Lucendi

What's in your water?

We know!

Lucendi

AI-enabled smart measurement systems

founded in 2016

UCLA Ozcan Research Group – Birthplace of our technology

NSF

NATIONAL INSTITUTES OF HEALTH

DEPARTMENT OF THE NAVY ONR Science & Technology

SCIENCE TO SHAPE THE FUTURE OF THE ARMY — ARMY RESEARCH OFFICE 1951

DEPARTMENT OF DEFENSE — UNITED STATES OF AMERICA

HHMI HOWARD HUGHES MEDICAL INSTITUTE

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BILL & MELINDA GATES foundation

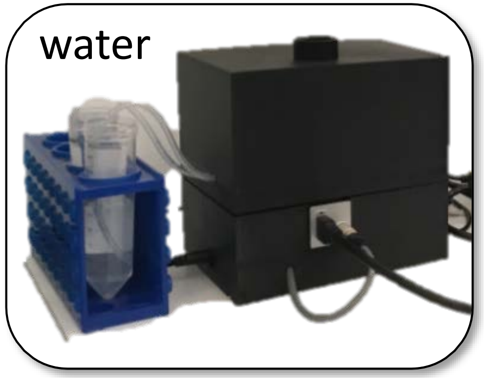
Vodafone Americas Foundation™ Wireless Innovation Project™

NATIONAL GEOGRAPHIC™

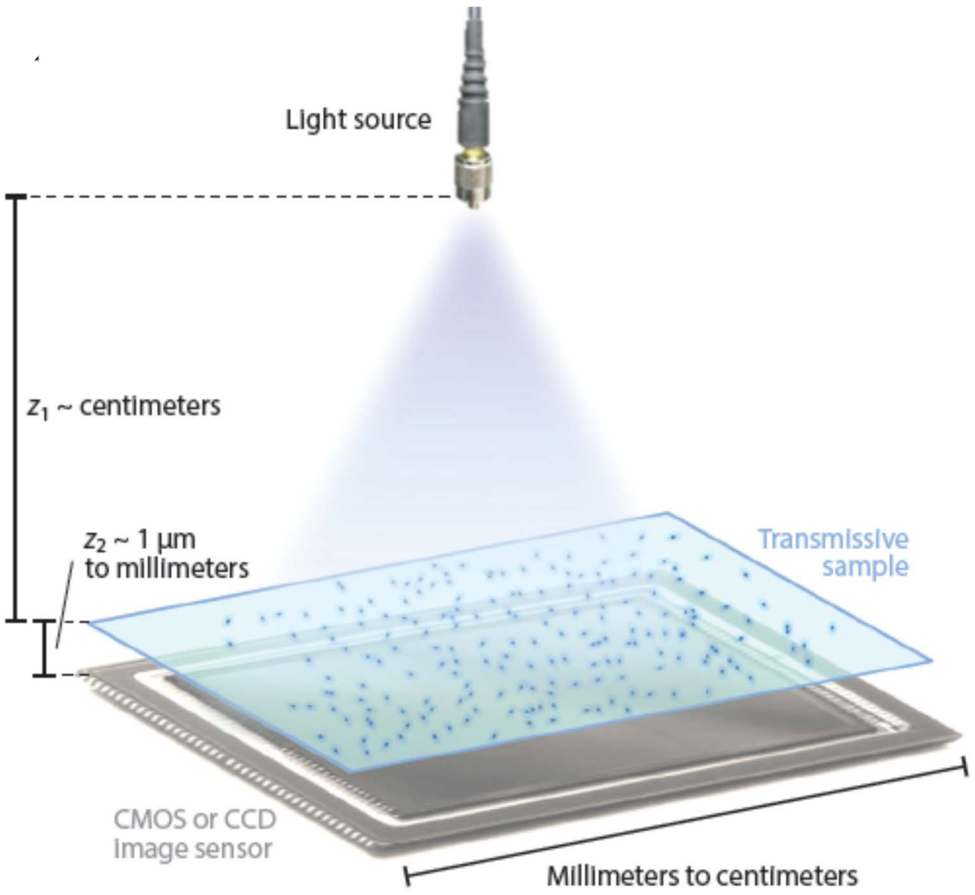
Google

Lucendi Platform Technologies

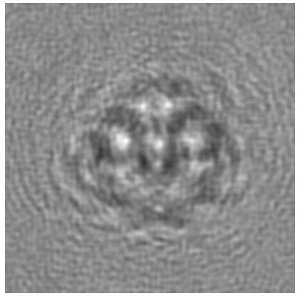
- Core components of our technology platform:
  - Lens-free computational imaging devices:
    - Static and flowing samples
    - Different sample media (i.e. water, air, bodily fluids)
    - High-throughput
    - Resolution of **1 micron** and above **with flowing samples**
    - Can achieve **sub-micron resolution** with static samples
  - AI-based big data algorithms:
    - Deep Learning for image processing
    - Micro-object classification through Deep Learning and classical machine learning algorithms (e.g. SVM)
- Lucendi devices are constructed with existing and verified mass-produced components and, therefore, are low-cost, reliable and robust
- Can replace many existing microscopy solutions and sensor modalities across many applications



