AILARON

Autonomous Imaging and Learning Ai Robot identifying planktON taxa in-situ

Machine Vision - Machine Learning - Hydro-dynamics - AI Planning/Execution

Presenter: Dr. Aya Saad, Department of Engineering Cibernetics ITK, NTNU
Project Leader: Assoc. Prof. Dr. Annette Stahl, Department of Engineering Cibernetics ITK, NTNU

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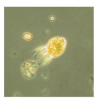
Project team:
Assoc. Prof. Dr. Nichole Aberle-Malzahn [TBS, NTNU]
Dr. Emlyn Davies [SINTEF MC]
Prof. Dr. Geir Johnsen [TBS, AMOS, NTNU, AUR-Lab, UNIS]
Prof. Dr. Martin Ludvigsen [IMT, AMOS, NTNU, AUR-Lab]
Dr. Raymond Nepstad [SINTEF MC]
Dr. Tor Nordam [SINTEF MC]
Adjunct Intnl Chair Prof. Kanna Rajan [ITK, AMOS, NTNU]
Dr. Aya Saad [ITK, NTNU]
Assoc. Prof Dr. Annette Stahl [ITK, AMOS, NTNU]

Concept

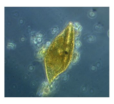
- Imaging-classification-analysis-control chain for plankton-taxa classification in-situ
- Intelligent mobile robotics target sampling on an autonomous under-water vehicle (AUV) for upper-water column microbes biology

Background

- Planktonic organisms are of fundamental importance to marine ecosystems:
  - Basis of the aquatic food web
  - Influence global-scale bio-geo-chemical cycles
  - Indicator of ecosystem condition



Lohmaniella oviformis
a cosmopolitan ciliate and functions as a key species during phytoplankton blooms



Dinoflagellates
Gyrodinium spirale with an ingested phytoplankton cell inside

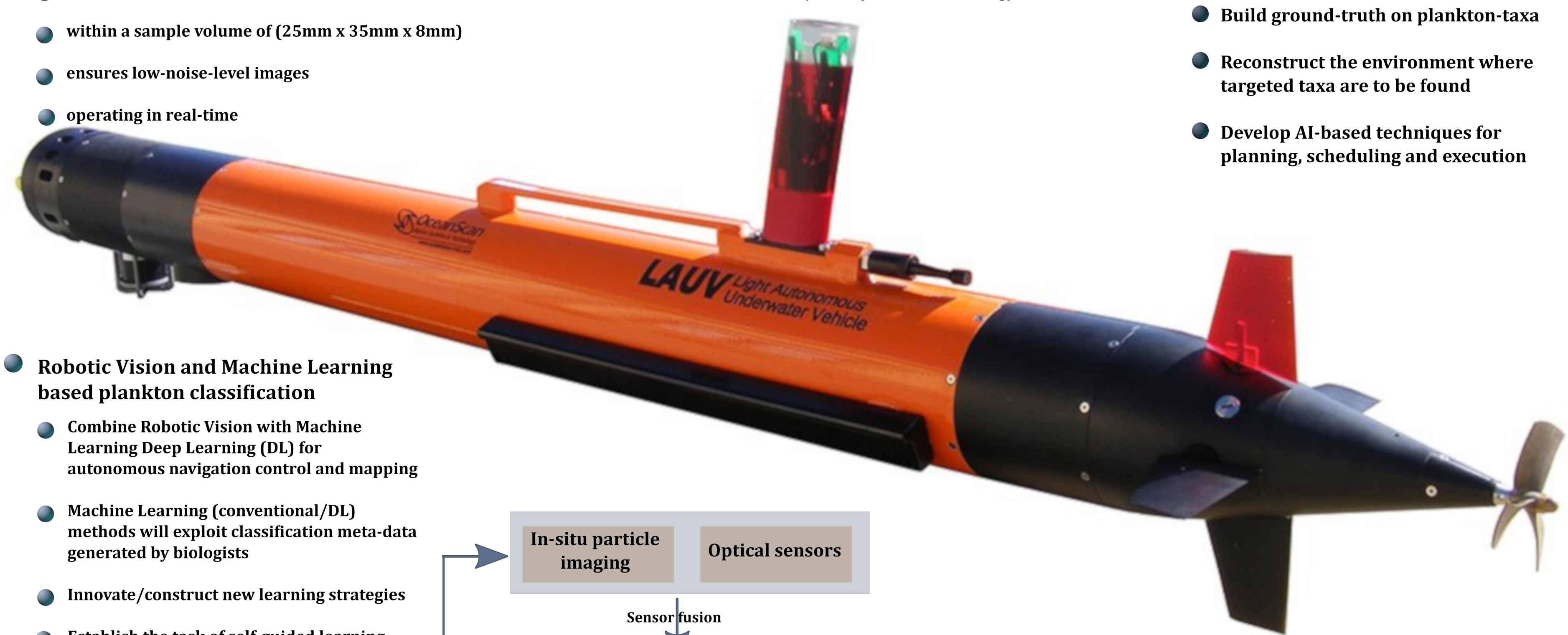
(Courtesy Alexandra Kraberg)

