3D Sonars for Subsea Autonomy

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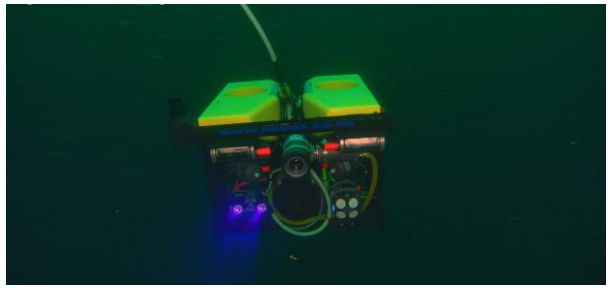
SINTEF Ocean

Preliminaries – What is underwater autonomy?

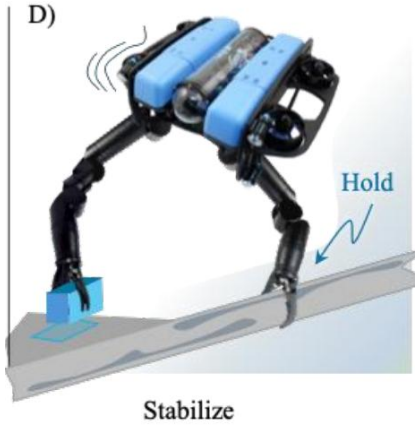
- We want our ROVs/UUVs to:
  - Be equipped and capable for the task
  - Know their state and situation
  - Understand the environment
  - Think and execute the given tasks

Cascading dependencies



- Underwater autonomy is the result of addressing:
  - Hardware and control
  - Localization and state estimation
  - Mapping and perception
  - Task and motion planning

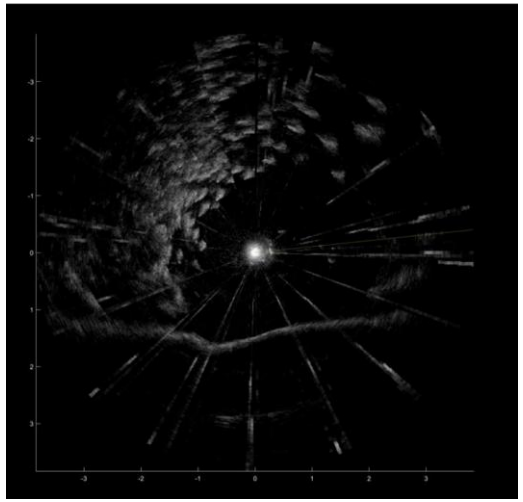
Cascading dependencies



What is the current state for Underwater Autonomy?

Cascading dependencies

- Hardware and controls
  - Potentially challenging logistics
  - Generally well understood and solved
- Localization and state estimation
  - Often with surface support (USBL) or with good visibility
  - Challenging in arbitrary conditions
- Mapping and exteroception
  - Mostly with 2D sensing or relying in visibility conditions
  - Major challenges in arbitrary conditions & real-time ambiguities in 3D
- Task and motion planning
  - Limited with 2D assumptions and far from action
  - Human supervised close to structures (at best)



What are we missing for underwater autonomy?

- Why *autonomous* underwater robots remain in general far from structures?
- Why underwater robots cannot currently autonomously navigate, explore, and map complex structures (underwater caves, industrial areas, harbours, etc.)?
- Why underwater autonomy involves close human supervision from basic controls to task execution?
- Why underwater autonomy lags >20 years behind space, aerial, ground robots?

➢ Space, aerial, and ground robots have robust 3D sensing (LiDARs, IRs, etc.)

  ➢ The same technologies are impractical underwater due to turbidity and poor light propagation

