EDI: ESKF-based Disjoint Initialization for Visual-Inertial SLAM Systems

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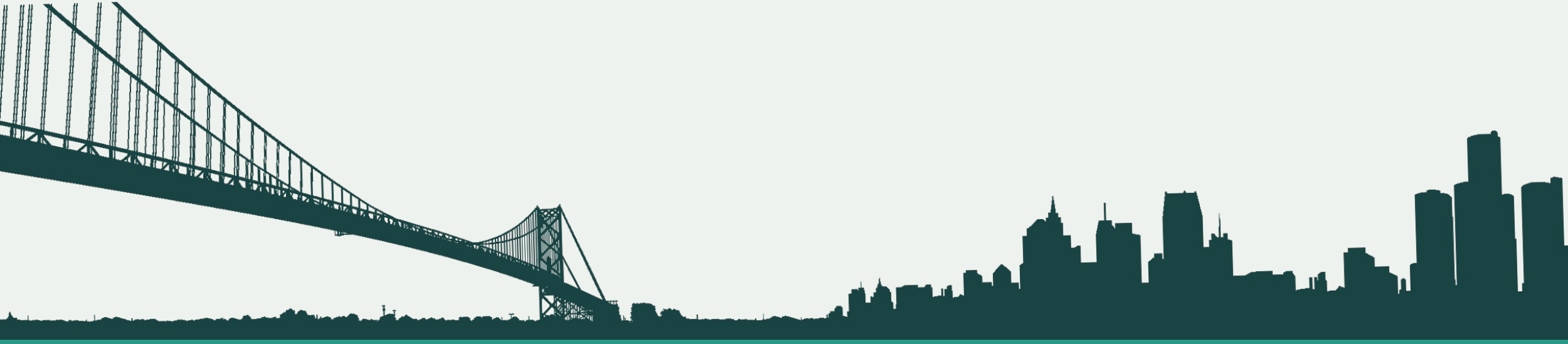
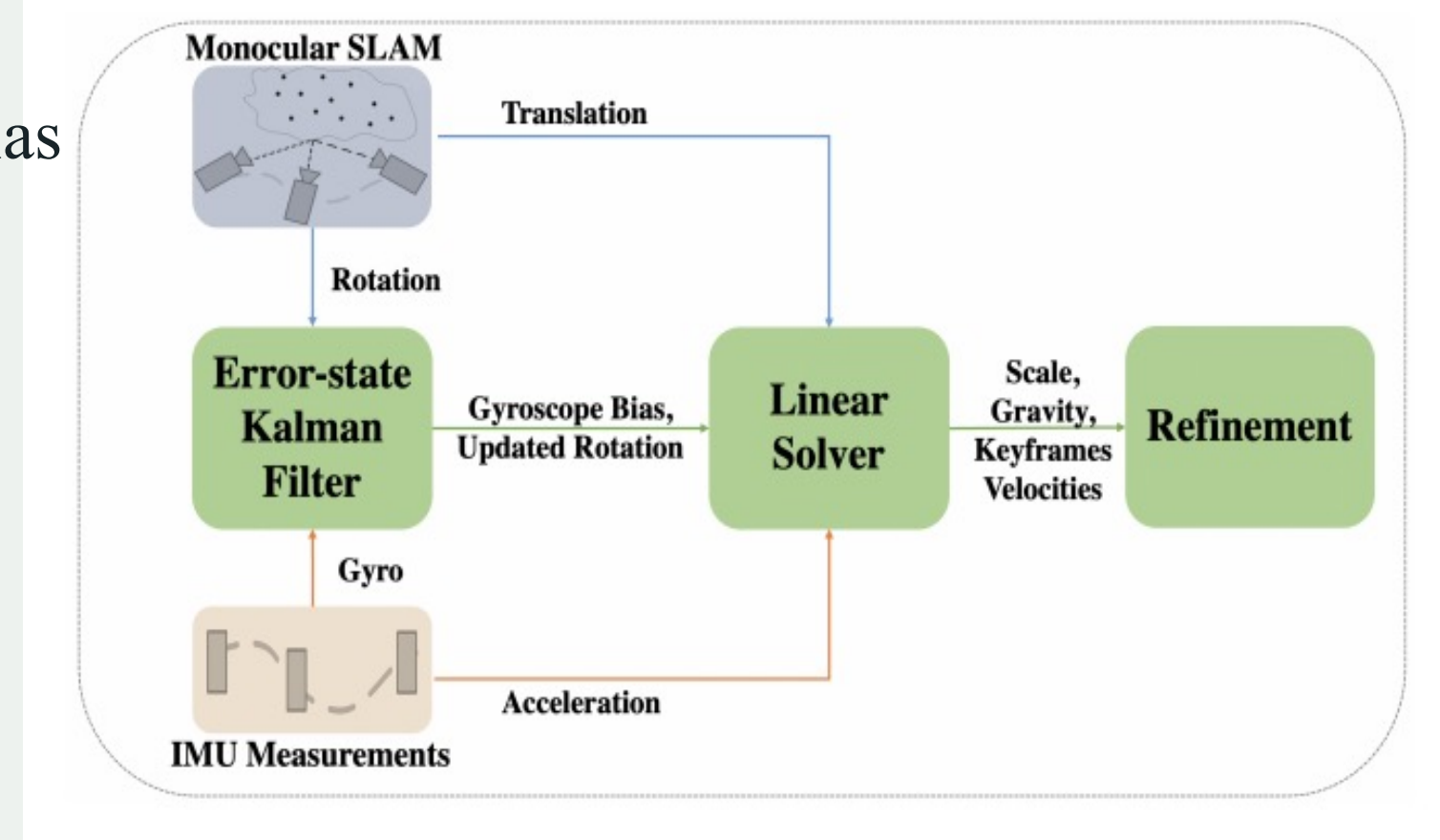


