Optimizing Underwater Image Enhancement Algorithms Through HoloOcean Simulator

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DEMO VIDEO

INTRODUCTION

Challenges

- Underwater images suffer from light distortion, and color loss, which impact autonomous underwater vehicles (AUVs) to perform tasks such as navigation, and inspection.
- Testing image enhancement algorithms in real-world underwater environments is costly and logistically challenging due to environmental factors and limited access.

Our Approach

- Test and refine image enhancement algorithms using HoloOcean simulator.
- Allow us to optimize performance without the need for physical underwater access and reduce both cost and complexity.

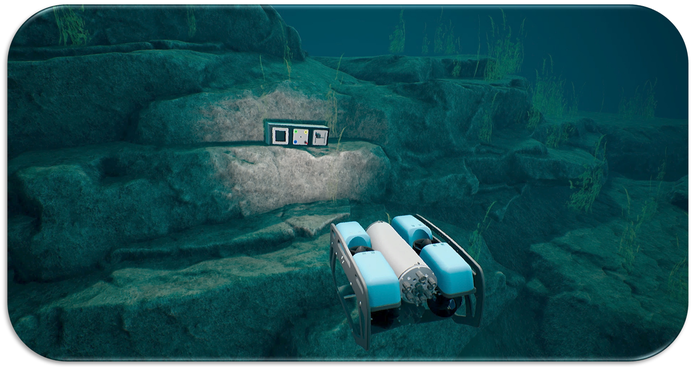


Figure 1. HoloOcean is an open-source underwater simulator, built upon Unreal Engine 4.

HoloOcean [1]

- Simulates realistic 3D environments with controllable conditions (turbidity, lighting, depth).
- Enables experiments without the need for real-world underwater access.
- Supports high-fidelity rendering of underwater physics and flexible API for diverse use cases.

METHODS

3D Environment

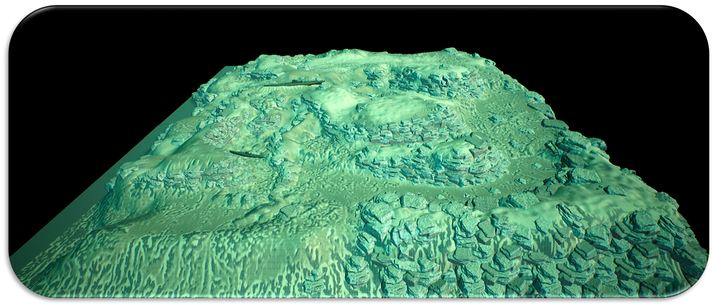
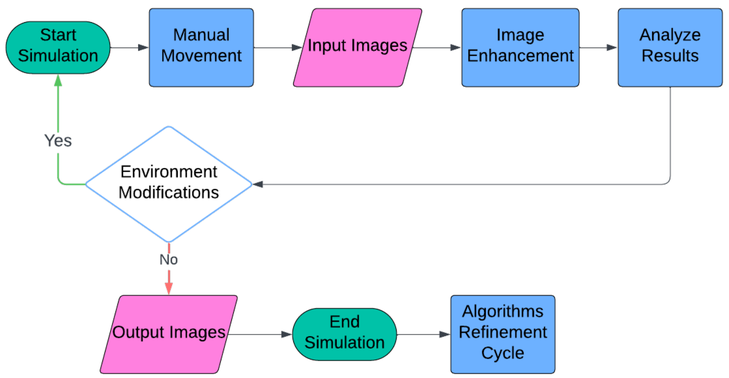


Figure 2. 3D terrain with turbidity and underwater lighting simulated.

Image Enhancement Algorithms

- URCST [2] captures both local and global dependencies to enhance images but is computationally intensive.
- FUnIE-GAN [3] is fast and efficient for real-time image enhancement.



Algorithms Refinement Cycle

- Image clarity and sharpness
- Color balance and restoration
- Noise reduction
- Detail recovery
- Performance in varied conditions
- Object features preservation

RESULTS

Figure 3. Output from HoloOcean with two image enhancement algorithms.

Conclusion

The flexibility of HoloOcean allows us to rigorously test and optimize image enhancement algorithms in ways that would be difficult and costly in real-world underwater environments.

Future Work

Further simulate underwater conditions and environments to test and refine algorithms.

REFERENCES

[1] E. Potokar, S. Ashford, M. Kaess and J. G. Mangelson, "HoloOcean: An Underwater Robotics Simulator," 2022 International Conference on Robotics and Automation (ICRA), Philadelphia, PA, USA, 2022, pp. 3040-3046.

[2] Z. Liu et al., "Swin Transformer: Hierarchical Vision Transformer us- ing Shifted Windows," in Proceedings of the International Conference on Computer Vision, 2021.

[3] M.J.Islam,Y.Xia,andJ.Sattar,"Fastunderwaterimageenhancement for improved visual perception," IEEE Robot. Autom. Lett., vol. 5, no. 2, pp. 3227-3234, 2020.

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