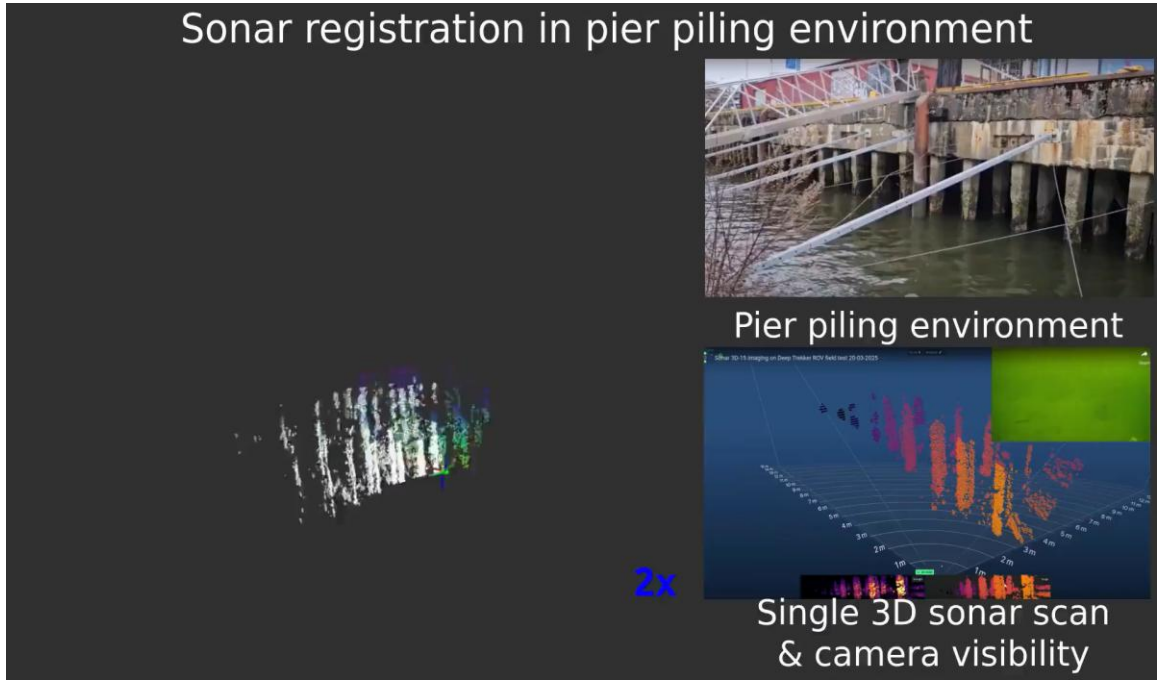
❖ Our thesis:

*"Sensors providing 3D spatial awareness will **immensely grow** and **transform** the underwater domain…*

