

Collab. Res.: NRI:INT: Cooperative Underwater Structure Inspection Mapping

NRI: 1943205

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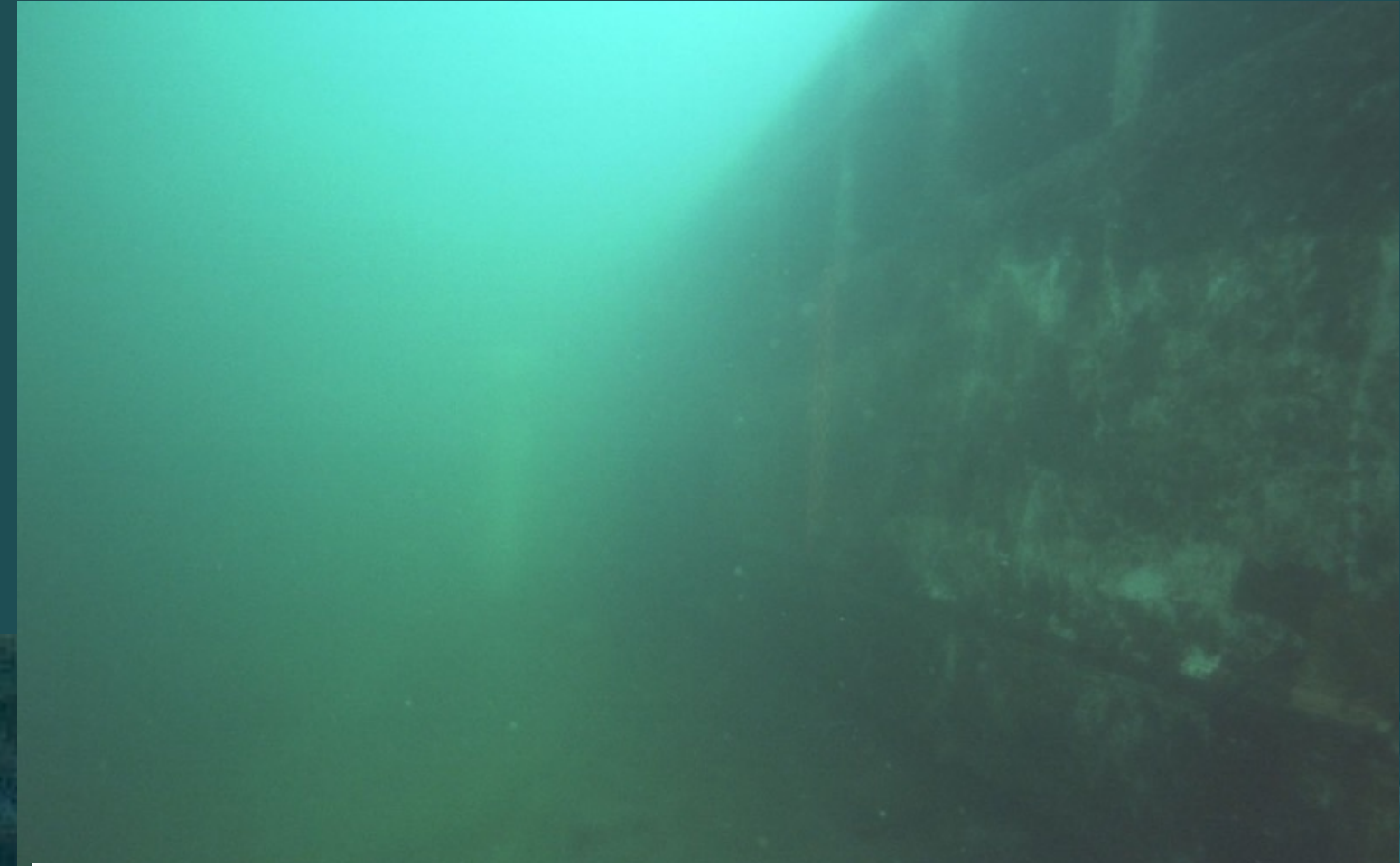
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Visual SLAM Challenges Underwater