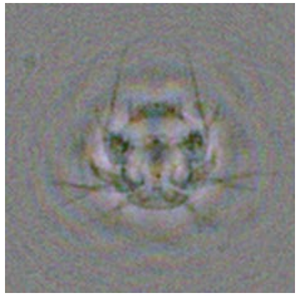
Lens-free computational principles: Digital Holography



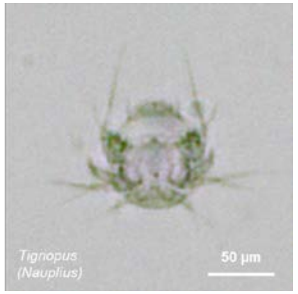
Hologram intensity



Reconstructed phase contrast image

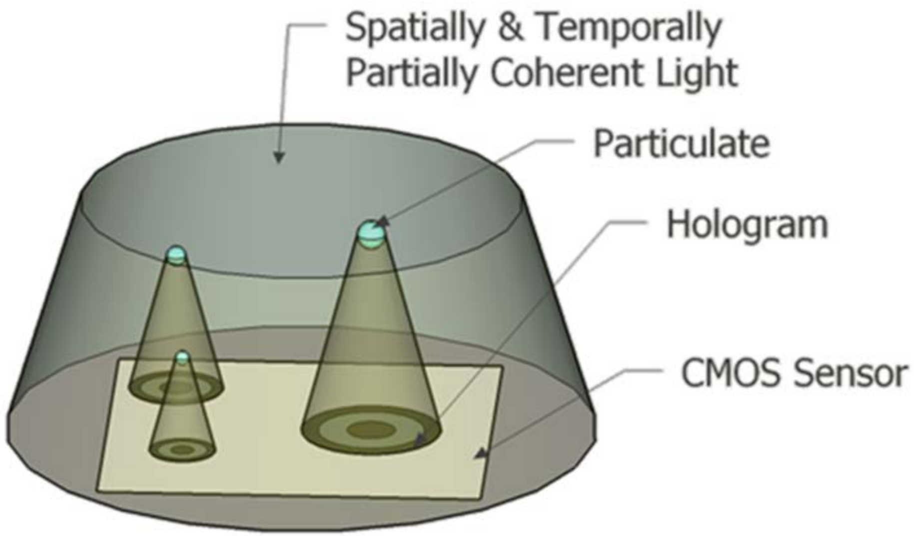


Recovered phase contrast image

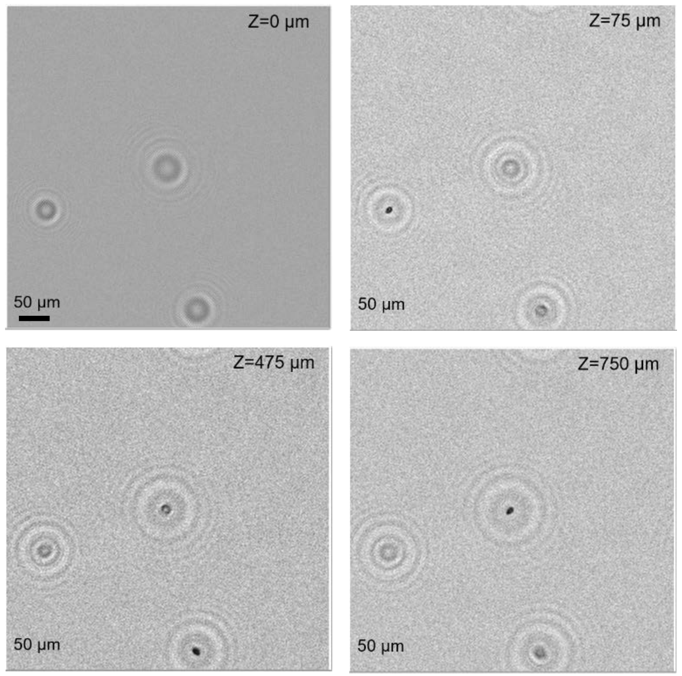


- (Partially) coherent light source illuminates a transmissive sample
- The light scattered by the objects interferes with the non-scattered light, generating a circular interference pattern (i.e. a hologram) for each object
- Applying light field propagation, it is possible to retrieve **phase** and **amplitude** images of the light field at the sample's plane
- Typical steps:
  - Image pre-processing
  - Reconstruction (amplitude and phase)
  - Phase recovery

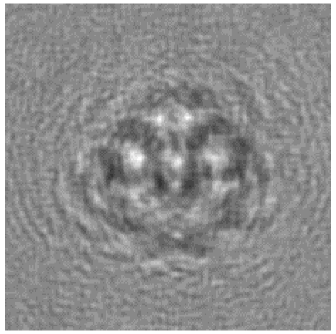
Advantages of digital holography



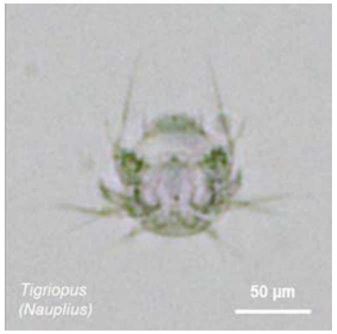
- Trading optical/mechanical for computational complexity
- Provides large space-bandwidth product (large FOV and high resolution)
- Cost-effective and portable
- Depth-resolved 3D imaging
- Supports color imaging
- Supports volumetric imaging (focusing on different heights of sample plane)