Introduction

- **The initialization process is crucial for Visual-Inertial SLAM system, as it requires a good initial estimation for the scale, gravity, velocities, acceleration and gyroscope biases.**
- **Visual-inertial initialization is classified into two categories:**
  - Joint methods
  - Disjoint methods
- **Limitations of previous two classes of methods:**
  - Joint methods: Ignore the gyroscope bias in the closed-form solution, resulting in limited accuracy and are computationally expensive.
  - Disjoint methods: The accuracy is highly dependent on pure monocular SLAM.
- **We propose an innovative disjoint initialization approach to overcome the limitations of the previous disjoint methods.**

Technical Approach

- Pure Monocular SLAM
- ESKF-based Gyroscope Bias Estimation
- Linear Solver
- Refinement

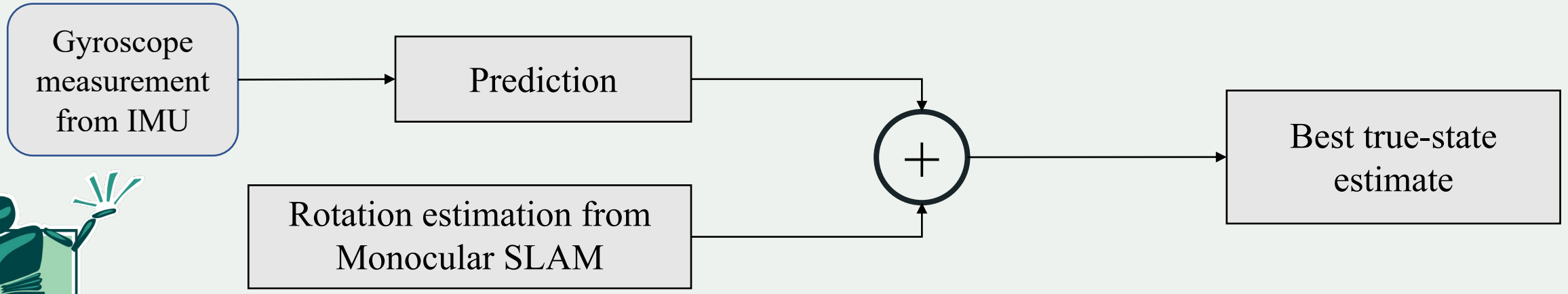


ESKF-based Gyroscope Bias Estimation

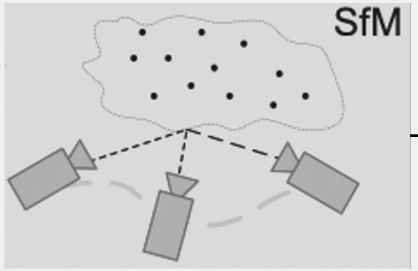
Goal: Estimate gyroscope bias and refine rotation estimation from pure monocular SLAM.
Input: Nominal state and error state for rotation and gyroscope bias.
Output: True-state estimate for rotation and gyroscope bias.

