In situ agriculture & aquaculture microbiome monitoring using scalable optofluidic microscopy

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Motivations & Goal

Microbes is critical in

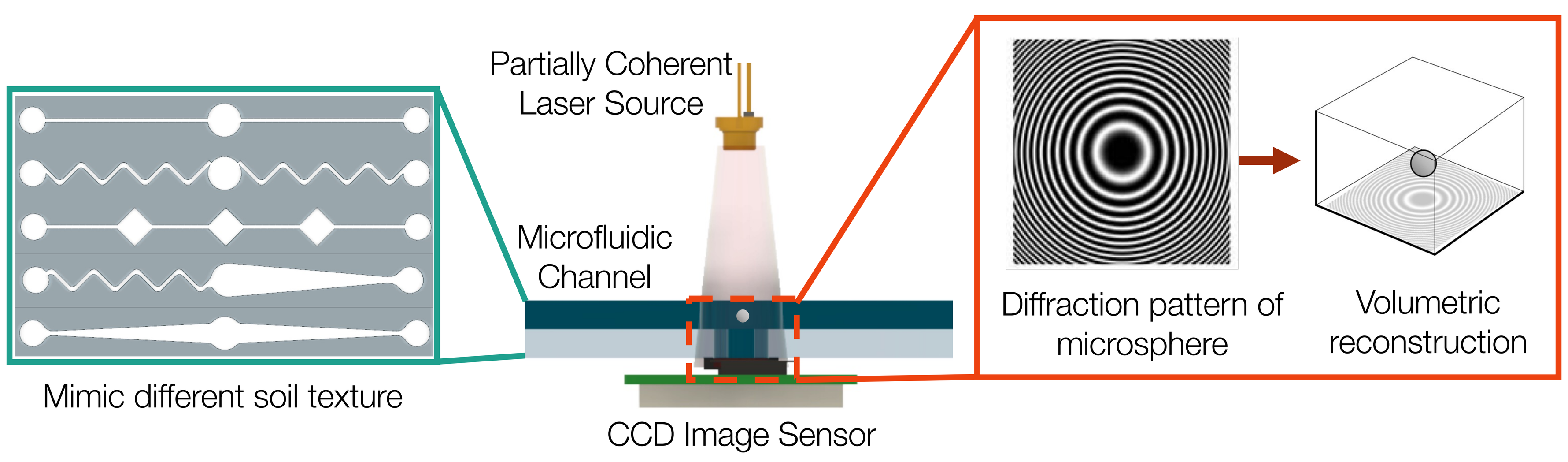
- Global nutrients cycles
- Plant & animal life stability & resiliency
- Land-ocean-atmosphere carbon exchange

Yet it is one of the biggest unknown in global climate change. Understanding and predicting the impact of climate change on microbiomes and the ecosystem services they provide present a grand challenge and major opportunity.

We are developing a real time in-situ continuous microbiome monitoring system using holographic microfluidic microscopy for aquaculture & agriculture resiliency.