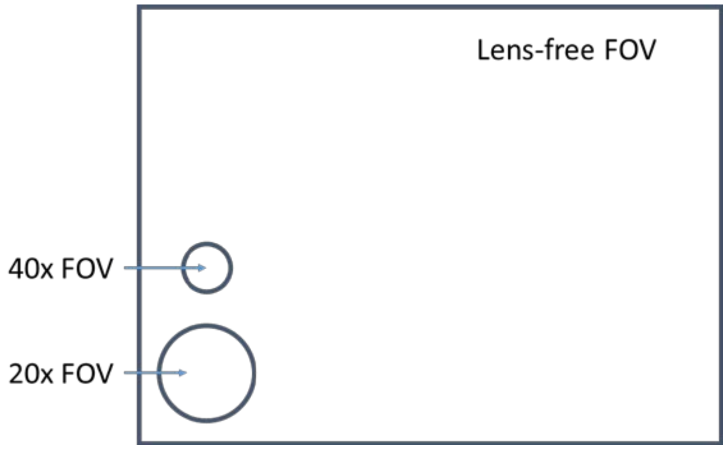


Hologram intensity

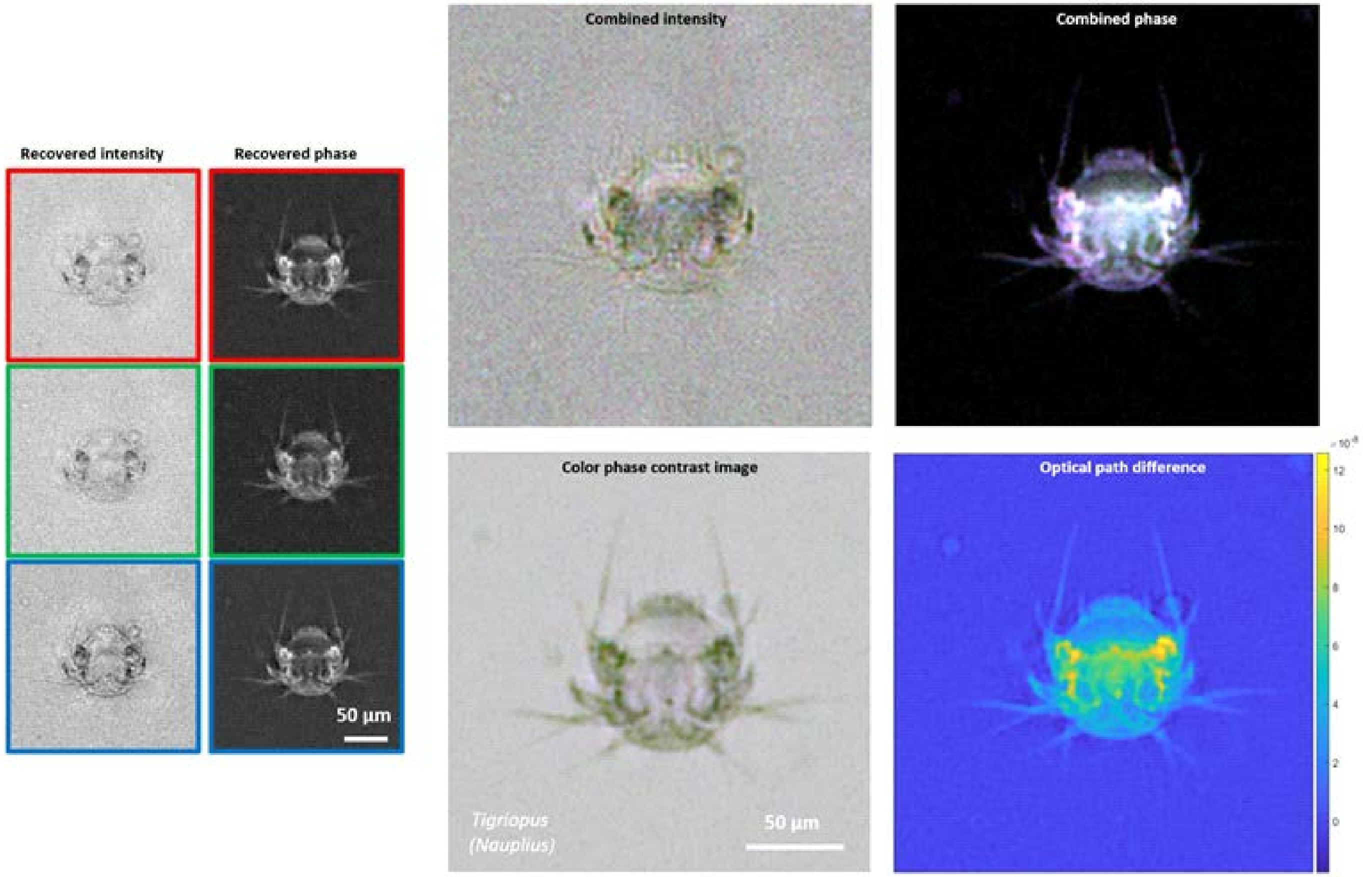


Recovered phase contrast image





Advantages of coherent imaging by Aqusens



- For every object in FOV, we capture not just intensity, but also phase information in each of the red, green, and blue color channels
- Transparent parts of an object are not visible in the conventional bright field (combined intensity) color image, but due to the mismatch of refractive index between the exoskeleton and the surrounding water, it becomes visible in phase
- We can also compute
  - a phase contrast image (fusing intensity and phase)
  - a high contrast color image of the object
  - the optical path length, which contains information of the thickness and refractive index distribution of the object