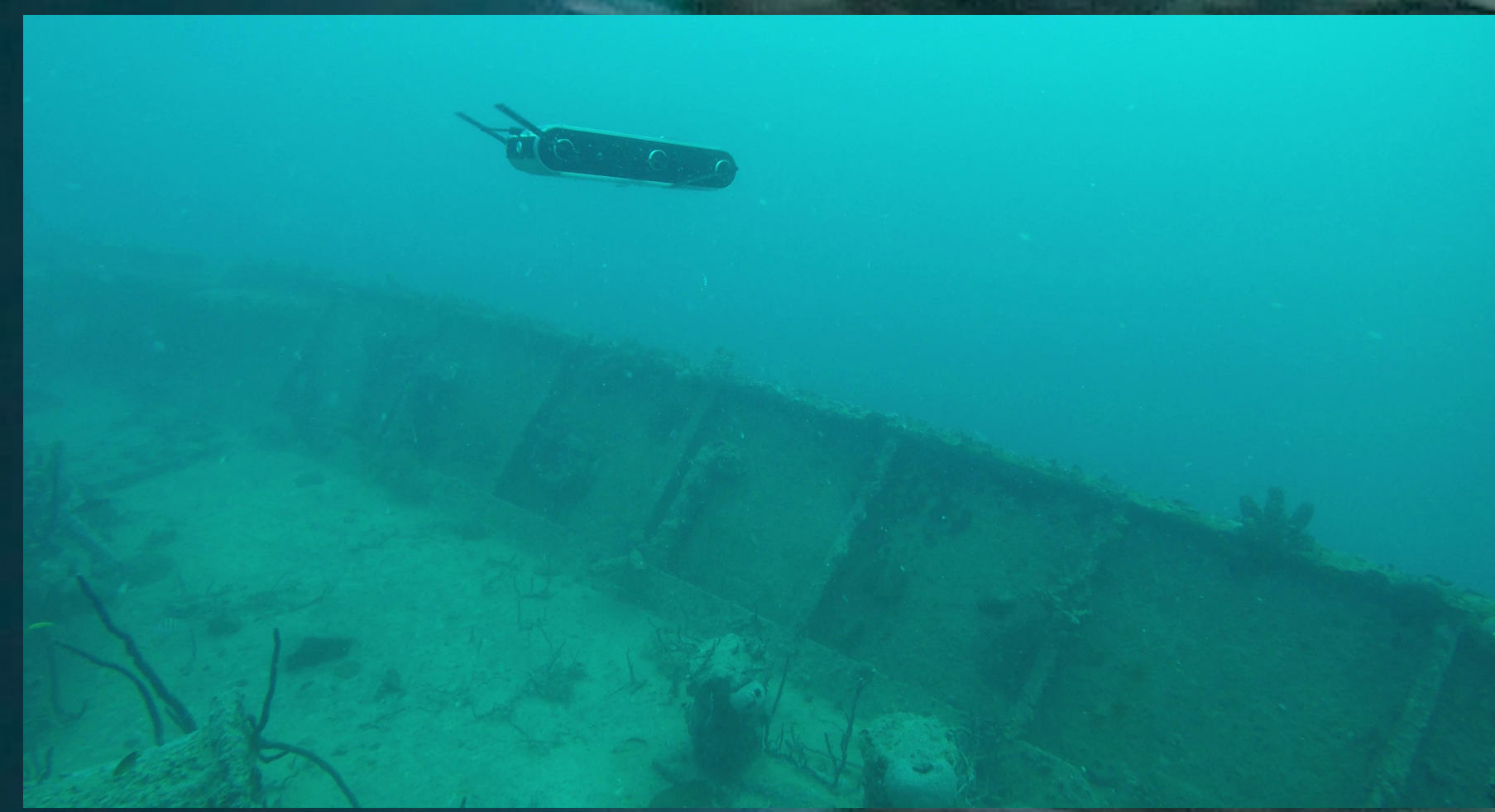
Coral Saturation – Aqua2 AUV over coral reef