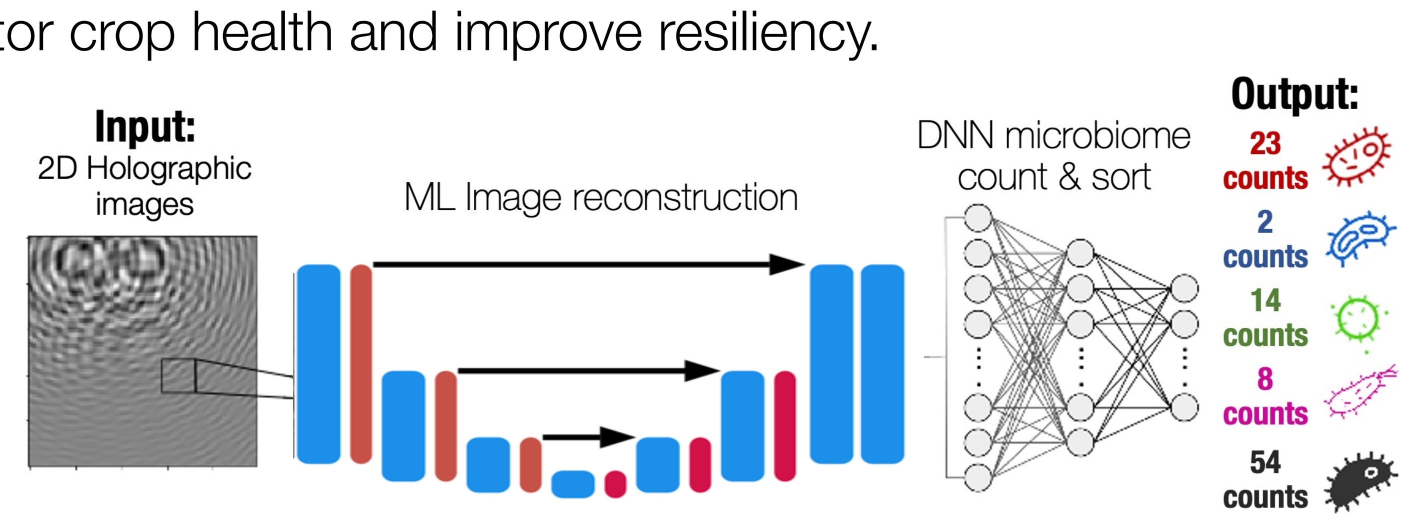
Methodology

Optofluidic microscopy combining lens-free in-line digital holographic microscopes (DIHM) with microfluidic channels for microbes filtering. Scalable design enable higher spatial resolution.



Schematic of DIHM. Coherent light illuminates an object and forms a highly magnified diffraction pattern captured by the image sensor. The 2D diffraction pattern captures 3D information.

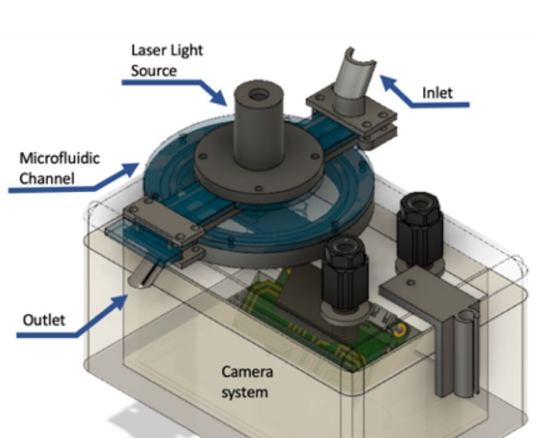
Deep Neural Network for image & volume reconstruction and estimate microbe population distribution. Data collected can be synthesize to monitor crop health and improve resiliency.

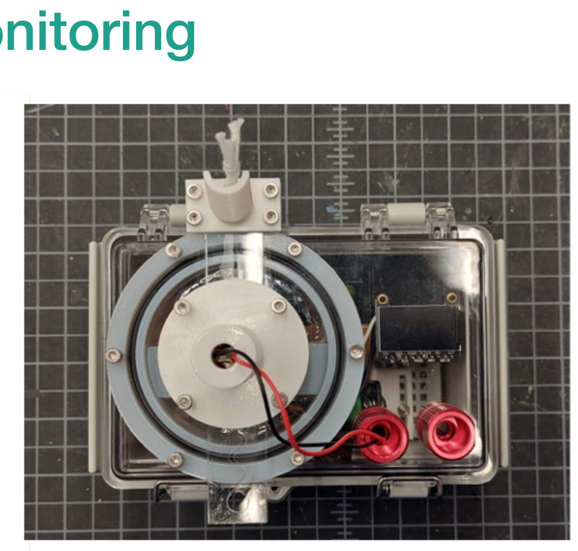


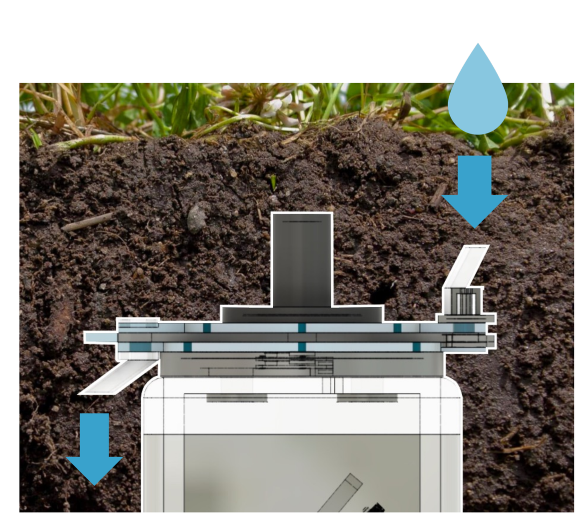
The monitoring system is designed for a network of optofluidic sensors and continuous week-long, in-situ monitoring.