*…. **and it is taking place NOW**"*

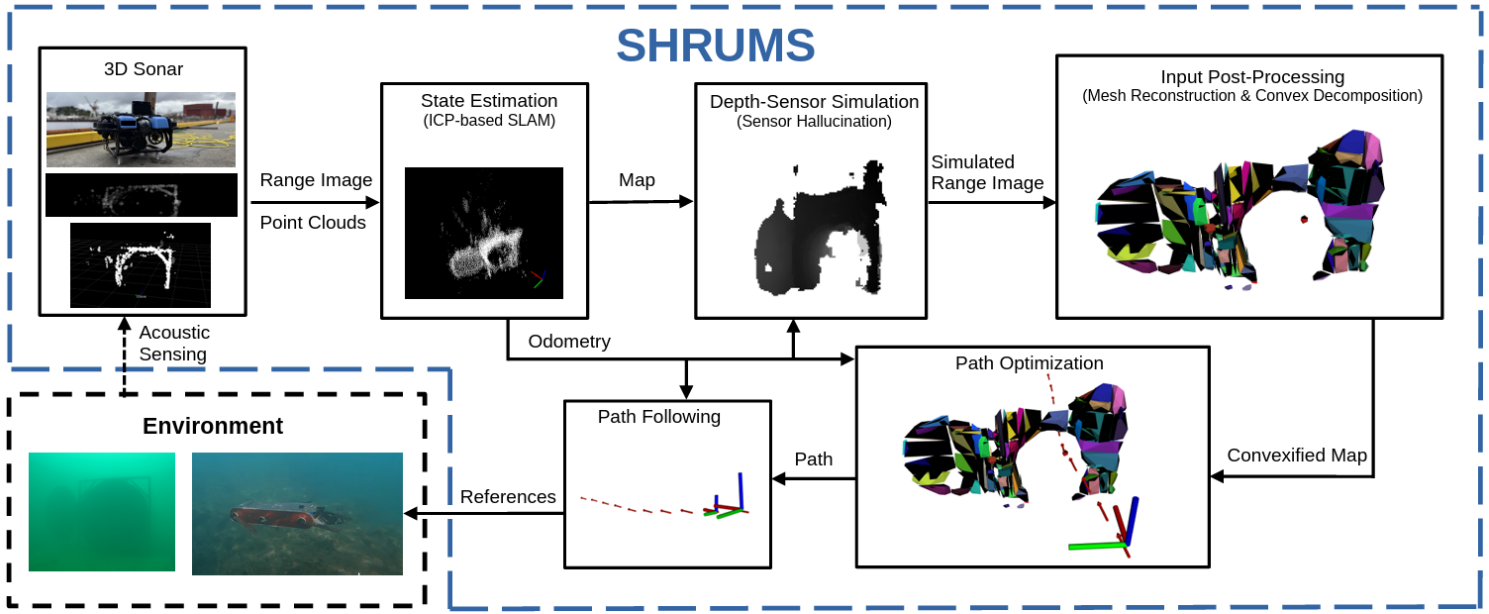
3D SLAM

- SINTEF has provided the first SLAM framework utilizing compact 3D sonars
- Wide range of sensor configurations have been previously explored
  - DVL + imaging sonar
  - Multibeam sonar, FOG, IMU
  - DVL, pressure sensor
  - Pipe-profiling sonar + camera
  - DVL + depth camera
  - Side Scan Sonar + dead reckoning
- 3D sonar framework replaces all of them



3D autonomous navigation

- We also provide the first framework for autonomous navigation utilizing compact 3D sonars
- Enabling «aerial robot capabilities» underwater

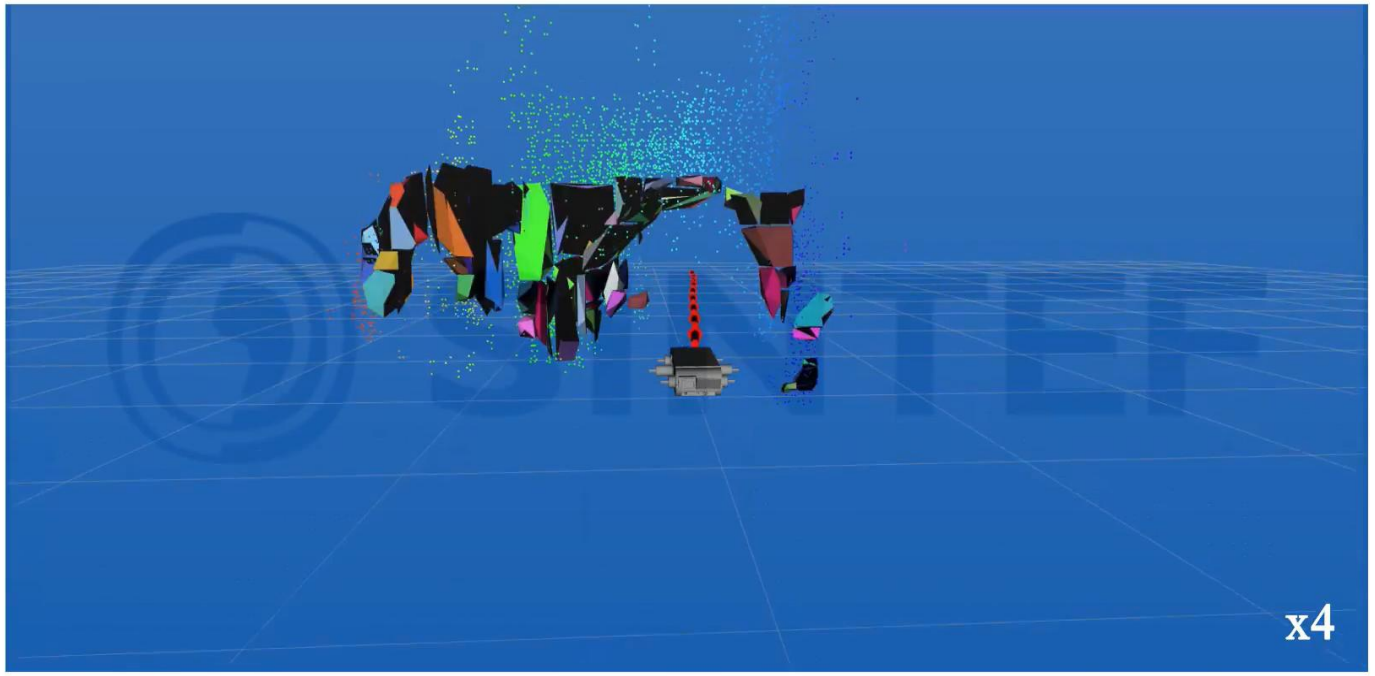


3D autonomous navigation

Real-Time 3D Autonomous Navigation

(Real data / Simulated Robot)