Aqusens: Micro-object characterization in flowing liquids

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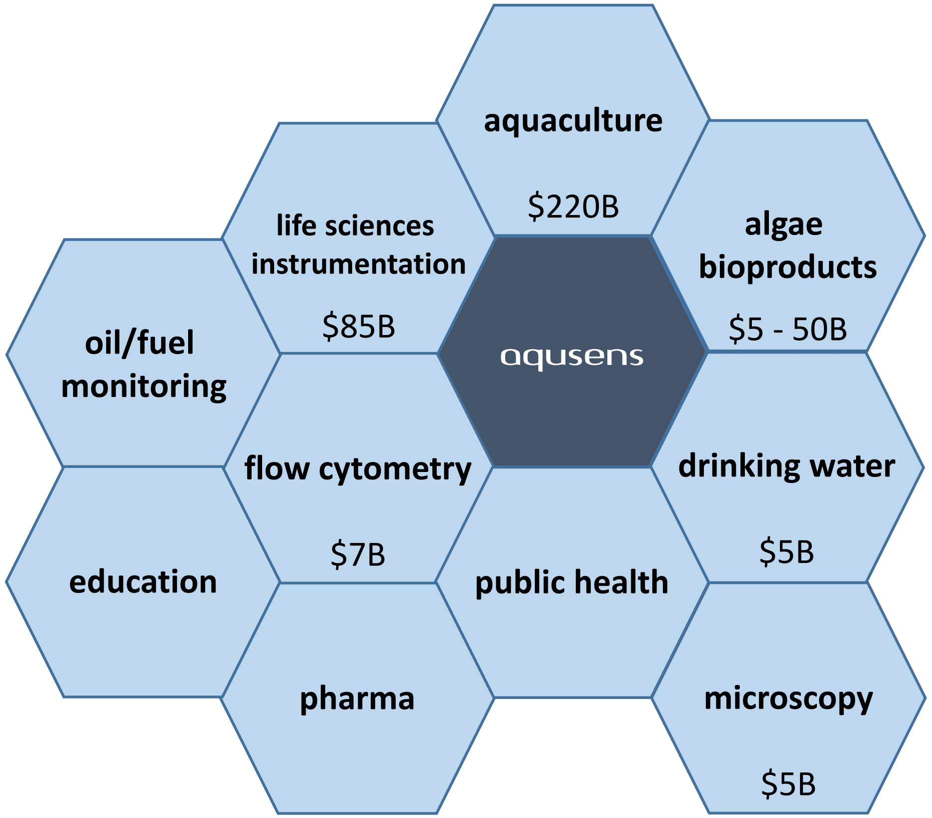
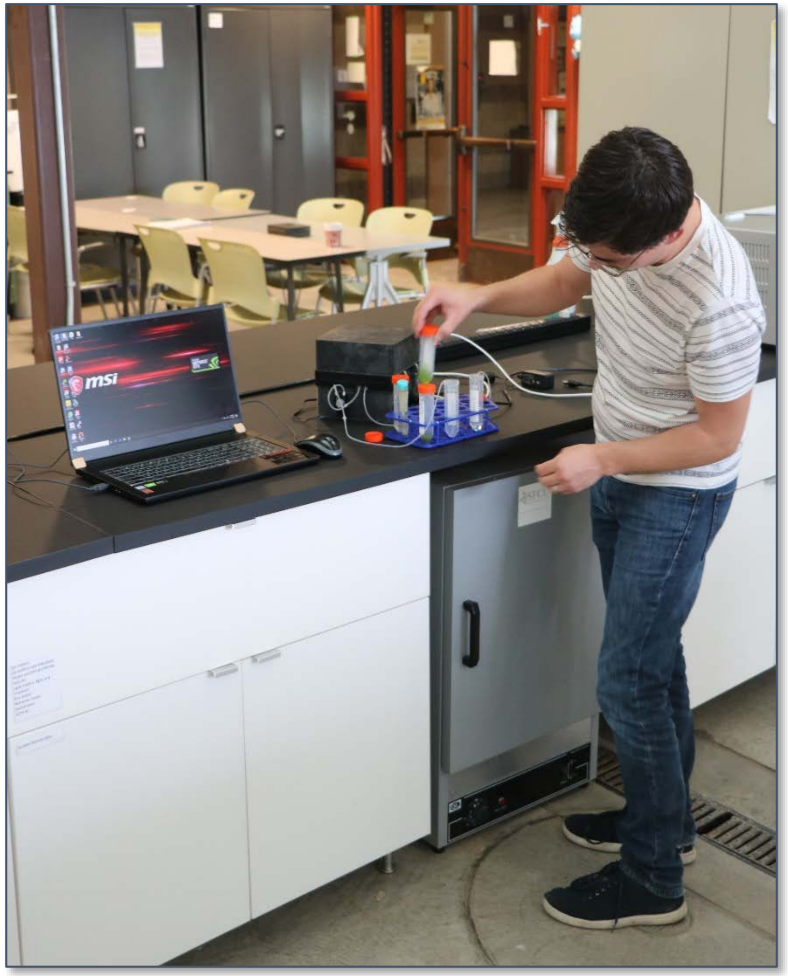
Aqusens: Platform for micro-object identification in liquids



