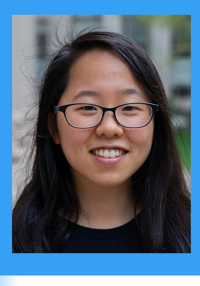
Holographic Microscopy Drifter for Monitoring the Health of Aquaculture Microbiome



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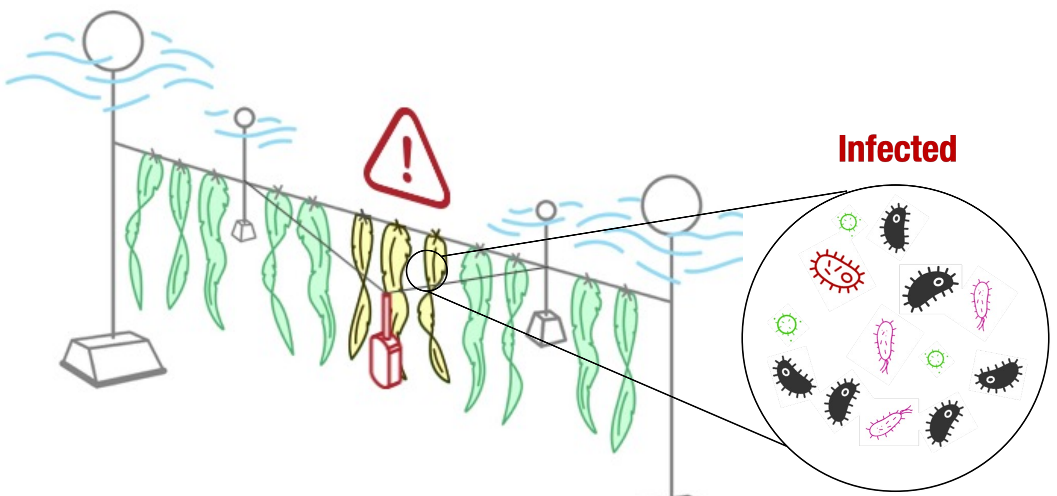
Project Overview

Seaweed aquaculture has the potential to feed the world, fight climate change, and restore our ocean. Microbiome population and diversity are indicators of the health and resilience of the seaweed ecosystem[1]. We are developing a machine learning based aquaculture monitoring and response system that uses microbiome data to predict and prevent disease.



Scalable in-situ
real-time monitoring system
Concept design of the monitoring system

Methodology

Scalable low-cost aquaculture microbiome & environment monitoring system

- in-situ digital in-line holographic microscopes (DIHM) for monitoring microbiome
- environmental sensors (temperature, salinity, pressure, optical)
- machine learning network for Holographic image reconstruction combined with particle sorting and counting algorithm

Output:

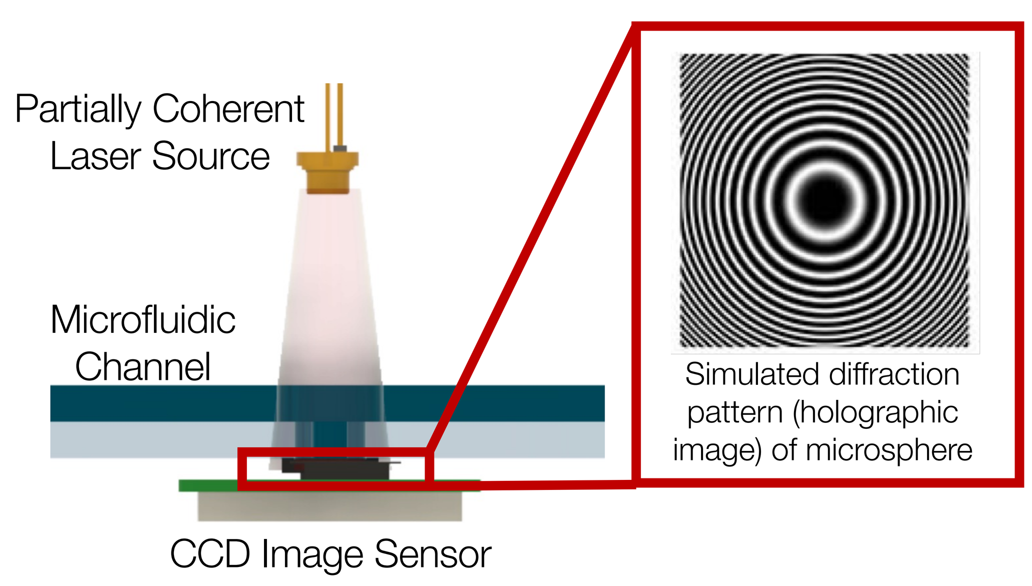


Fig 1. Schematic of DIHM. Coherent light illuminates an object and forms a highly magnified diffraction pattern captured by the image sensor. The 2D intensity image records the whole information of the 3D scene. The object's complex wavefront is hidden in the diffraction pattern