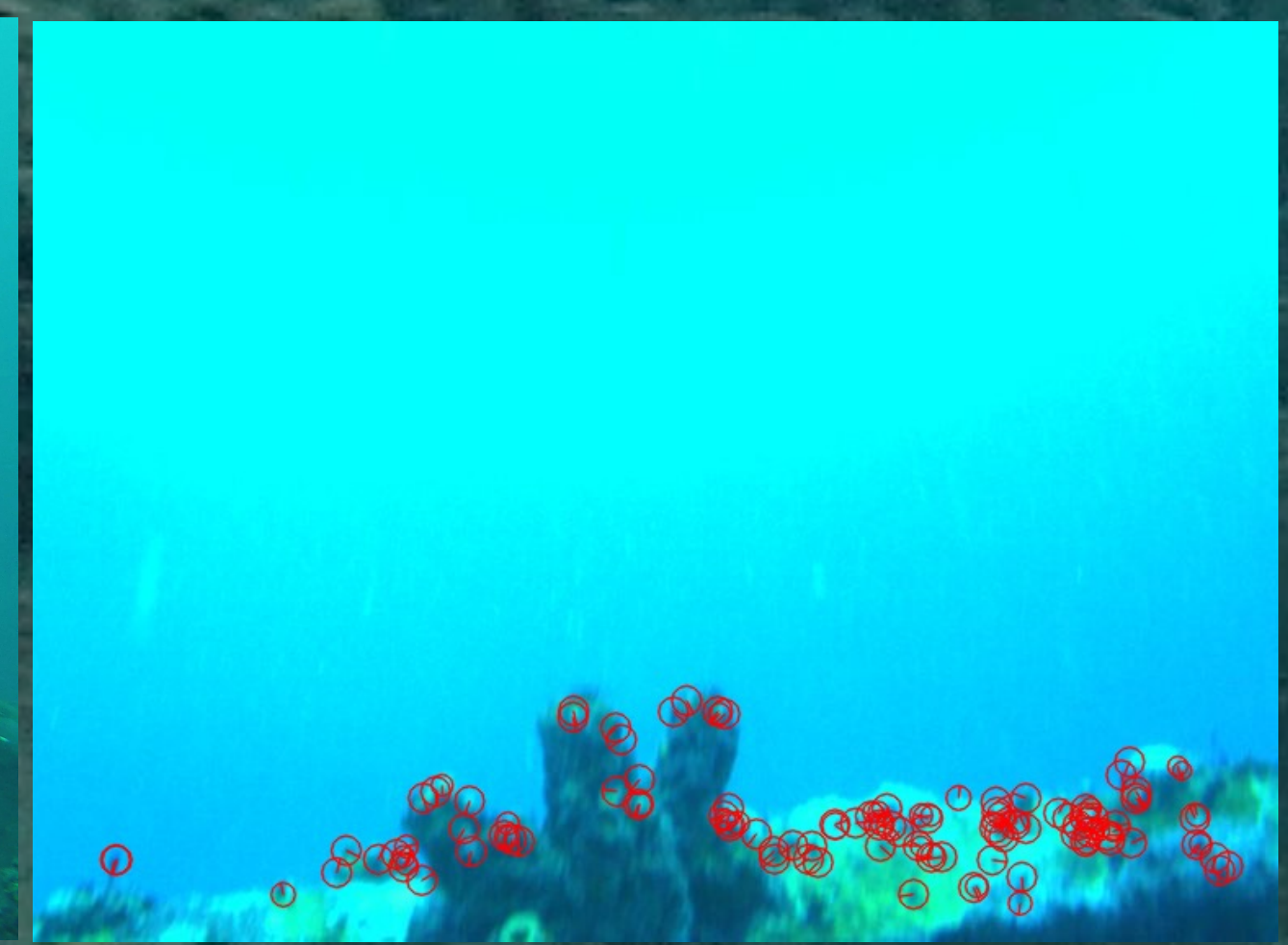
Low visibility – UW Sensor Suite outside a sunken bus [2]

- Lightweight Inexpensive camera sensors
- Integrated with IMU for scale information
- Challenging due to color attenuation, floating particulates, low visibility, and varying illumination.

