Mechanical Sonar Scanning Strategies for Fast Underwater Collision Detection on a Reef Surveying Autonomous Surface Vessel

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Surveying our Reef: AIMS-ASV

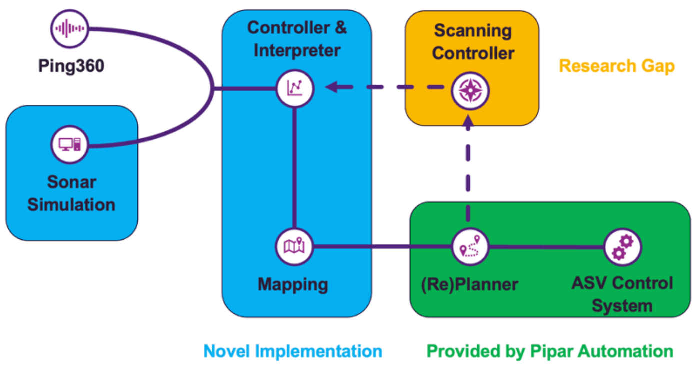
Objective: develop underwater obstacle avoidance for the AIMS-ASV for surveying on hazardous and unmapped reef terrain. Sonar is necessary underwater, but has an imprecise propagation profile and very slow scanning speed

Thesis Scope

Mapping – design of a Bayesian occupancy based cartesian map based on experimental probabilities

Simulation – complete simulation of the sonar, and visualisation tools for planning and interfacing

Scanning Strategy – to address the slow speed of sonar, fast strategies are developed to maximise information gain and therefore obstacle detection



Results - Mapping

Successful deployment of prototype to Brisbane River for data collection

Mapping is qualitatively accurate to satellite imagery across wharf, pole, water, bridge and bank environments

Noise sources are identified and Bayesian updated out of map

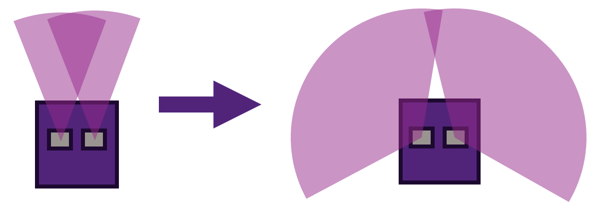
Scanning Strategy – Background Considerations

Mechanical scanning sonars are *slow*, so to prevent obstacles approaching too quickly, restricted scanning segments based on speed are required [1]. Range, which directly translates to sampling period, should also be optimally switched for time optimisation [2].

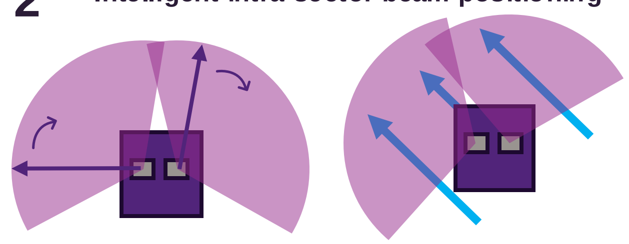
At 10m, it takes 8s to sample 360°. A collision obstacle would approach 16m if the ASV is travelling at 2m/s!

Scanning Strategy Features

1 Sparse sampling in windscreen wiper pattern for maximal dual sonar coverage



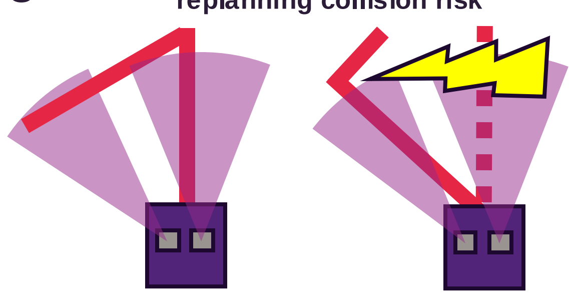
2 Intelligent intra-sector beam positioning



Beam synchronisation to avoid sonar interference

Movement over ground centring (responsive to ocean conditions)

