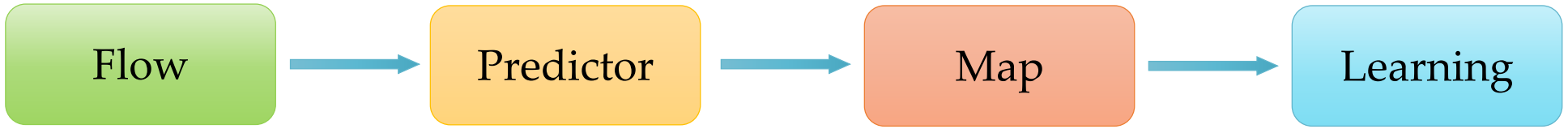
- ➢ Requires photometric calibration
- ➢ Not robust to illumination changes

What is Flow?

Sensor Data Flow:

- Continuous motion patterns of time varying sequential data
- Explicit representation of temporal consistency of input data
- Comply to regular patterns according to laws of physics
- Make the unpredictable, predictable

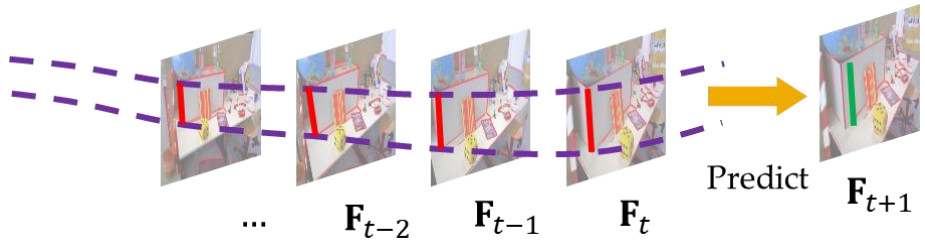




Predictor and Map

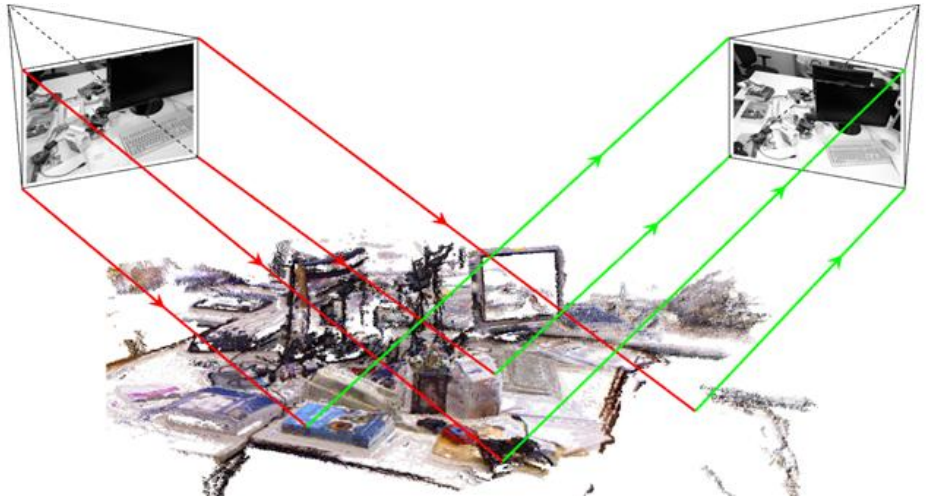
◆ Predictor: the engine of efficient SLAM

- Recurrent state inference: a generative model
- Infer the current state from history
- Provide guidance to reduce computational cost



◆ Map: an invariant representation

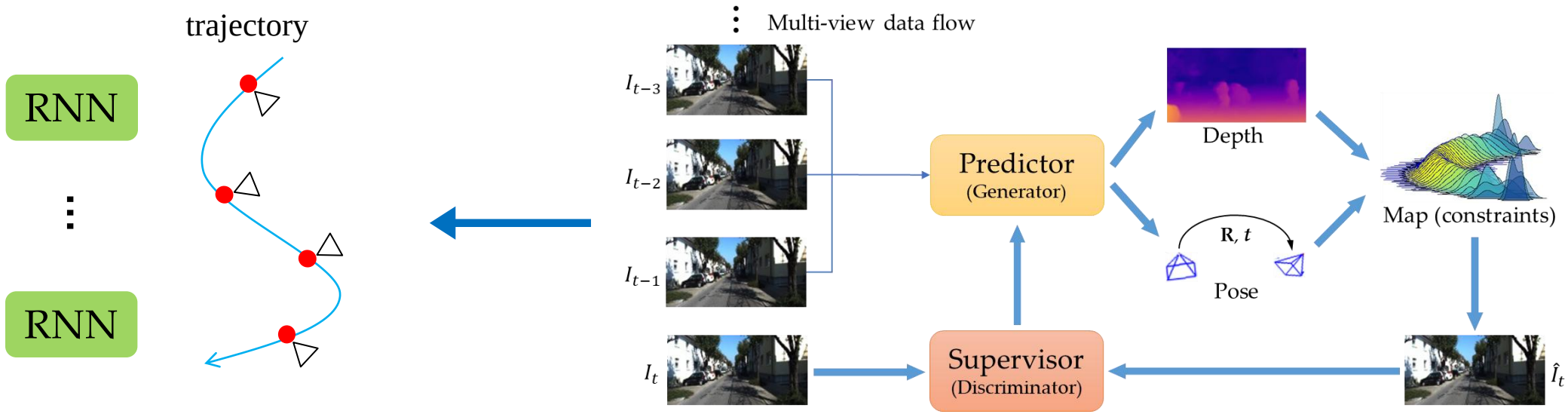
- Implicit/explicit representation of physical world
- Provide constraints as regularization
- Supervisory information for prediction