Aim: Robust Localization



Robots frequently see open water during operations



Very few features

Visual SLAM is bound to fail

VIO Health Tracking

Track the health of VIO to detect failures

of 3D keypoints tracked (~10)

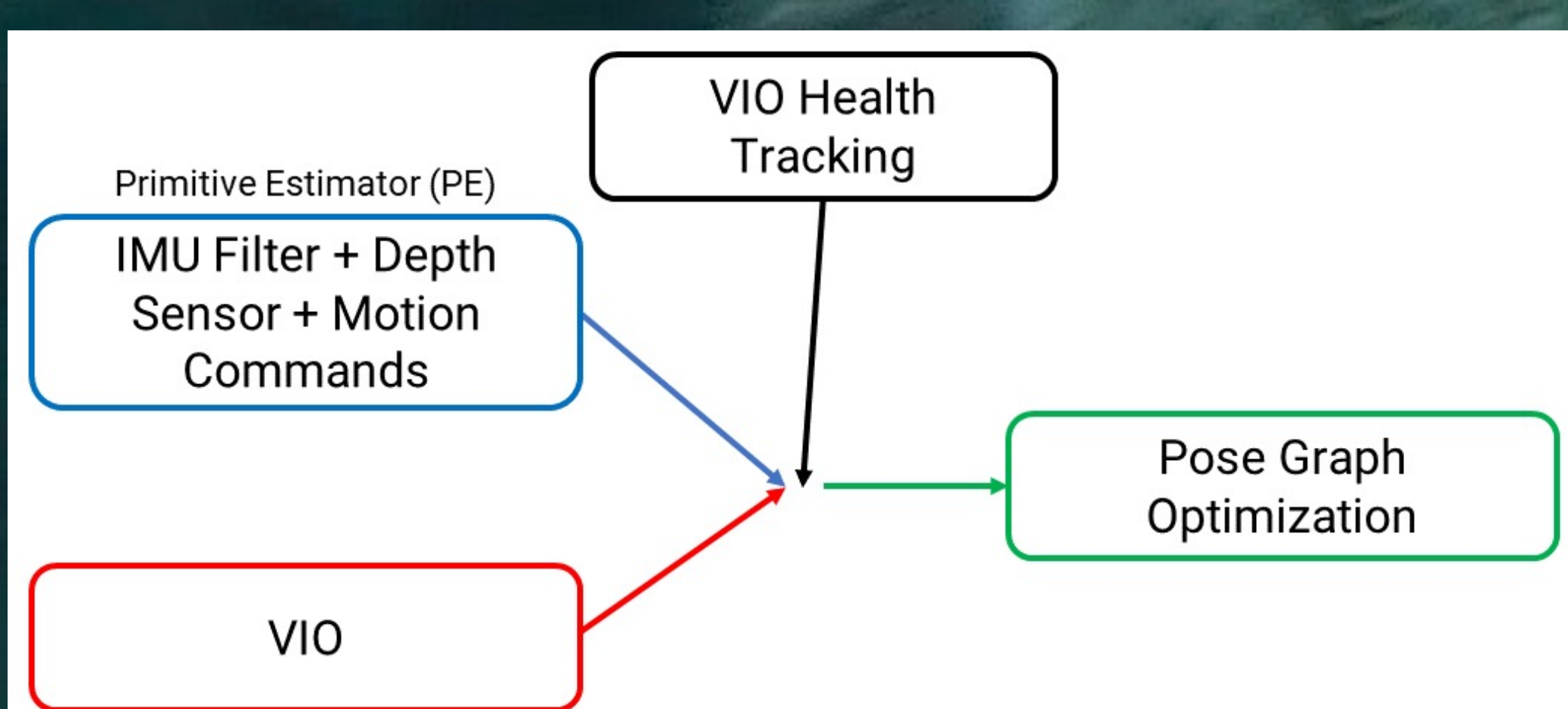
of feature per quadrant (~3)

Ratio of new to tracked keypoints (~0.75)