Objectives

- Combine robotic vision with bio-optical sensors for in-situ identification and classification of plankton-taxa in order to:
  - generate qualitative measurement of support
  - opportunistic sampling
  - performance orientated navigation
- Secondary Objectives:
  - Calibrate sensor fusion data
  - Build ground-truth on plankton-taxa
  - Reconstruct the environment where targeted taxa are to be found
  - Develop AI-based techniques for planning, scheduling and execution

Methods

- **Imaging technology and bio-sensor data fusion**
  SINTEF scientists have developed the SilCam:
  - to measure particles ranging from 50µm to 12mm
  - within a sample volume of (25mm x 35mm x 8mm)
  - ensures low-noise-level images
  - operating in real-time



- **Robotic Vision and Machine Learning based plankton classification**
  - Combine Robotic Vision with Machine Learning Deep Learning (DL) for autonomous navigation control and mapping
  - Machine Learning (conventional/DL) methods will exploit classification meta-data generated by biologists
  - Innovate/construct new learning strategies
  - Establish the task of self-guided learning within DL context → new plankton classes found are learned unsupervised
- **Flow Estimation and Plankton Transport**
  Predicting future positions of plankton hotspots requires:
  - accessing to a time-resolved current field
  - running a full-scale circulation model
- **Artificial Intelligence and robotic control**
  - dynamically synthesize survey plans
  - continuously perform updates to mission plans from goals transmitted from shore
  - use advanced methods in Sampling and Control

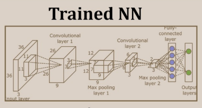
In-situ particle imaging | Optical sensors

Sensor fusion

Labeled database verified

Train NN

Trained NN



Raw data images

Domain expert

Discover new classes

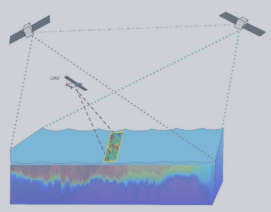
Labeled database computed

Image Segmentation

Measure Distribution

Planktom Classification

Generate statistics



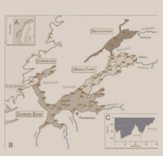
Navigation sensor data

Hydrodynamic assimilation

3D Map

Evaluate target taxa hotspot

Localization estimation



Adaptive planning

Scheduling

Execution

Impact

- Determine temporal changes in community structure abundance and dispersion of plankton organisms
- Study of microbial time-series in ongoing studies of the changing planet
- Accelerate the time consuming process of obtaining water samples, storage, transport, microscopy and analysis
- Leveraging advances in imaging and robotics hitherto not accomplished before
- Real-time predict and plan LAUV survey mission trajetories based on identified hotspots
- Enable targeted observation and sampling in the process of constructing oceanographic models of plankton distribution

NTNU AMOS
Centre for Autonomous Marine Operations and Systems

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