- **Aqusens:** High-throughput quantitative imaging-flow cytometry with AI-based characterization
- Widely applicable and simple adaptation for new markets
- Near term focus on the following markets:
  - Aquaculture
  - Water monitoring (microplastics and other pollutants)
  - Algae bioproducts
  - Life sciences instrumentation
- Existing approaches
  - Laboratory evaluation based on optical microscopy
  - Automated systems based on light scattering technology
  - Optics-based flow cytometers
- Current approaches limitations
  - Expensive (over $60K)
  - Low-throughput
  - Require expertise to operate (and additional costs)
  - Accuracy concerns
  - Not capable of object classification

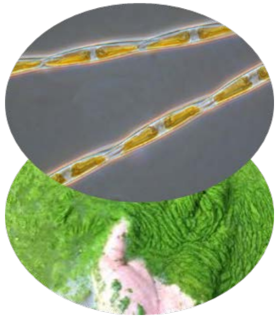
Aqusens device



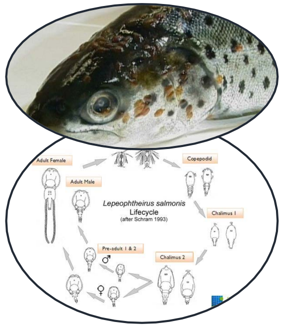
- Cost-effective liquid sample monitoring system using digital holography and machine learning
- High-throughput:
  - Default 100 mL/h at 3 fps,
  - Tested at 1L/hour (can be increased)
- Field-portable
  - Weight: ~1.5 kg,
  - Dimensions: 19cm x 19cm x 16cm
- Resolution of ~**1-2 microns with flowing samples**
- Able to distinguish objects 4µm – 1mm (adjustable)
- Detailed particle characterization (i.e. morphology, color, etc.)
- Characterization of phase to estimate internal structure, lipids content, etc.
- Optional modules for bulk fluorescence and polarization imaging
- Automated detection of biological microobjects and particles of specific type via Deep Learning

Aqusens use case examples

- Platform for micro-object identification and characterization in flowing liquids coupled with AI algorithms
- Currently developing platform versions for specific applications:
  - Monitoring and identification of potentially dangerous microorganisms in aquaculture
    - Harmful algae
    - Dangerous pathogens (i.e. sea lice)
  - Optimizing algae-based bioproducts/biofuels production
    - monitoring and characterization of cultivated algae (i.e. growth patterns, lipids content, etc.)
    - identification of invasive/predatory microorganisms in dense samples
  - Identification and characterization of microplastic particles in water
  - Advanced particle counter (including identification of *Giardia* and *Crypto*)

