Big Eyes in the Ocean

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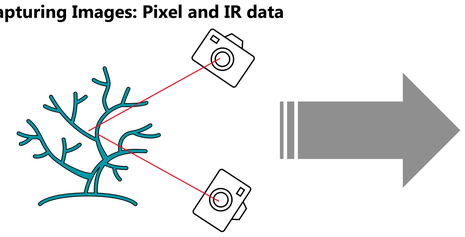
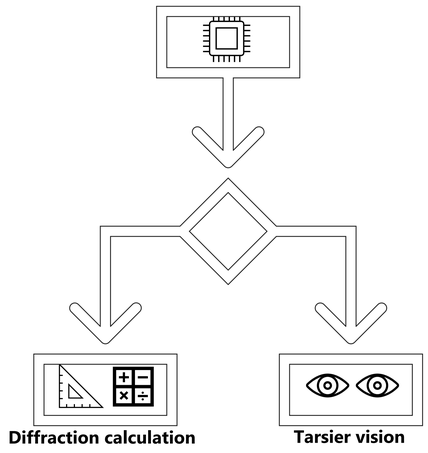
Abstract

Coral reefs are the central hub in supporting diverse marine life and are facing escalating threats from global warming and human activity. Reefs are important to human life as they provide protection from coastal storms and are a source of food and scientific insight. The increased need for motoring the life of reefs necessitates cameras capable of capturing reef conditions over time in shallow to deep water. This research proposes a novel approach of combining insights from the visual biology of tarsiers with previous work that created affordable depth cameras for high-fidelity imaging.

Capturing Images: Pixel and IR data



Computational Processing in MatLab



Tarsier Background

Tarsiers are remarkably small primates with a length of 9–16 cm and have the largest eye-to-head ratio of any mammal. Tarsiers' vision systems utilize their eye size to take in a large quantity of light allowing them to efficiently hunt insects in low-light conditions. [1][4]

Previous Research

Previous research at Disney Research Zurich found a method of modifying the software of low-cost depth cameras to create detailed 3D representations of reefs. The researchers created a calibration optimizer based on the refraction of the waterproof housing of the depth camera and the water. The first step in my research is ecreating the algorithm in MatLab. [3]

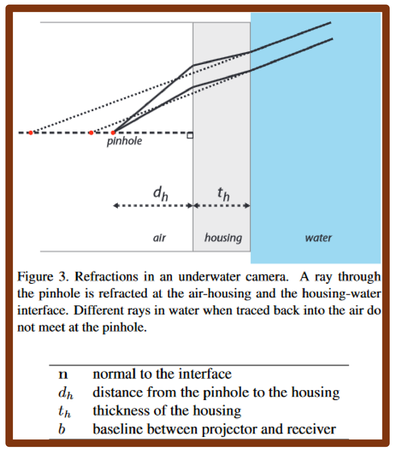


Figure 3. Refractions in an underwater camera. A ray through the pinhole is refracted at the air-housing and the housing-water interface. Different rays in water when traced back into the air do not meet at the pinhole.

$\mathbf{n}$	normal to the interface
d_h	distance from the pinhole to the housing
t_h	thickness of the housing
b	baseline between projector and receiver

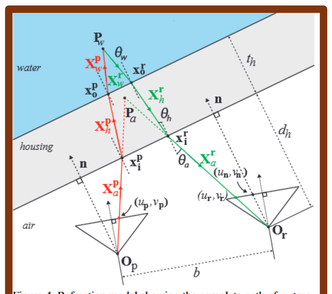


Figure 4. Refraction model showing the complete path of a structured IR ray in an Intel RealSense along with all model parameters. The ray starting from the projector is refracted multiple times before reaching the receiver.

Depth Optimization

Applying this heightened depth perception to ocean imaging cameras can help improve image quality at depth with low light. The standard the National Oceanic and Atmospheric Administration advises for reef research and restoration utilizes large-area imaging to create 3D topographic representations of the reefs using structure-from-motion software.[1][3]

Research Goal

The goal of this research is supplement previous work of low-cost depth camera through the creation of a color correction algorithm inspired by the tarsier's vison system. They are entirely carnivorousness mammals that hunt primarily at dawn and dusk. Their eye have evolve to track and differentiate objects in the low light conditions which are key components to coral imaging. Adapting this vision system to depth cameras can augment the resolution, accuracy, and cost-effectiveness of coral reef imaging. By contributing to more affordable reef imaging cameras, more communities can contribute to the comprehension and monitoring of coral reef ecosystems amidst mounting environmental pressures.

Citations

[1]
C. B. Edwards *et al.*, "A Guide to Large-Area Imaging for Coral Reef Monitoring, Research and Restoration," *Coral Reef Information System*, 2023. https://www.coris.noaa.gov/activities/lai_guide/welcome.html (accessed Mar. 08, 2024).
[2]
Britannica, The Editors of Encyclopedia Britannica, "tarsier," *Encyclopedia Britannica*. Britannica, Sep. 21, 2023. Available: https://www.britannica.com/animal/tarsier
[3]
S. T. Digumarti, G. Chaurasia, A. Taneja, R. Siegwart, A. Thomas, and P. Beardsley, "Underwater 3D Capture Using a Low-Cost Commercial Depth Camera," Mar. 2016, doi: https://doi.org/10.1109/wacv.2016.7477644.
[4]
M. Simon, "Absurd Creature of the Week: The Tiny Primate That Was Probably the Inspiration for Yoda," *Wired*, Jan. 09, 2015. https://www.wired.com/2015/01/absurd-creature-of-the-week-tarsier/