Progress

Soil Microbiome Monitoring







1. Bury the sensor under the soil
2. Rain & irrigation carries the microbes through the channel
3. Capture diffraction image of the microbes as they flow through

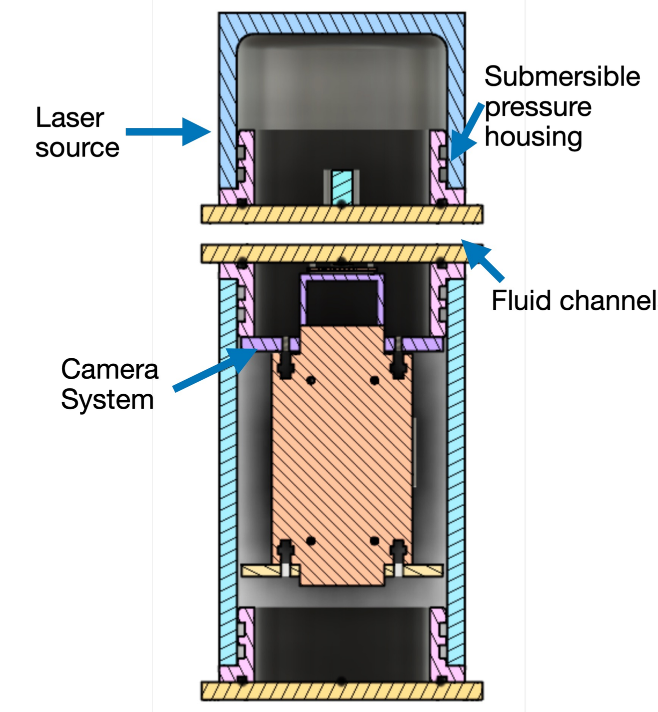
Progress

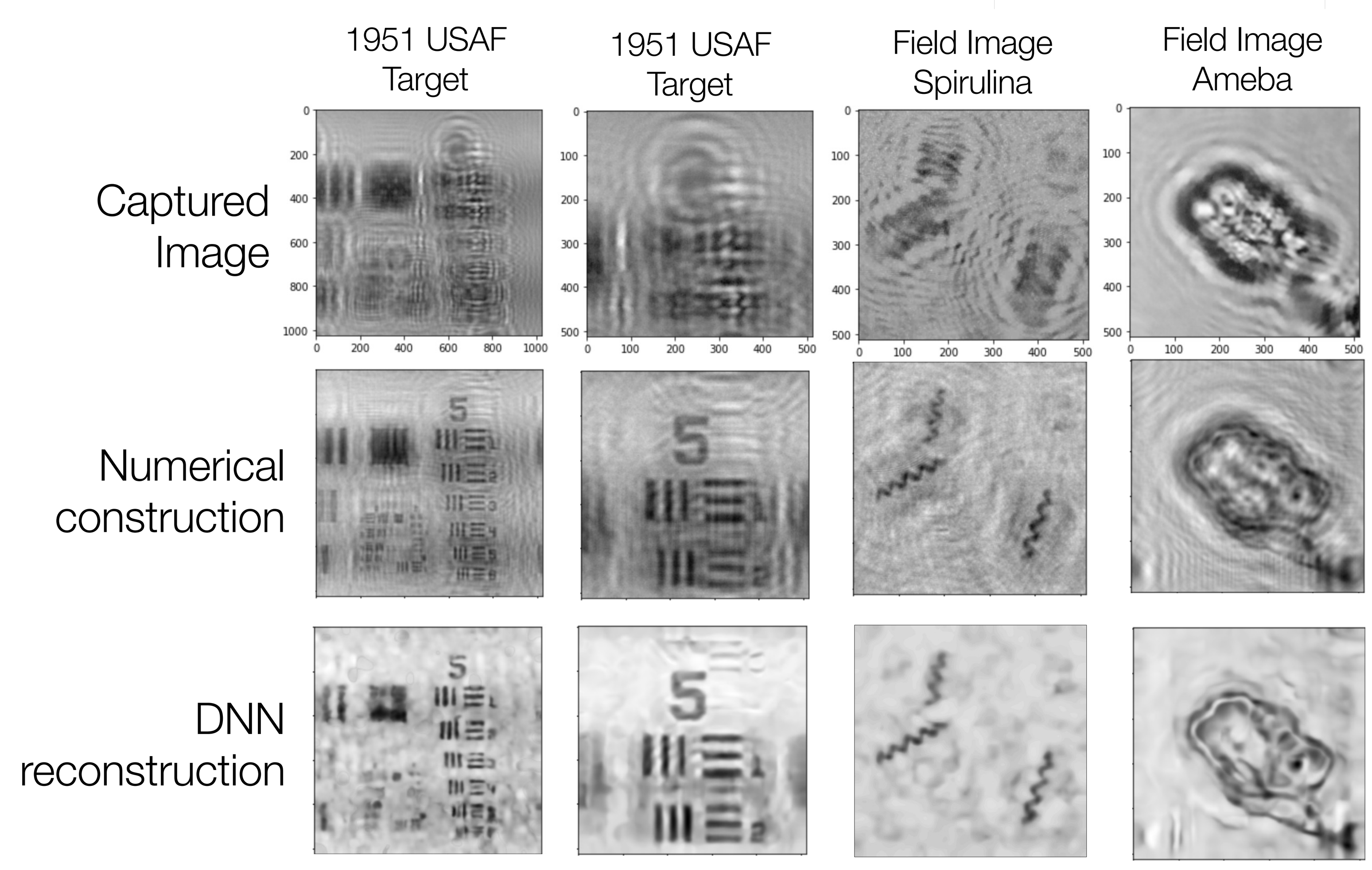
Marine Microbiome Monitoring

Submersible up to ~300m.

