Optimization-based VINS: Consistency, Marginalization, and FEJ

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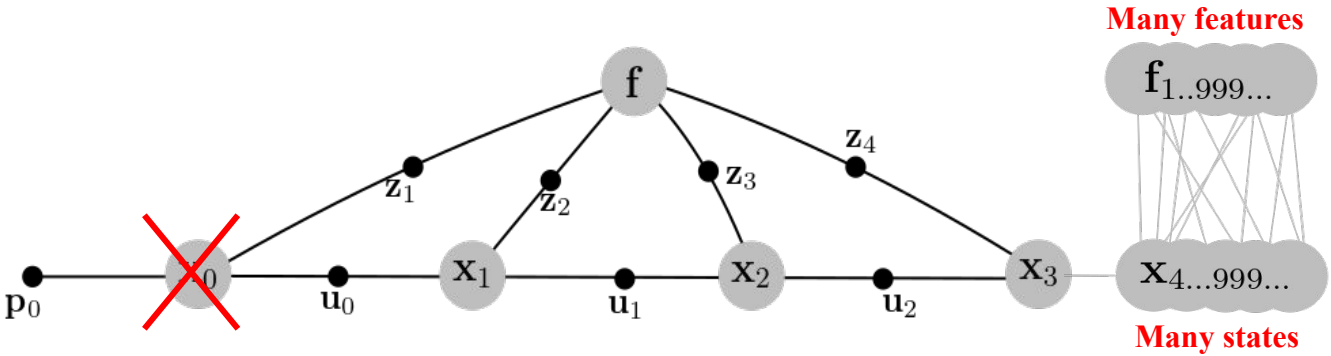
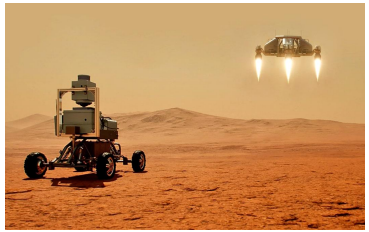
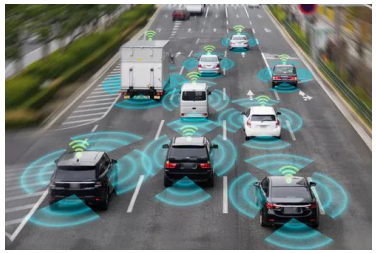
Sliding-window Optimization-based VINS

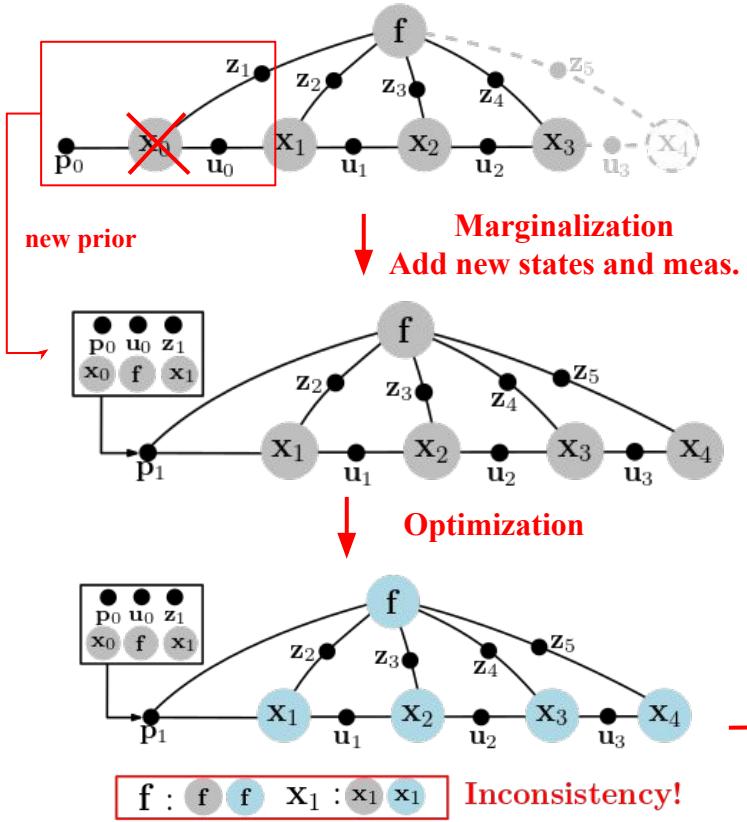






- **Visual-inertial Navigation Systems (VINS)**
  - **Applications:** AR/VR, robotics, autonomous driving, etc.
  - **Input**: Inertial Measurement Unit (IMU) + Camera meas.
  - **Goal**: Estimate 6 d.o.f motion
- **Optimization-based VINS**
  - Nonlinear least square (NLS) - iterative solver
- **Marginalization**
  - Bounds computation - Enables large-scale & long-term navigation