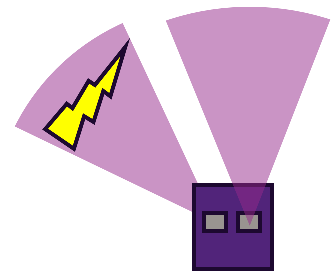
3 Path-aware strategy to minimise replanning collision risk



Pre-scans scheduled path turns

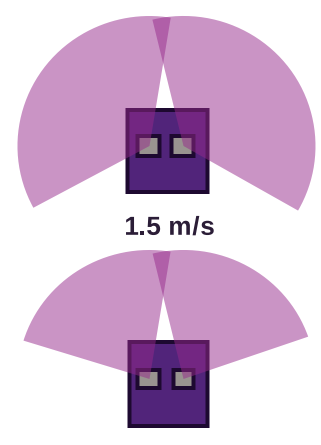
Checks replanned route in real time for path validation

4 Fast and detailed scanning on obstacles



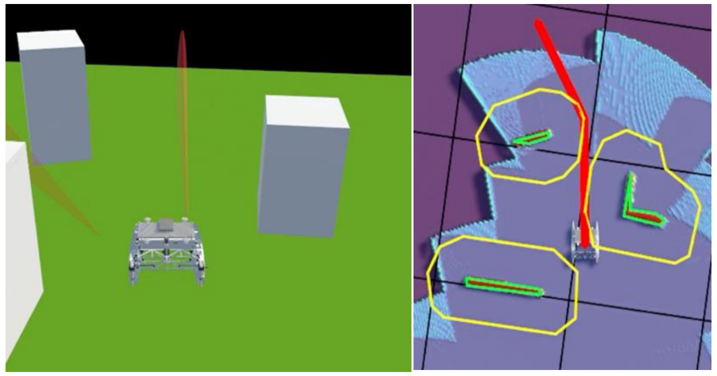
Prioritises by additive (for new obstacles) and subtractive (for removing noise) information for responsive updates

5 Speed-adjusted sector width for constant obstacle threat approach [1]



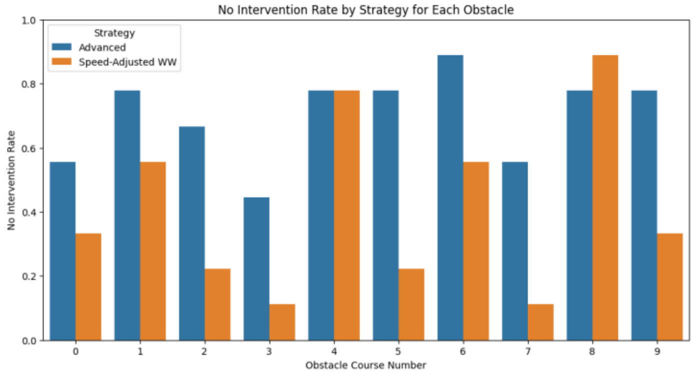
Results – Strategy & Simulation

Planning, mapping, sensor simulation and interfacing integrated into a comprehensive scene in Unity game engine allowing for realistic testing and iteration on strategies



Adaptive scanning outperforms a simple speed-adjusted strategy in 9/10 randomly generated obstacle courses, improving average no-intervention rate from 0.411 to 0.7.

Performance across speed, reflection intensity and information gain is also improved with the adaptive strategy



References

[1] Heidarsson, Hordur K. and Gaurav S. Sukhatme (2011). "Obstacle detection and avoidance for an Autonomous Surface Vehicle using a profiling sonar". In: 2011 IEEE International Conference on Robotics and Automation, pp. 731–736. doi: 10.1109/ICRA.2011.5980509.

[2] Galarza, Cristian, Ivan Masmitja, J. Prat, and Spartacus Gomariz (June 2016). "Design of obstacle detection and avoidance system for Guanay II AUV". In: pp. 410–414. doi: 10. 1109/MED.2016.7535959.

Acknowledgements

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