Learning: A Systematic Solution

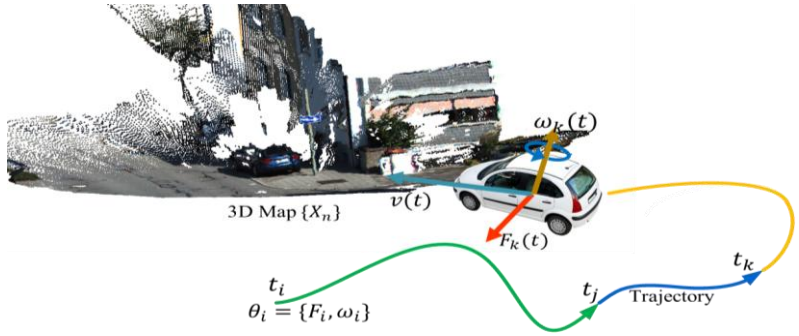
- Learning camera pose in a supervised manner
- Modelling the data flow using RNN

- Self-supervised, online learning
- Generative Adversarial Networks (GAN)

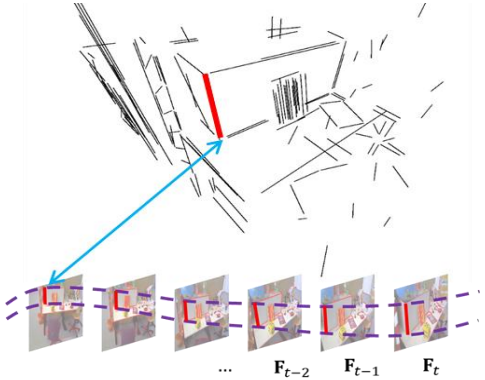


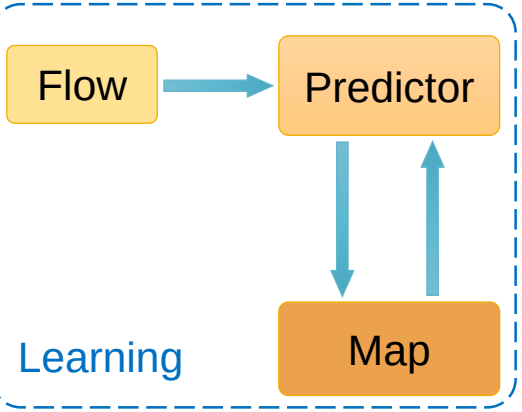
Our Related Research

◆ Dynamics Model



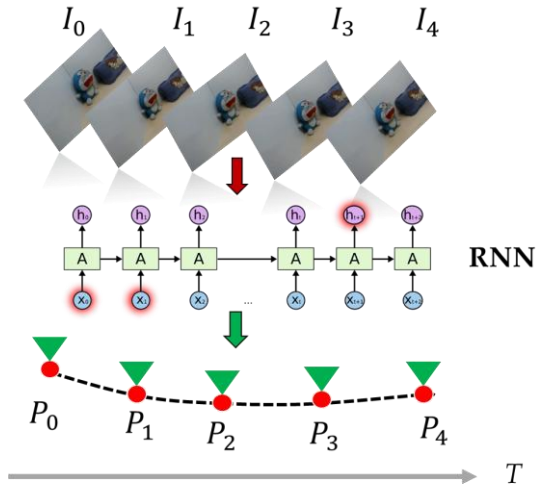
◆ Line Flow



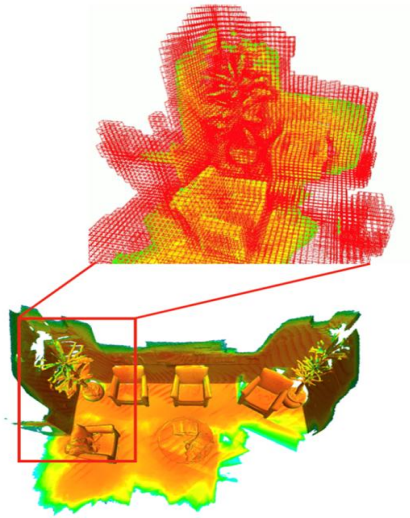


Goal: **Unsupervised online learning** for SLAM

◆ RNN Learning



◆ Probabilistic Map Representation



Conclusions

◆ A flow-based learning paradigm for SLAM

- Dynamics model based visual odometry
- Structural SLAM: Line flow in video stream
- Incremental data fusion with a probabilistic map
- RNN visual odometry: a step to online learning SLAM

◆ Future work

- Multi-sensor data fusion
- High-level semantic representation and mapping
- Robust to dynamic scenes

Thank you!