Achieved resolution of down to 6um

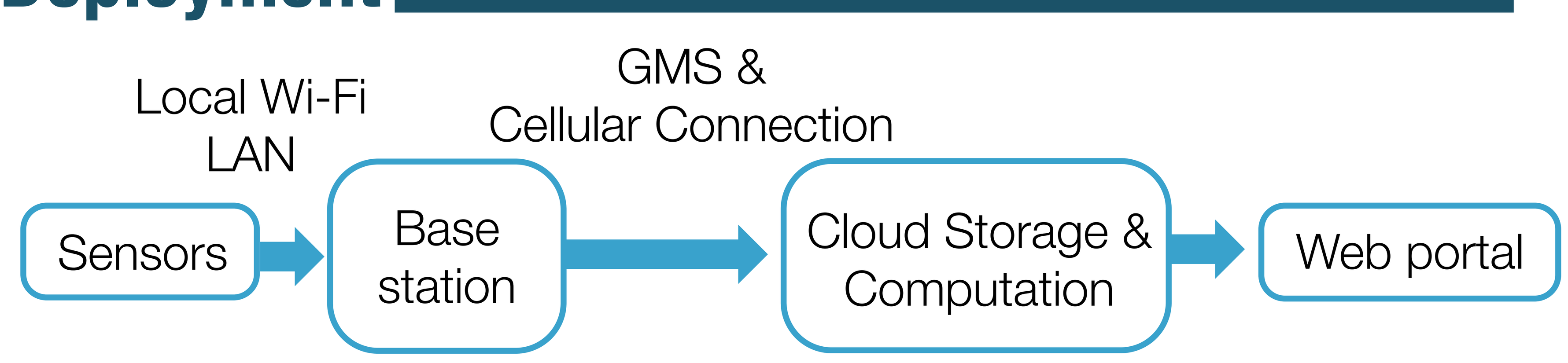
Frame rate up to 24/sec. With 1 image per 5 minutes, the system can last up to3 days.



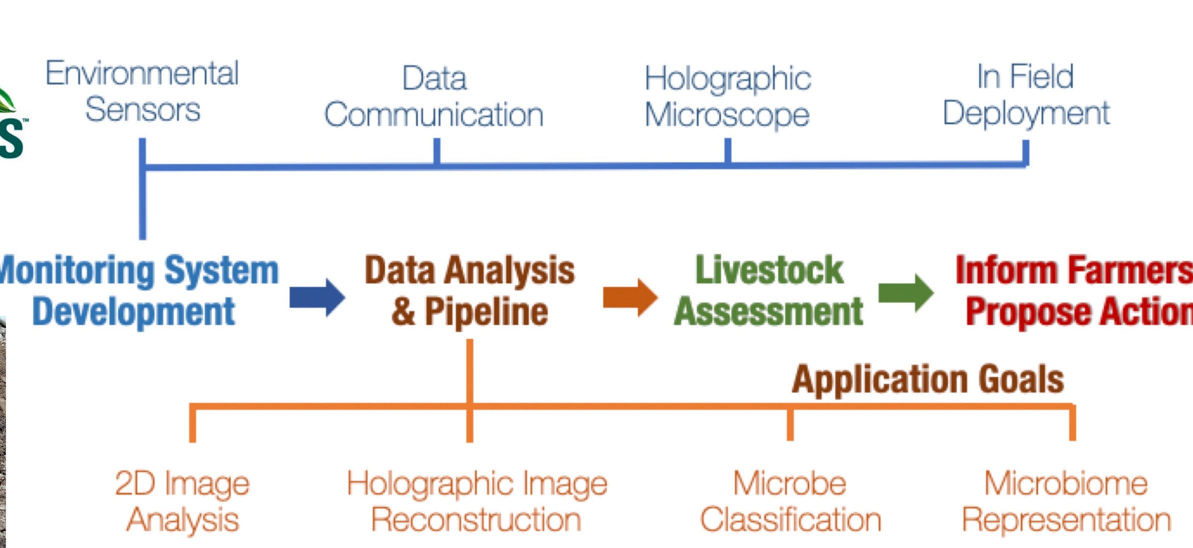


Next step is to reduce reconstruction computation resources and improve speed. Another network will be used to evaluate microbiome population and potentially infer health of crop.

Deployment



We partner with local agriculture farm and seaweed aquaculture farms for deployment and testing.



The novel opto-fluidics monitoring system will further contribute to the modeling and understanding of microbes' activity in the environment and the health of our planet.

References:

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