

## Depiction of Coral reefs Through Advanced 3D Photogrammetry

Matan Yuval, MSc project

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Coral reefs are built mostly by colonial organisms of the phylum Cnidaria. As ecosystem engineers, and pioneers in an oligotrophic oasis, the habitat created by their growth modulates the availability of resources to a wide variety of organisms. Photosynthetic algae reside within the coral animal host, and this symbiosis is susceptible to ocean acidification and rising sea temperatures.

In coral reefs, complex structural topography correlates with species diversity and richness. Nevertheless, corals themselves exhibit complex 3D structures which pose a major challenge in the measurement of their structural complexity and attributes such as live cover.



Photogrammetry is the science of making measurements from images and it can be harnessed to measure the correlation between fine-scale bathymetric structural complexity and biodiversity.

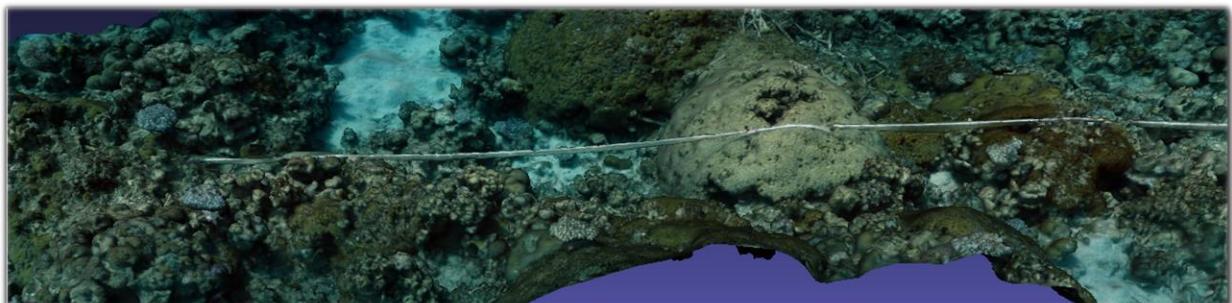
Matan Yuval proposes to utilize Structure from motion (Sfm), a photogrammetric method that uses triangulation to estimate 3D scene structure.

Using a system composed of a stereo camera set mounted on a Diver Propulsion Vehicle (DPV) and an Autonomous Underwater Vessel (AUV) with custom machine vision cameras and strobes, the research team aims to create high definition, real color and texture 3D maps of the coral reef.

Matan Yuval's working hypothesis is that the temporal dynamics of benthic structures along a depth gradient can be studied through the creation of wide-scale, highly detailed, underwater map models followed by survey repetition in predefined locations of interest (<https://vimeo.com/283278894>).



Furthermore, he speculates that a wide spatial resolution combined with a fine taxonomic genus specific semantic segmentation ability will allow researchers to reveal significant and never-before-seen patterns in coral reef ecology, distribution, and connectivity.



Study site: 140 m<sup>2</sup> reef section at the Japanese Garden Site, Eilat, Israel

# Advanced 3D Photogrammetry in Epibenthic Community Structure Surveys



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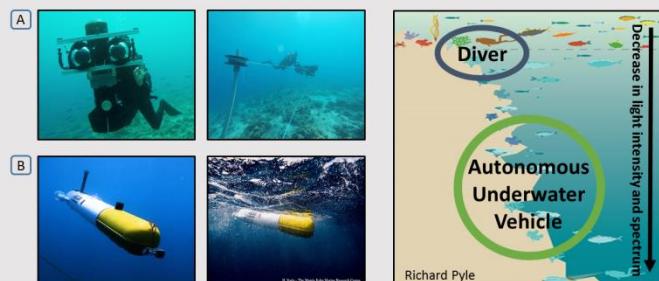
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## Introduction

A protocol that integrates coral reef ecology and computer vision. Using a system composed of a stereo camera-set mounted on a Diver Propulsion Vehicle (**A**) and a hovering class Autonomous Underwater Vessel (AUV) SPARUS II (**B**), photogrammetry can be applied to examine specific hypothesis in coral reef connectivity, distribution, and ecology.



## Methods and Results

### Image Correction

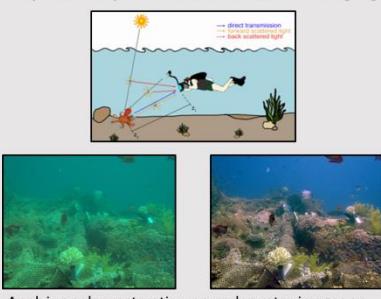
#### Challenges

- Bad visibility and contrast
- Illumination and range issues
- Color distortion

#### Solutions

- Color correction
- Backscatter reduction

### Physical Properties of Underwater Imaging [1]



Applying color restoration on underwater images [2]. Before (left) and after (right).

### Structure From Motion Photogrammetry

Input: A sequence of 2D images

Output: Relative motion and 3D structure



900 consequent images (A) were used to reconstruct a 110m<sup>2</sup> (B)

### Automatic Coral Colony Classification

An ortho-mosaic image (A) is broken into segments (B), annotated, and reformed.



## Conclusions and Future Plans

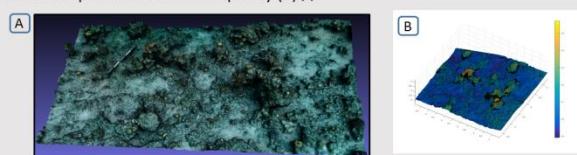
### Wide Scale Abilities

The study site at the interuniversity Institute for Marine Sciences (IUI), Eilat, Israel.



### Spatial Metrics

Metrics can be derived from a 3D map model. Functional morphology (**A**) can be coupled with terrain complexity (**B**) [3].



### Genus Specific Resolution

A 3D mesh and texture with a 1m long scale bar. Community structure can be systematically described.



### Availability

3D map models are made widely available on online platforms.



1. Akkaynak, Denya, et al. IEEE, 2017.  
2. Berman, Diana, Treibitz, Tali, and Avidan, Shai. BMVC, 2017.  
3. Friedman, Arieli, et al. PLoS one 2012.

