

Cooperative optimal coverage for seabed surveys with USVs

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About Maritime Robotics



- Established in 2005
- Located in Trondheim, Asker and Eggemoen (Norway)
- Main markets: geophysical mapping, environmental monitoring and defence/security





UNMANNED SYSTEMS COST EFFICIENT AND RISK-REDUCING MARITIME DATA ACQUISITION





Unmanned Aerial System - The PX-31





Maritime Robotics - Unmanned Surface Vehicles

SHELTERED WATERS



OTTER

COASTAL/OPEN WATERS



MARINER

OPEN OCEAN



WAVE GLIDER LIQUID ROBOTICS



Otter USV - Specifications

Electrical thrusters Max speed: 6.0 kn (4.0 kn with sonar) Dimensions: 200 x 108 x 81.5 cm Endurance: 20+ hours at 2 kn with Norbit iWBMS

Optional: * AIS receiver

* Camera

* GSM modem

Splits into pieces < 15-20 kg



Use Case - Reservoir Mapping with Multibeam Sonar



Norbit iWBMS, Applanix AP20 and CPOS RTK



Use Case - Underwater Hyperspectral Imager Research on Algae Classification













Optimal coverage for seabed surveys







Lidar-based SLAM & complete coverage path planning







System: Otter USV + low cost lidar





RPLidar A3

Example data: indoor, small room





Complete coverage path planning (CCPP)

Boustrophedon-based CCPP



Bio-inspired neural network based CCPP









Autonomous online path planning and path-following control for complete coverage maneuvering of a USV

Jan Henrik Lenes

Supervisor: Roger Skjetne Co-advisor: Arild Hepsø (Maritime Robotics)



https://youtu.be/hqOUKtosnFw





Field results: Boustrophedon-based CCPP







Some challenges

➤ Lidar:

- Max detection range of lidar in the field: 14m (indoor: 25m)
- Only detections if surface hit at right angle
- No detections for black objects, e.g. ships with black hull
- Low jetty not detected due to 'high' mounting of lidar
- False detections due to sunshine
- State estimation and localization
 - Offsets in IMU data caused 'angled' detections in SLAM map
- > SLAM
 - Cartographer corrections only made when lidar detects obstacles





Multi-vehicle surveys for optimal coverage







Formation control for optimal survey coverage

Marine survey operations are cost and time intensive, and still mostly performed by a single, large vessel with high daily operating costs.





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➤ USVs could:

- follow a survey vessel in formation
- run as a group of USVs in formation
- Result: cost- and time-efficient surveys





Formation Control







Leader-follower formation control: <u>https://youtu.be/ir1_1nlmJtM</u>







Considering the actual sonar coverage







SafeCOP final demonstration: Otter USVs in formation behind Telemetron USV. The follower positions are calculated based on sonar coverage of leader USV. <u>https://youtu.be/oIBdRzhpJpU</u><u>http://www.safecop.eu</u>

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Thank you for your attention!



Questions?

Unmanned Surface Vehicle

MADT