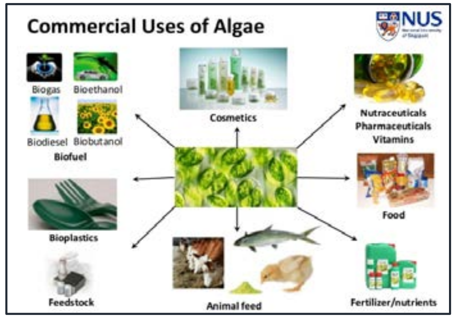


toxic algae and research

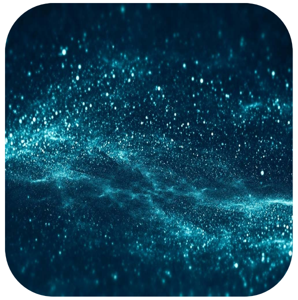


dangerous microorganisms

microplastics



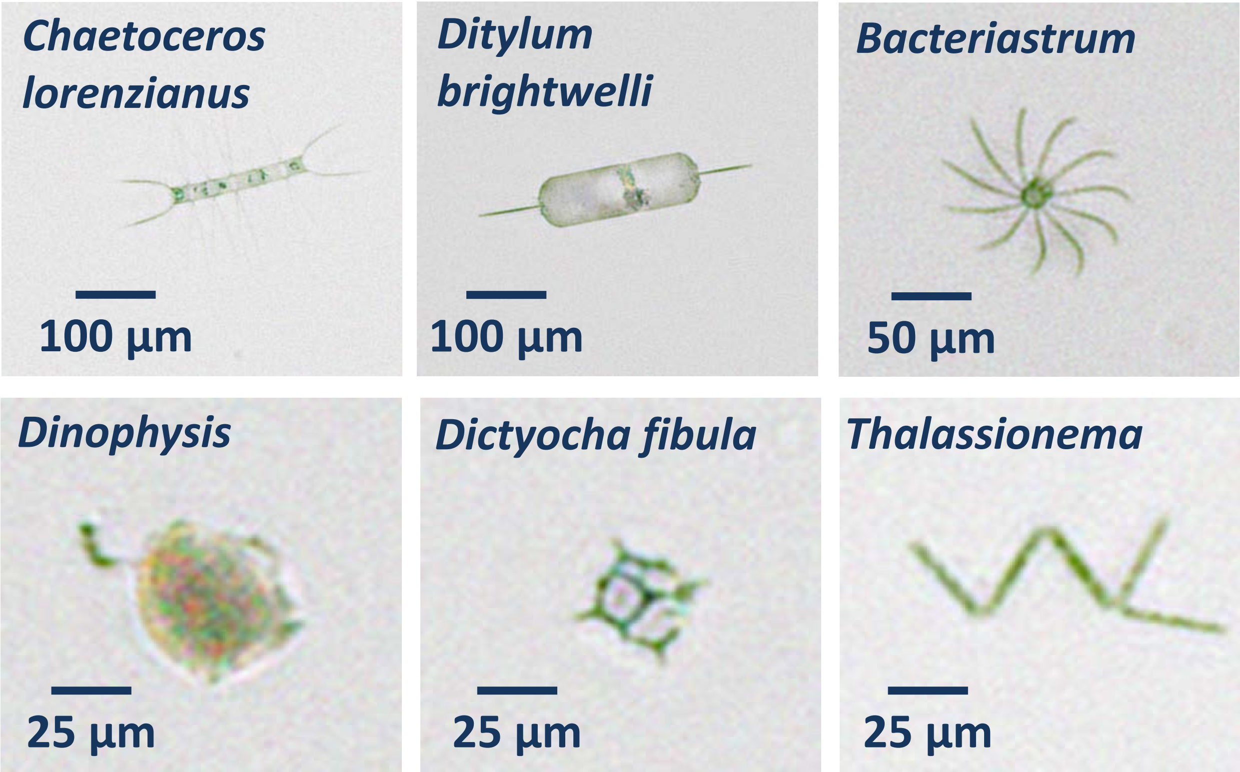
algae for bioproducts

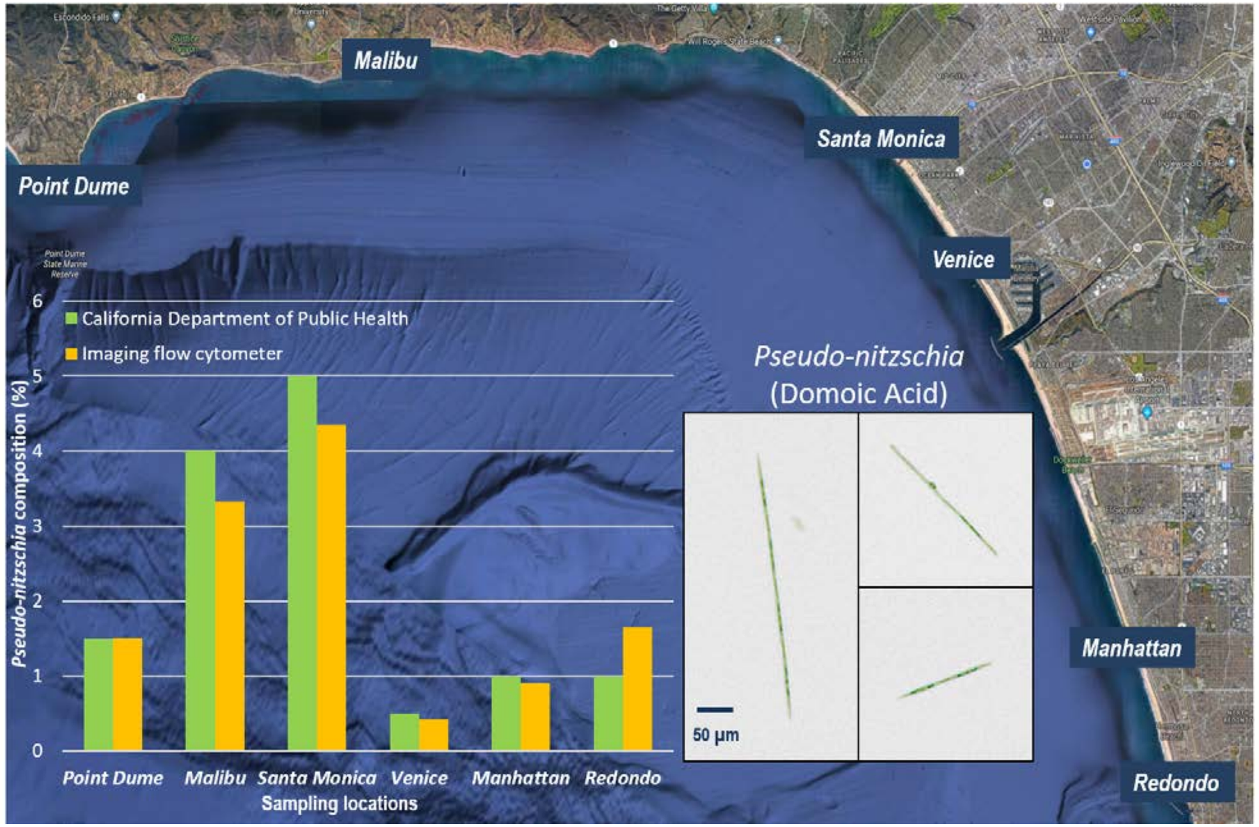


particulate in water

Validation of Aqusens Capabilities In-field

- Lucendi's technology was demonstrated (see *) to identify harmful microorganisms in hours vs. weeks in comparison with conventional assessment as performed by CA Department of Public Health
- Lucendi is currently preparing pilot projects with aquaculture and algae-based bioproducts companies