Average corner response of detector

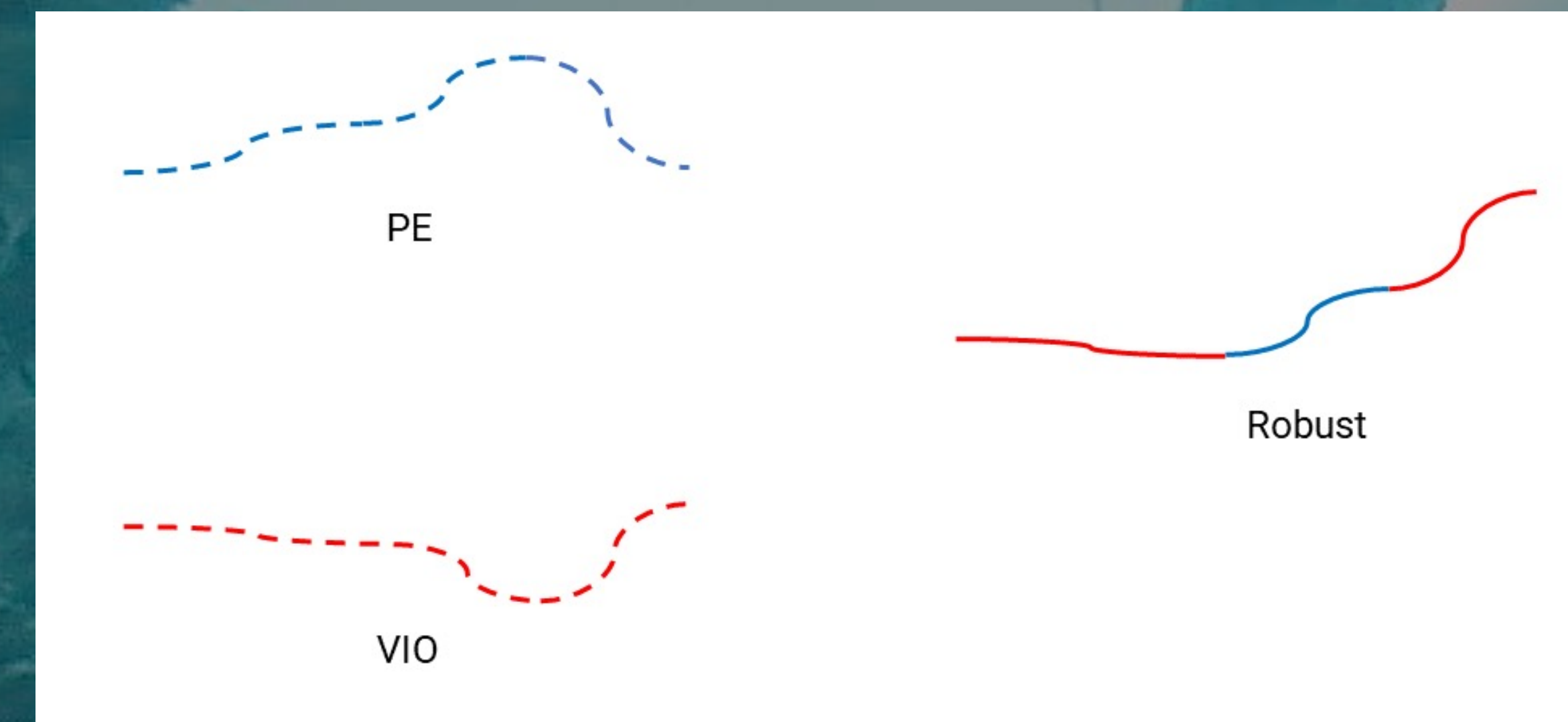


Robust Switching State Estimation



- Primitive estimator (PE) does not depend on camera
- PE less precise than VIO
- Switch to PE when VIO health tracking detects failure
- Optimize the combined pose graph