Error state Kalman Filter (ESKF)

- Nominal state
- Error state
- True state



Linear Solver & Refinement



Rotation & Translation

Linear Solver

Gravity, KFs' velocities & scale factor

Refinement

Preintegration of translation & velocity

Refined gravity, KFs' velocities, scale factor and acceleration bias

Accuracy & Computation Speed Evaluation

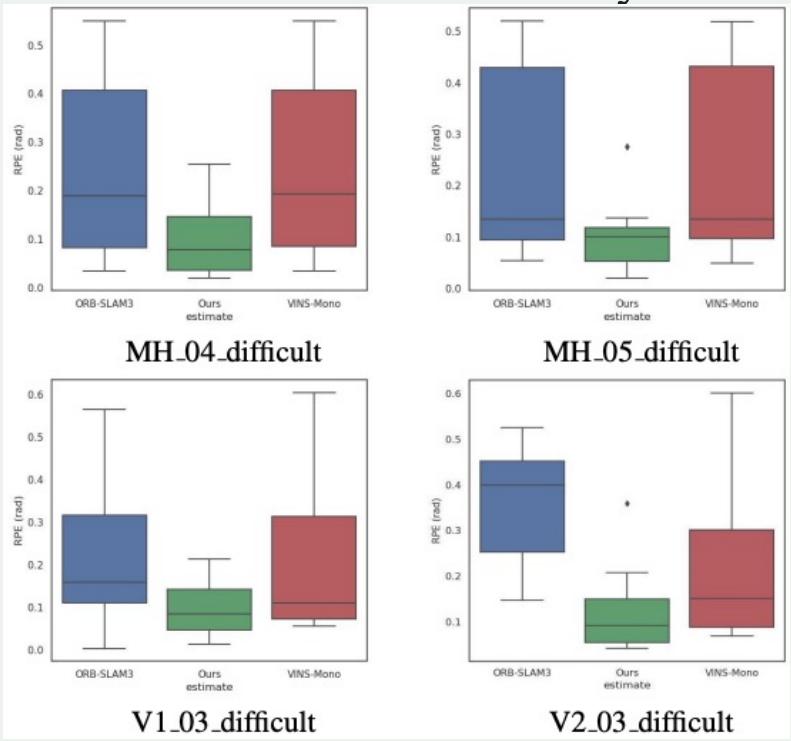
- Evaluation on EuRoC dataset.
- Compares average the scale error and run-time using 10 keyframe for initialization.
- Scale Error:
  - $|s^* - \hat{s}| / |s^*| \times 100\%$ (1)

	Ours	ORB-SLAM3 (without VI-BA)	ORB-SLAM3 (with VI-BA)	VINS-Mono
Time (ms)	0.54	1.36	36.28	0.45
Scale error (%)	5.8	114.2	27.3	15.0

Robustness Evaluation

- Test methods in challenging conditions such as motion blur and illumination change using sequences MH_04 difficult, MH_05 difficult, V1_03 difficult, and V2_03 difficult
- Introduce noise to the rotation estimates of keyframes used in the initialization.

- ORB-SLAM3 in Blue
- EDI in Green
- VINS-Mono in Red



Seq name	EDI RMSE (rad)	ORB-SLAM3 RMSE (rad)	VINS-Mono RMSE (rad)
V1_03_difficult	**0.116**	0.302	0.298
V2_03_difficult	**0.160**	0.374	0.291
MH_04_difficult	**0.125**	0.304	0.304
MH_05_difficult	**0.127**	0.297	0.297
Avg	**0.132**	0.319	0.298

Thank you