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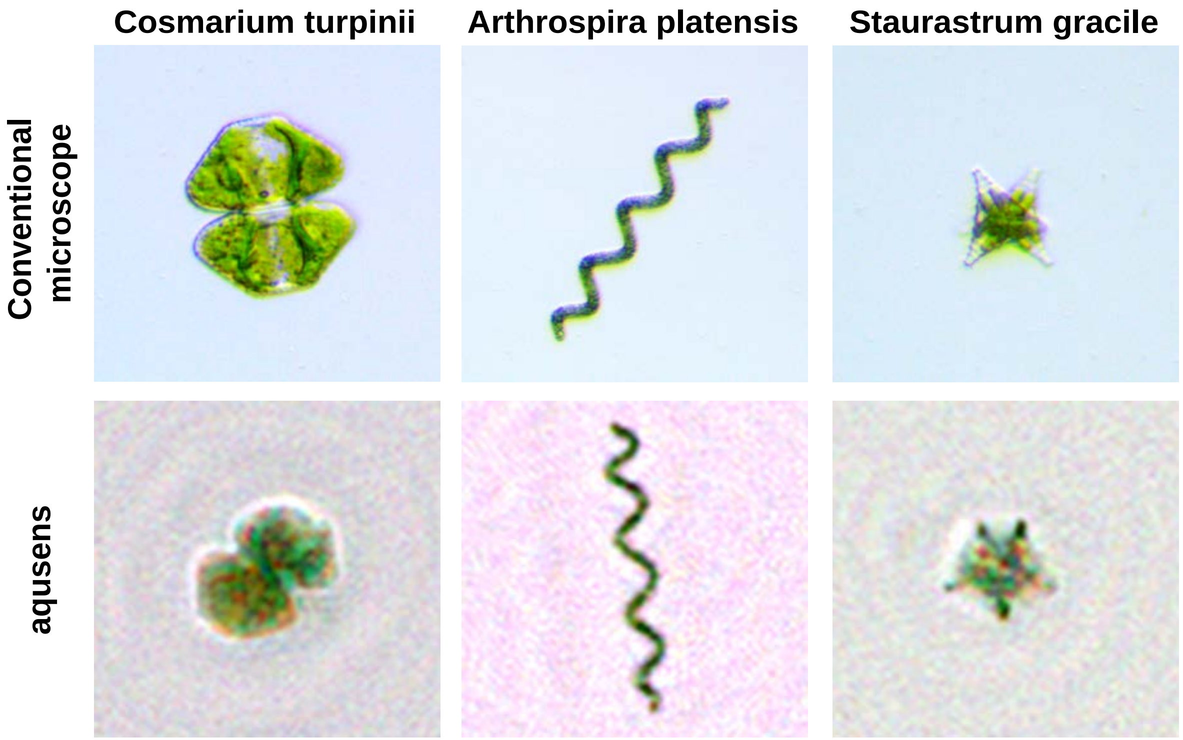
*Göröcs, Z. *et al.* "A deep learning-enabled portable imaging flow cytometer for cost-effective, high-throughput, and label-free analysis of natural water samples." *Light Sci Appl* 7, 66 (2018). https://doi.org/10.1038/s41377-018-0067-0

Classification of micro-objects via Deep Learning



Classified Class	Actual class			
	Arthrospira	Cosmarium	Staurastraum	Other
Arthrospira	**100**	0	0	0
Cosmarium	0	**98**	0	2
Staurastraum	0	0	**99**	1
Other	0	2	1	**97**

Classification of micro-objects via Deep Learning: Algae bioproducts application

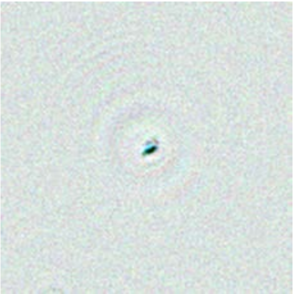
Monoculture experiments (SFCC and Lab)

		Predicted	
		Scenedesmus	Other
Actual	Scenedesmus	106	0
	Other	3	417

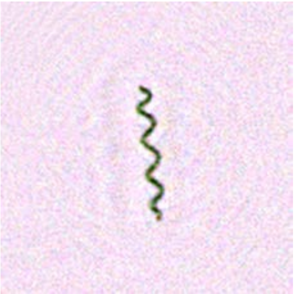
		Predicted			
		A	S	P	O
Actual	A	100	0	0	0
	S	0	100	0	0
	P	0	0	100	0
	O	0	0	0	100

Multi-culture experiment (SFCC)

		Predicted		
		Arthrospira	Pest	Other
Actual	Arthrospira	301	0	2
	Pest	0	103	3
	Other	3	1	576

