QIF 2020 North America

Autonomous Driving via Active Stereoscopic Vision and Online Expectation-Maximization

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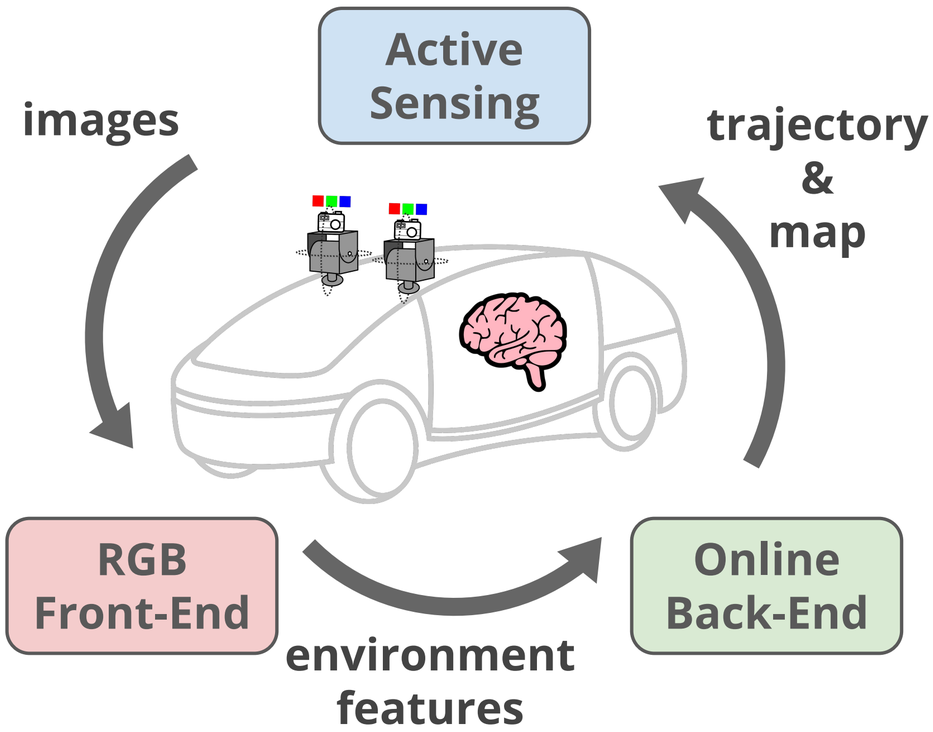
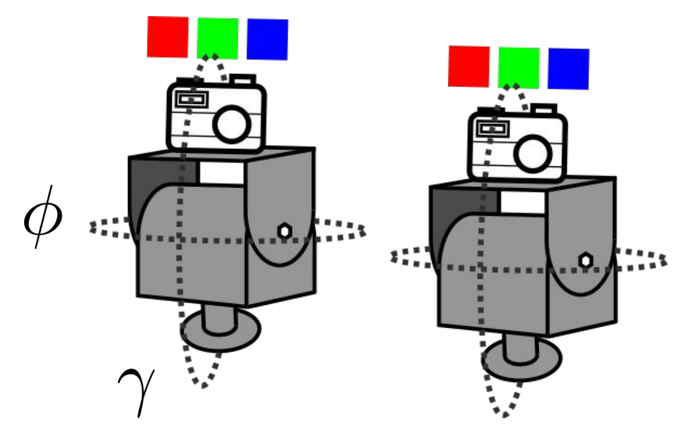


Introduction

- Self-driving vehicles need **robust, computationally efficient** visual-inertial SLAM for **safe, real-time navigation**.
- Modern visual-inertial SLAM systems require **expensive sensors** accompanied by **extensive data**.
- We lower the hardware and computational requirements by **fundamentally improving the efficiency** of **information collection and processing** from three aspects.

