UNDERLOC

IMAGE BASED RELOCALIZATION AND ALIGNMENT FOR DYNAMIC UNDERWATER ENVIRONMENTS

QUT Centre for Robotics

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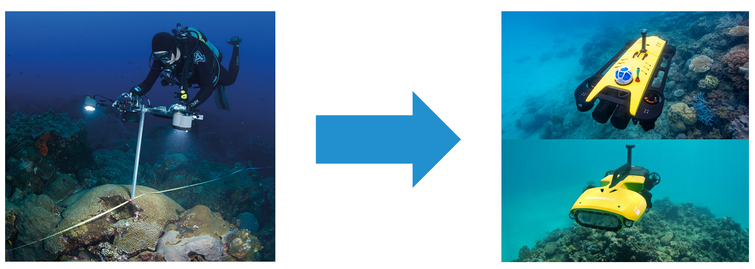
Abstract

Underwater ecosystem monitoring is crucial but challenging to automate due to the complexities of underwater imagery which hinder traditional visual methods. Our integrated **Visual Place Recognition (VPR)**, **feature matching**, and **image segmentation** pipeline enables robust identification of revisited areas and change analysis from **video-derived images**.

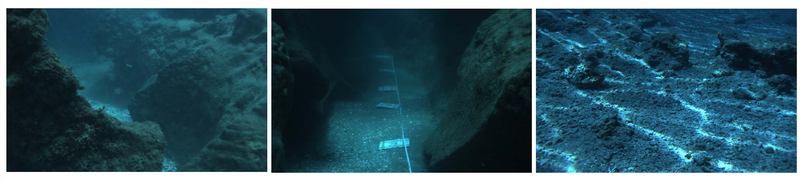
Furthermore, we introduce the SQUIDLE+ VPR Benchmark—a large-scale **underwater VPR benchmark** with diverse data from multiple robotic platforms.

Why Visual Place Recognition?

- VPR enables **effective, safe, and non-invasive monitoring** and conservation of vital yet threatened underwater ecosystems.



- Unique underwater conditions (turbidity, light attenuation, caustics, distortion) make reliable visual localization challenging.

