

Receding Horizon Planning and Tracking for Monitoring Surface Vessels with Passive Sonar: Initial Field Experiments

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- Rigidly-mounted planar hydrophone array
- Originally developed for active synthetic aperture sonar
- Delay-and-sum beamformer
- Peak finder to identify the set of bearings of potential contacts
- Limitations:
 - Port/starboard ambiguity
 - Limited field-of-view (FoV)
 - Clutter
 - Undetected targets
 - Noise
 - Message latency
 - Merged measurements

U.S. NAVAL RESEARCH LABORATORY



- Multiple targets of interest
 - Unknown, varying number
 - Maneuvering
- Single observer
- Sensor
 - Limited field-of-view (FoV)
 - Bearings-only
- Motion planning



- Problem
- Filter
- Planner
- MOOS-IvP Integration
- Initial Field Experiments



Problem



- Objective: minimize error in target estimates within a fixed region of interest
- Target state: position, velocity, motion model
- Measurements: relative bearing
 - Limited FoV
 - Noise
 - Clutter
 - Probabilistic target detection
- Observer state: position, heading
- Actions: straight or turn to port/starboard







Graphical Model









- Based on random finite set (RFS) theory
- Approximation (doesn't label individual targets)
- Our extensions: handle
 - Limited FoV
 - Port/starboard ambiguity
- Limitations
 - Targets aligned in bearing
 - Targets close to the edge of the FoV
 - Merged measurements



- Predict: models for target motion, births, deaths
- Update: use measurements









- Given
 - Current belief
 - When measurements will occur
- Reward: Rényi divergence between:
 - Updated PHD at horizon
 - Predicted PHD at horizon

within the region of interest

Approximations to make this feasible









MOOS-IvP Integration



System Diagram





Initial Field Experiments



- AUV: Bluefin-21
- Target: Bluefin R/V Resolution





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U.S. NAVAL RESEARCH LABORATORY Preliminary Results (cont.)





- Planner generates waypoints approximating desired trajectory
- Extra waypoint following action
- Planning took longer than expected
- Generated waypoints ended up behind the vehicle









- Workarounds
 - Increase duration of straight segment
 - Only send waypoints which are still in front of the vehicle
- Solutions
 - Timeout and desired heading for each waypoint
 - Trajectory-following behavior



Conclusion



- Estimate states of an unknown number of indistinguishable targets
- Planning motion of AUV to obtain more informative measurements
- Initial experiment
 - Filter worked fairly well
 - Waypoint generation didn't work well
- Upcoming experiment later this year



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