Map: Container
Configuration: C1

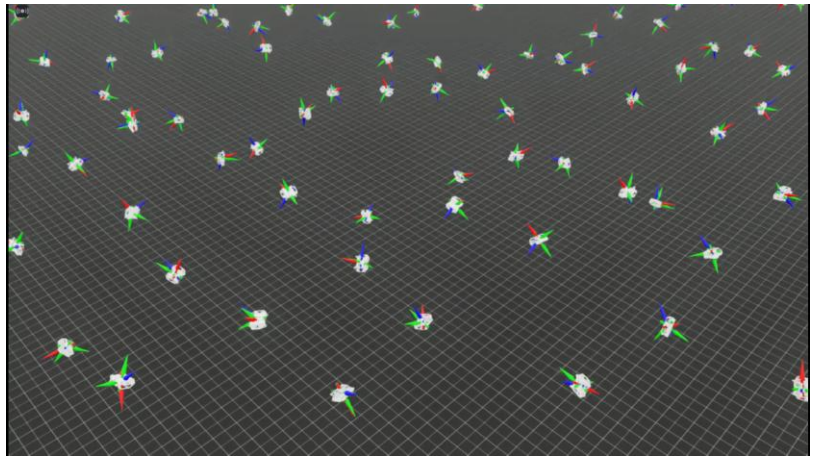


Other enabling technologies

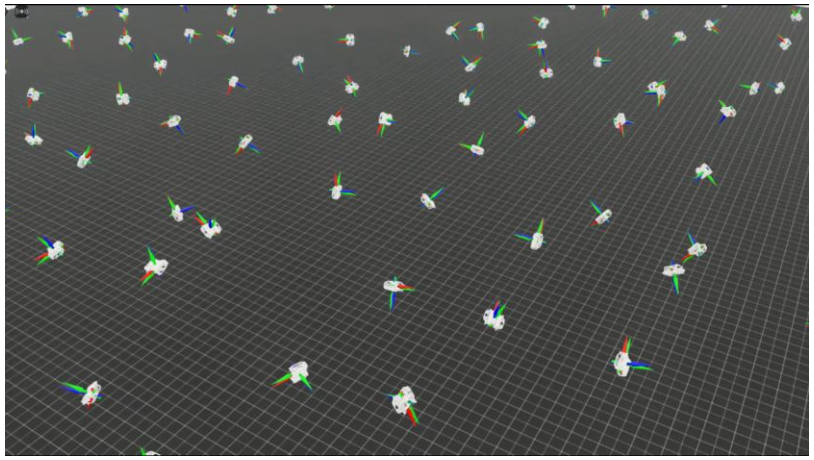
- Navigation and motion planning are part of a high level control system
  - What about the lower level? Motion control, position, attitude, velocity?
  - May require constant re-tuning based on changes in payload, variations between vehicles, etc.
- We recently introduced a solution to general UUV control: sim2swim
  - 6DOF reinforcement learning control – trained in 2 minutes – zero-shot application
  - Capable of robust, acrobatic control in all degrees of freedom
  - Considers changes in payload
  - Applicable to all vehicle types

sim2swim

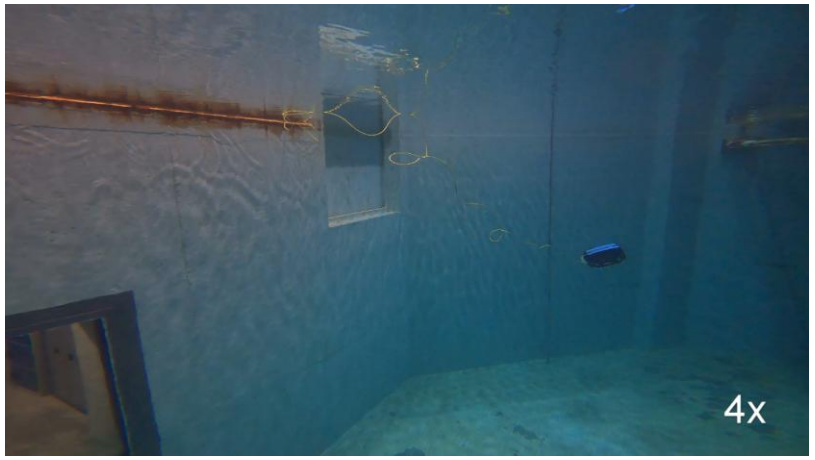
Before training



After training



Deployed on vehicle



Take home message

- Transformation into 3D SLAM and autonomous navigation in complex underwater environments is happening now!
- Learn controllers for any ROV in 2 minutes using RL
- Combining this => how we envision underwater autonomy will be performed from now on

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75 år med teknologi for et bedre samfunn

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