Consistency, Marginalization and FEJ



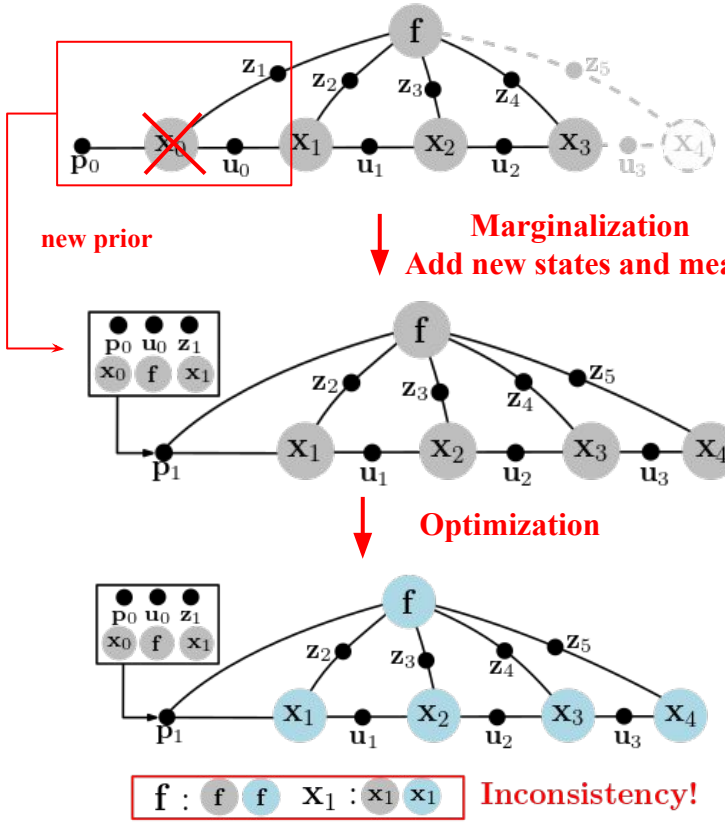
Marginalization causes issues!

- **Same** states have ***different*** linearization
- **Unobservable** direction → **Observable**

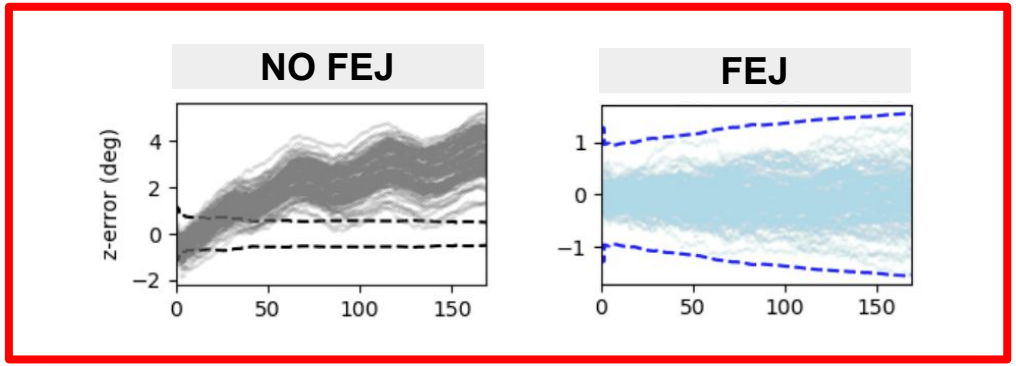
First-estimates Jacobian (FEJ):

- Fix linearization points to ensure the observability property
- **Improve both consistency and accuracy**