Assuming the laser distance is an infinite distance away, the image sensor intensity is

$$I(x, y) = |P_z[U(x', y')]|^2$$

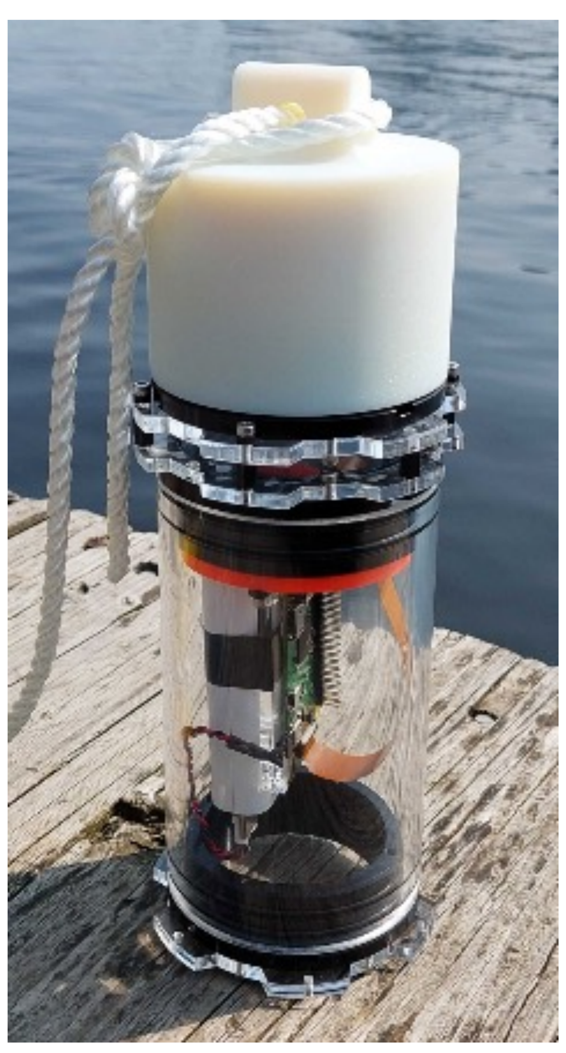
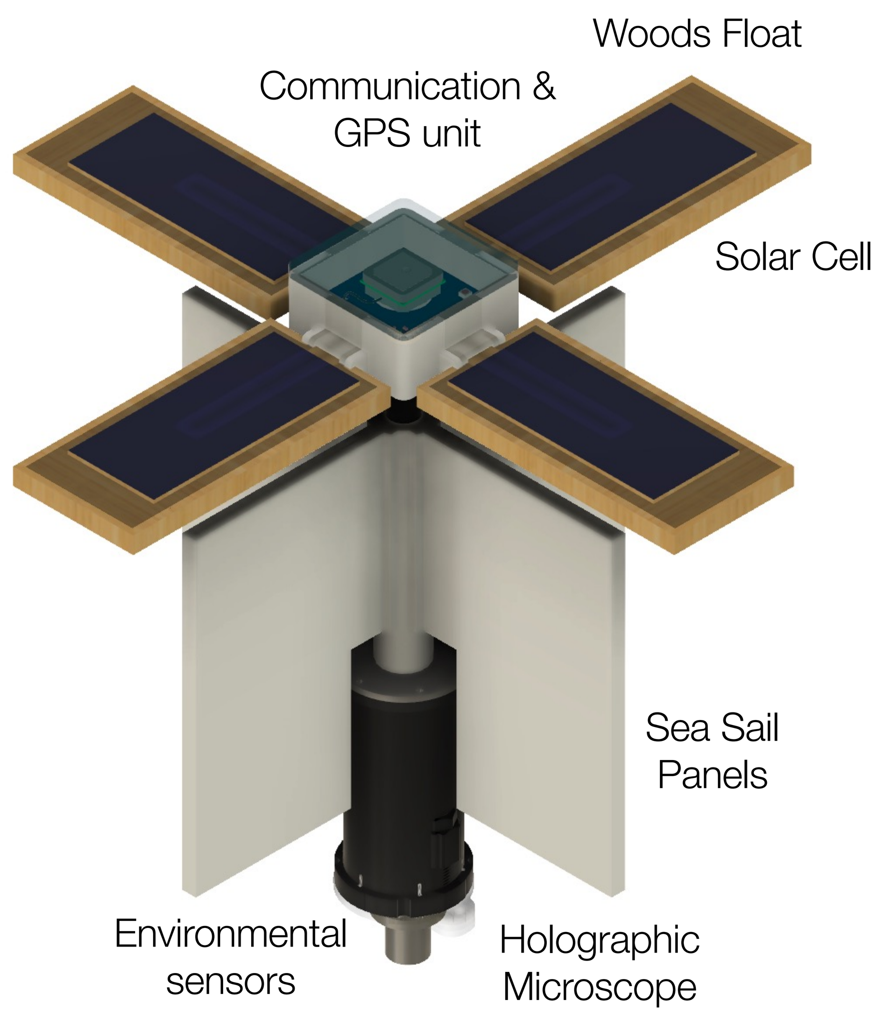