Switching between VIO and PE



Use sections from VIO and PE based on VIO health tracking

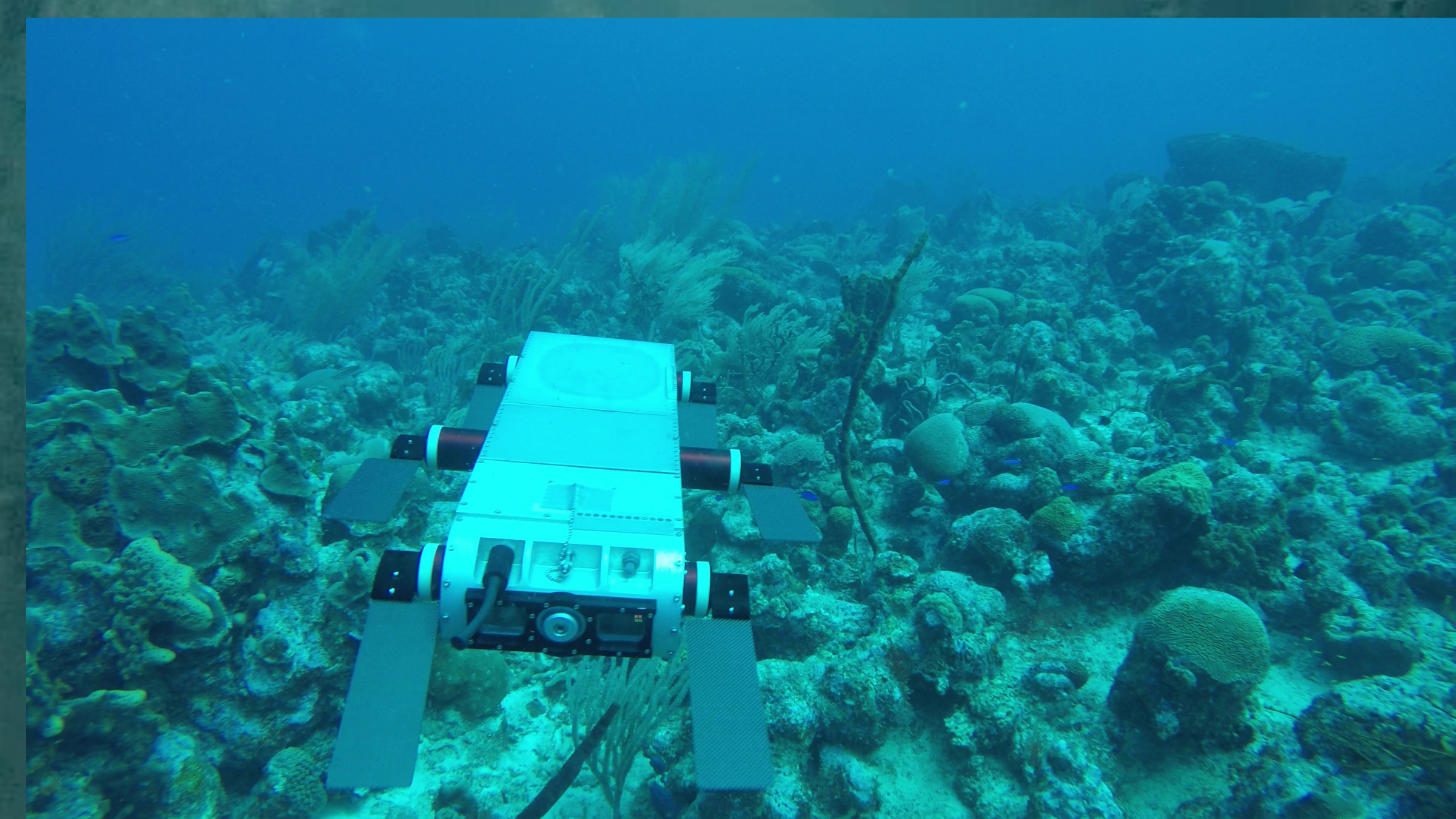
Datasets



Aqua2 performing lawn mower Stavronikita shipwreck



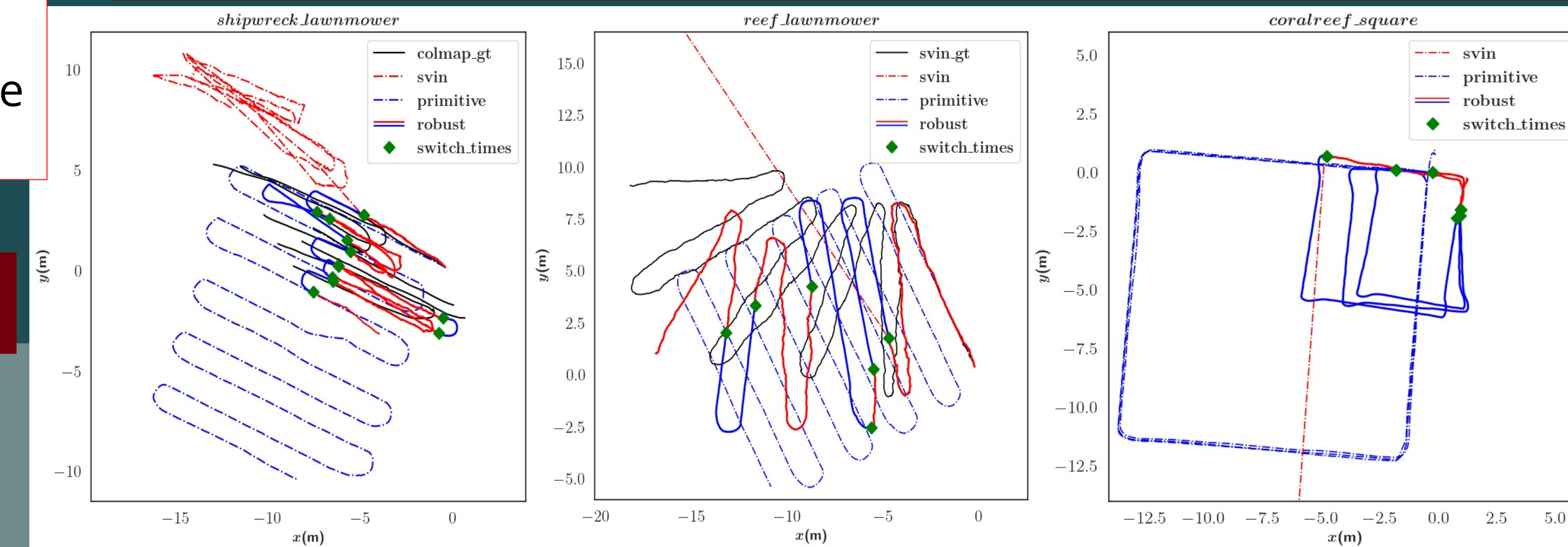
Aqua2 performing squares over coral reef



Aqua2 performing lawn mower over coral reef

- **Stavronikita**
 - ground truth obtained using COLMAP [3]
- **Coral Squares**
 - no ground truth, qualitative
- **Coral Lawnmower**
 - SVIn2 [4] VIO performs well; used as ground truth
 - Images artificially blurred to induce failures

Trajectories



Stavronikita Dataset

VIO Algorithm	Time to first track loss (in secs)	Recovery?	RMSE (in m)
OpenVINS [4]	23.7	No	X
OKVIS [5]	23.4	Partial	5.199
VINS-Fusion [6]	23.6	Partial	53.189
SVIN [3]	23.4	Yes	1.438
Switching Estimator	N/A	Yes	1.295

Comparison with COLMAP Trajectory after SE3 Alignment

Coral Reef Dataset

Dataset	Length (in meters)	mean rmse (in meters)	s.d. (in meters)
reef_lm_w_1_60	108.13	3.21	0.47
reef_lm_w_3_15	108.13	3.21	0.61
reef_lm_w_3_30	108.13	3.01	0.58
reef_lm_w_3_45	108.13	3.56	0.32
reef_lm_w_5_20	108.13	4.37	0.90

Induced failures by applying gaussian blur multiple times for multiple duration

Acknowledgements & References

The authors are grateful for the support and expert advice of Halcyon Diving Systems, FLIR, SINTAQ, and WKPP This project is supported by NSF awards 2024741, 2024541, 2024653, and 1943205.

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