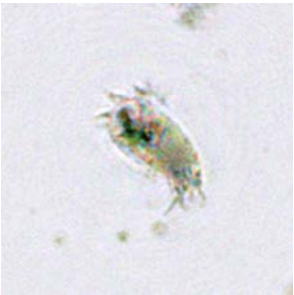


Scenedesmus



Arthrospira

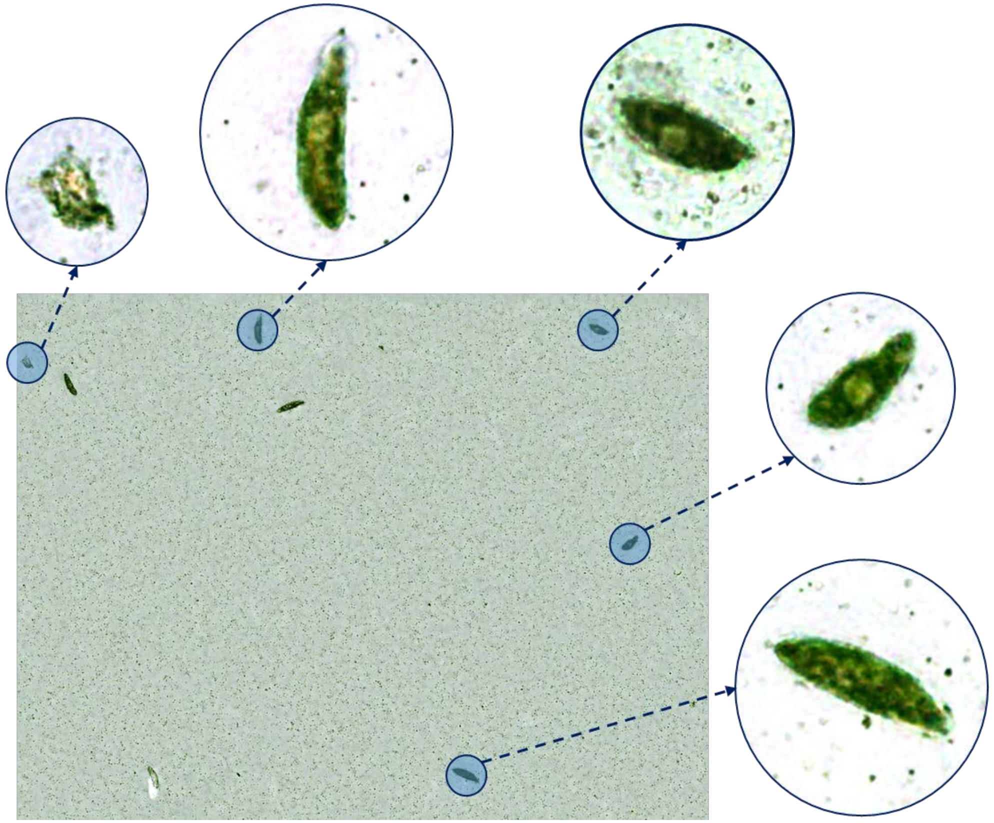
Paramecium



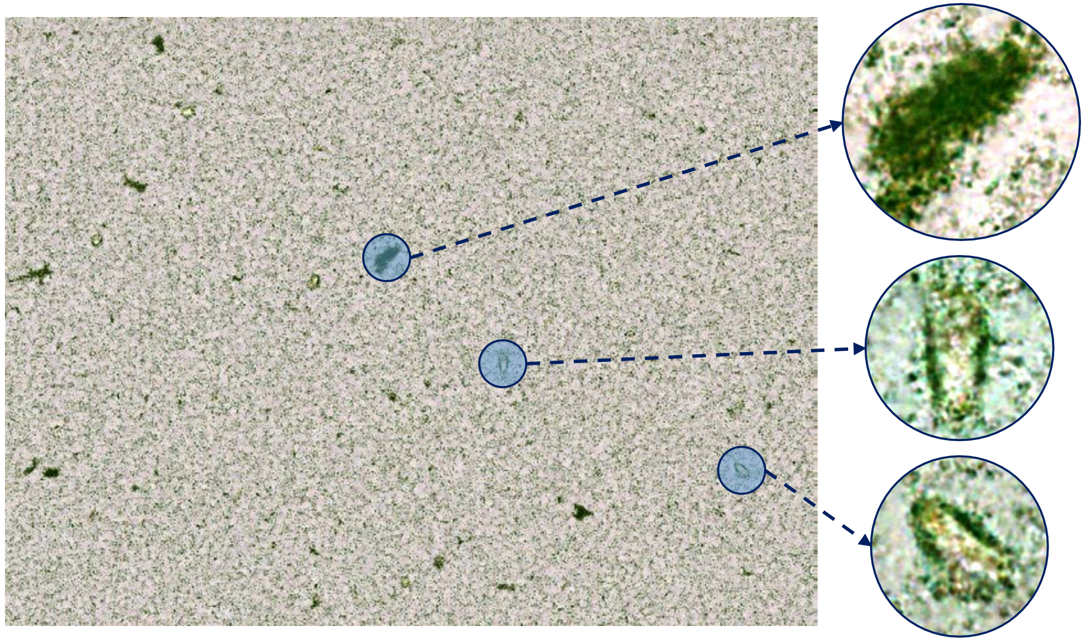
Euplotes

Imaging dense samples with Deep Learning

identify large pests in dense samples at high-throughput



- **Full FOV one-step recovered image**
- **800µm chamber at 100ml/hr throughput**



- **Full FOV one-step recovered image captured**
- **800µm chamber at 1L/hr throughput**

Aqusens pre-release in May, 2022

- A general purpose imaging flow cytometer as a research instrument
- Generic high throughput micro-object monitoring and analysis
- Label free imaging of every microobject in the sample
- Low cost disposable consumables
- Robust data analytics tools
- Customization is available for specific user needs

Contacts

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