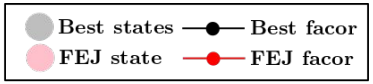
Consistency, Marginalization and FEJ



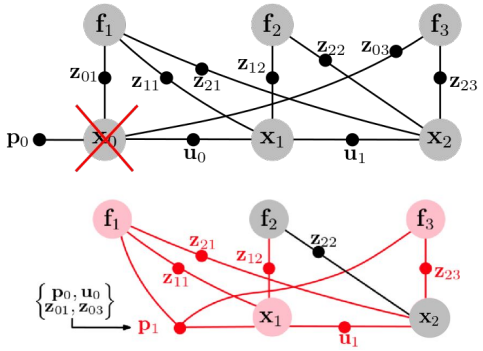
Marginalization causes issues!



Marginalization and FEJ: Numerical Study

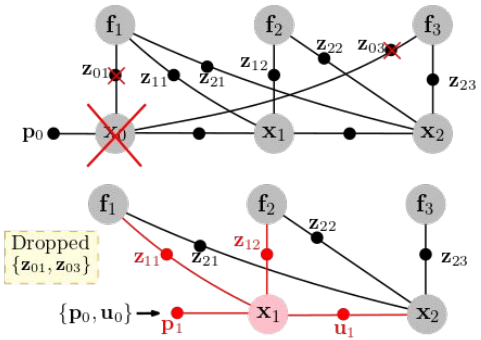


KEEP



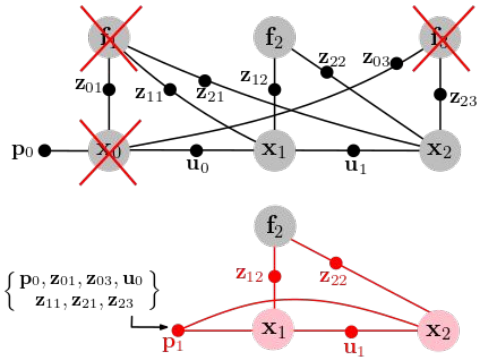
	ATE (deg/m)	NEES (3)
FEJ	0.380 / 0.132	3.057 / 2.733
No-FEJ	2.123 / 0.376	155.3 / 22.074

DROP



	ATE (deg/m)	NEES (3)
FEJ	0.919 / 0.289	2.661 / 3.103
No-FEJ	1.104 / 0.299	3.027 / 3.010

MARG



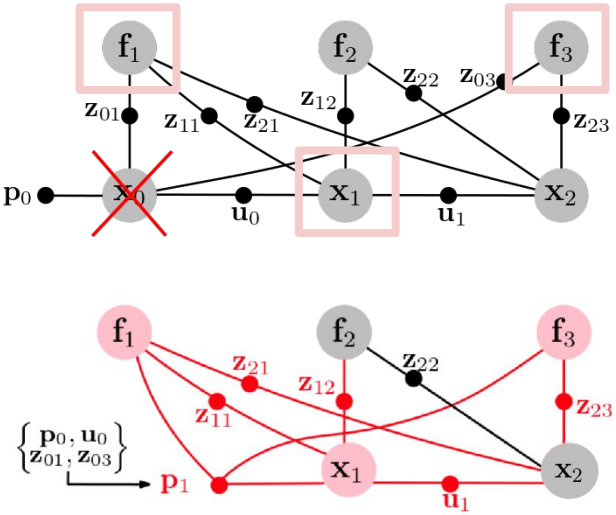
	ATE (deg/m)	NEES (3)
FEJ	0.816 / 0.235	2.979 / 2.619
No-FEJ	0.879 / 0.233	3.037 / 2.476

- FEJ improves both consistency and accuracy!
- Different marg. strategies require different states to have FEJ applied

- **KEEP:** use all available information
  - **FEJ:** best performance - accurate and consistent!
  - **NO-FEJ:** worse than DROP/MARG - inconsistent!

Summary

- **Sliding-window optimization-based VINS**
  - **Inconsistency** caused by marginalization
  - **FEJ improves** both consistency and accuracy
- **FEJ implementation:**
  - During marginalization, select **states connected in markov blanket**
  - **Fix** their current estimates as “FEJ” values
  - **Always** use that FEJ values to evaluate the Jacobian in the optimization



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