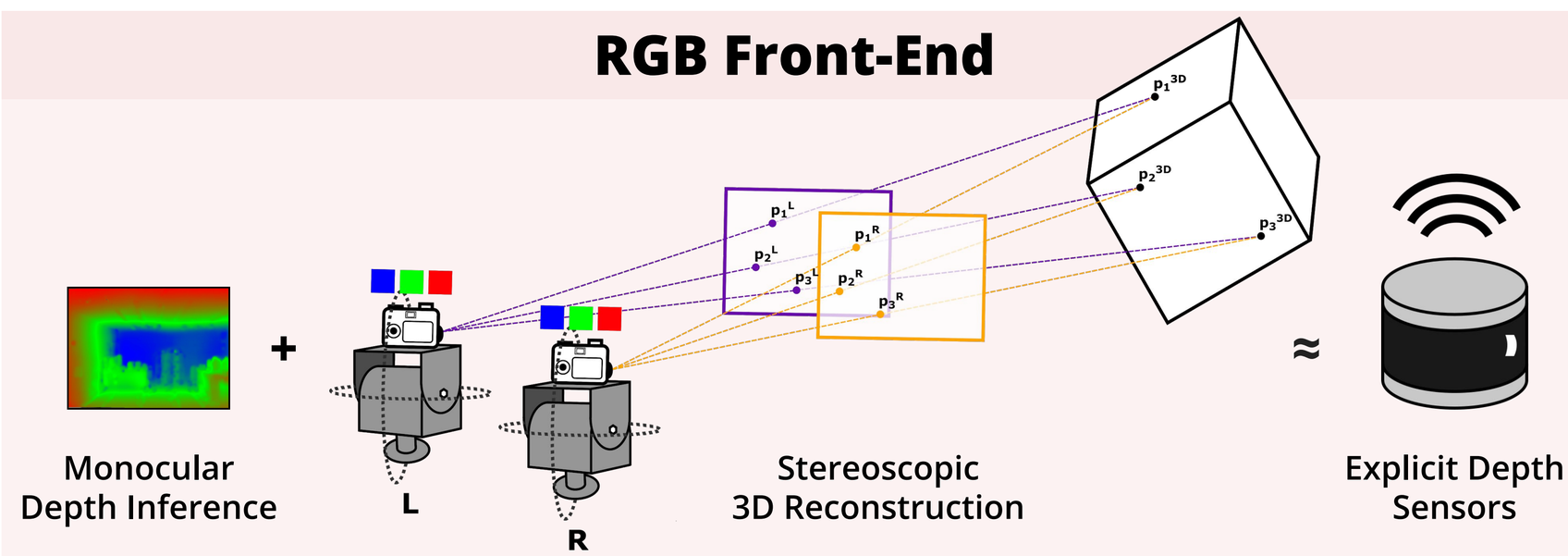
Active Sensing

- Exploration of the environment can increase confidence in map information during navigation.
- Instead of relying on sensors that passively collect data, we provide each camera with two more degrees of freedom via controllable pan-tilt units.
- This novel active sensing paradigm can provide autonomous agents with the means to maximize map coverage.



$$\arg\max_{\gamma_t,\phi_t} \quad \mathsf{E}[\,map\,coverage_t \,|\, trajectory_{t-1};\, map_{t-1}\,]$$
$$\text{s.t.} \quad \mathsf{Var}(trajectory_t) \le C$$

RGB Front-End

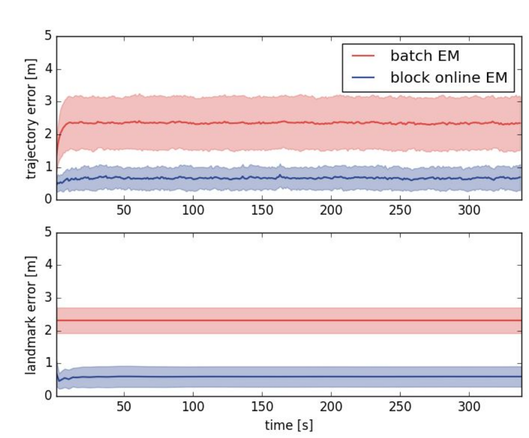


- Monocular depth inference can be improved by considering camera intrinsics.
- Combining monocular depth inference and stereoscopic reconstruction could be a more resourceful alternative to depth sensors.

Online Back-End

- The block online EM SLAM only needs to estimate the recent trajectory by encoding the old information in the landmark estimates.
- Therefore, the block online EM SLAM facilitates a real-time visual-inertial system with an explicit map.
- In each block:

$$\hat{\lambda}_{k,0} = \hat{\lambda}_{k-1},$$
$$Q_{k,n}(\lambda) = \mathsf{E}_{\hat{\lambda}_{k,n-1}}\left[\log p(S_{T_k:T_k+\tau_k}, O_{T_k:T_k+\tau_k};\lambda) | o_{T_k:T_k+\tau_k}\right],$$
$$\hat{\lambda}_{k,n} = arg\,max_{\lambda} Q_{k,n}(\lambda).$$



The SLAM performance of EM and block online EM in 2D with a point landmark.