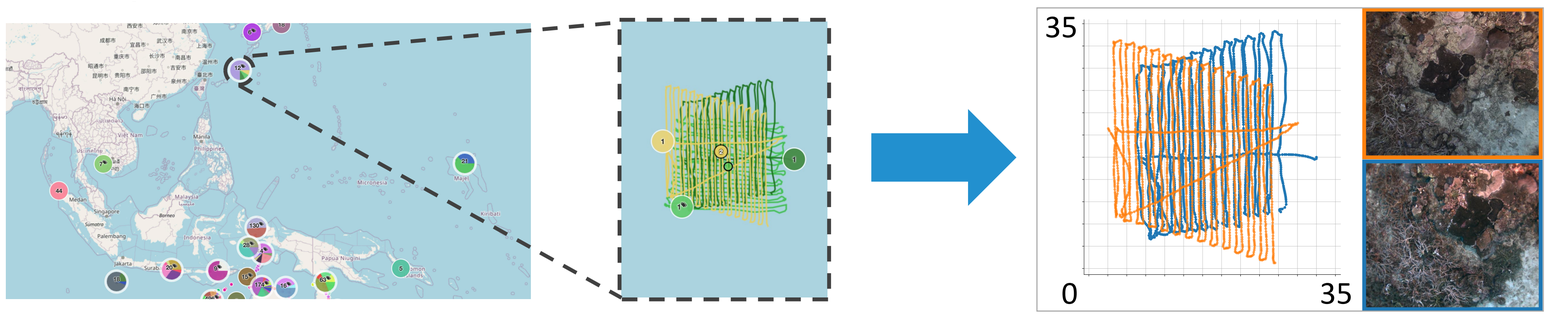


Turbidity | Light Attenuation | Caustics

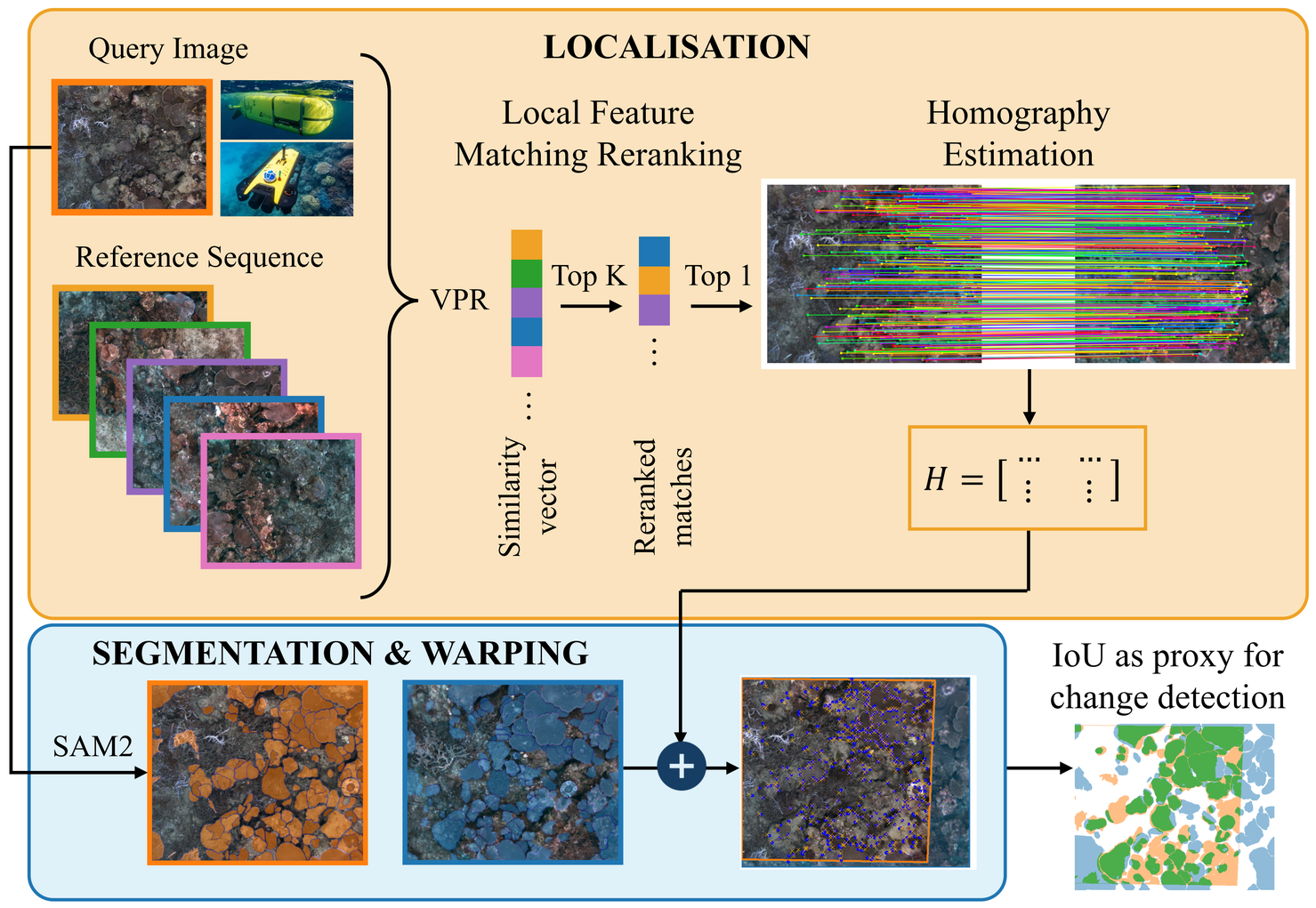
- Revisitation for tracking environmental changes and ensuring long-term ecosystem health.

SQUIDLE+ VPR Benchmark

- Current VPR benchmarks are largely based on terrestrial environments.
- We introduce a **new benchmark** for VPR in challenging underwater environments.
- 3 built-in sequences with code to **convert any SQUIDLE+ sequence** to our dataset format.
- Compatible dataset format with VSLAM Lab[1].



Technical Approach



UNDERLOC enables change detection using video streams from uncalibrated monocular cameras.

- VPR is used to find the **top K matches** per query.
- Matches are **reranked** and **filtered** using SuperPoint[2] keypoint correspondences and reprojection error.
- Semantic **segmentation masks** are extracted with SAM2[3] and **warped** using the homography matrix to enable change detection.

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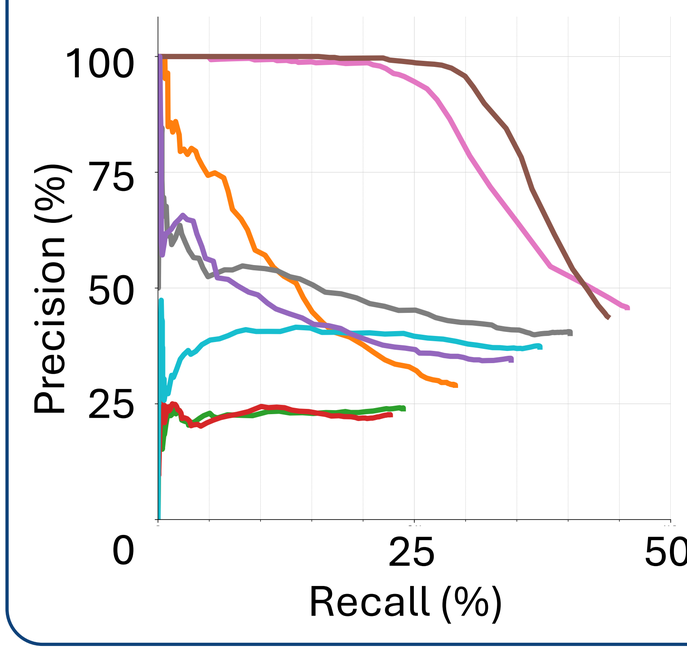
Results



- Our hierarchical method achieves comparable performance to brute-force matching with **x100 speedup**.
- Robust performance in challenging underwater scenes.

	AUC-PR	Time per Query (ms)
Superpoint Brute-Force	0.39	27150
MegaLoc + Superpoint (Ours)	0.38	275

MIXVPR — COSPLACE — NETVLAD — ANYLOC — MEGALOC — CRICAVPR — SUPERPOINT-B — SUPERPOINT-H

References

[1] A. Fontan, T. Fischer, J. Civera, and M. Milford, "Vslam-lab: A comprehensive framework for visual slam methods and datasets," arXiv preprint arXiv:2504.04457, 2025.

[2] D. DeTone, T. Malisiewicz, and A. Rabinovich, "Superpoint: Self-supervised interest point detection and description," in IEEE Conference on Computer Vision and Pattern Recognition Workshops, 2018, pp. 224–236.

[3] N. Ravi et al., "Sam 2: Segment anything in images and videos," 2024.

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