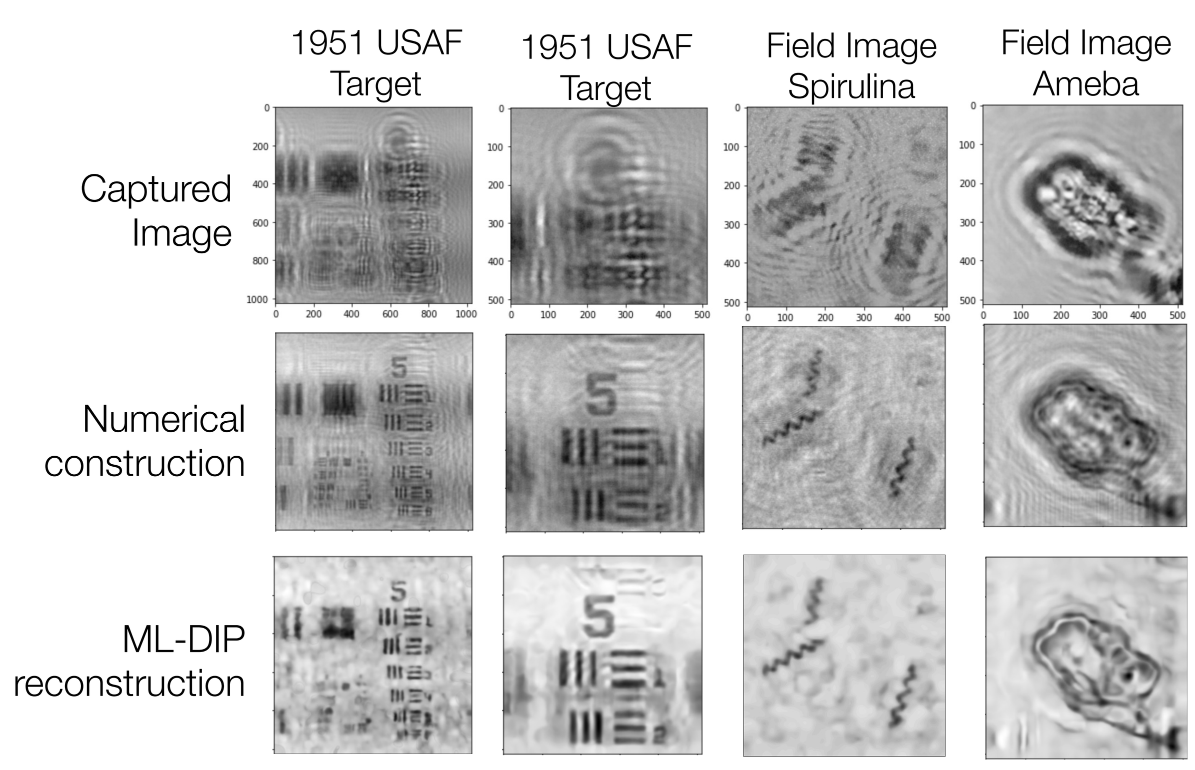
Fig 2. Prototype of underwater DIHM

where $U(x', y')$ is the complex sample transmittance and P_z is the angular spectrum propagator. The challenges of solving for U from I are the lost phase information, twin image artifact and noise. We explored numerical methods and ML deep image prior based (ML-DIP) methods[3] for holographic image reconstruction.

Design & Result



The drifter is inspired by CODE drifter[4] and aims to perform as an inexpensive lagrangian drifter. The cylindrical housing contains batteries and the sensor modules. Solar cells are attached to the wooden floats for recharging. Cellular communication and GPS units are positioned above the water line. The removeable sea sail panels allows the drifters to follow the surface water current if needed.



ML-DIP reiterative reconstruction method recovers the amplitude and phase information and suppresses the twin image and noise artifact. Resolution of 7.8um is achieved with the imaging system.

Deployment

Collaborate closely with our partner seaweed farms, a network of microbiome sensors will be deployed to monitor and predict parasitic snail invasion. The success of the deployment is determined by the reliability of the physical monitoring system to accurately monitor the microbiome population and distribution. In addition, lead by the Portugal team, the sensor system will be deployed to study the effect of the microbiome on coral reef biofilm and resiliency.

US & Portugal Partner Companies

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References:
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