NRI-FND: Human-Team-Supervised Autonomy with Application to Underwater Search and Rescue

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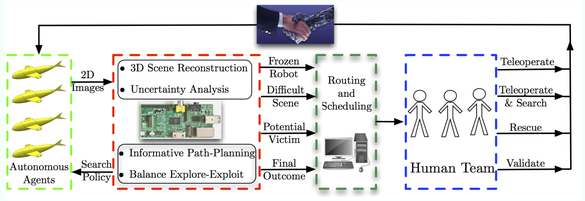
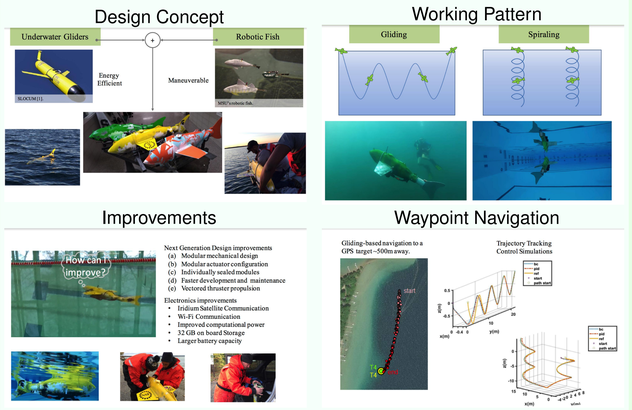
Project Objectives



- Development of a principled framework for the design of human-team supervised autonomy
- Optimal task allocation and scheduling for human-team supervision
- Informative path planning for target search
- Development of a heterogeneous group of gliding robotic fish, remotely operated vehicles (ROVs) and a robotic boat
- Experimental evaluation in field trials emulating underwater search and rescue

Improvements to Gliding Robotic Fish



Education and Outreach Activities

- Undergraduate research on underwater robotic development, HRI, and photogrammetry
- K-12 teacher training on using EEG data for HRI
- Demos of underwater robots at various outreach events

ROV Platform and Robotic Boat


ROV


Robotic boat

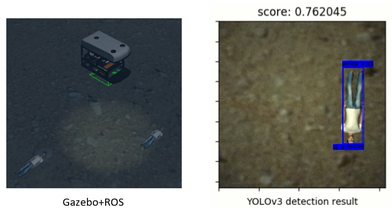

Side-scan Sonar

- ROV communicates through a buoy that floats on the surface of the water
- Boat carries assistive devices and can perform autonomous waypoint tracking
- Sidescan sonar unit is designed to operate remotely while being towed by the boat

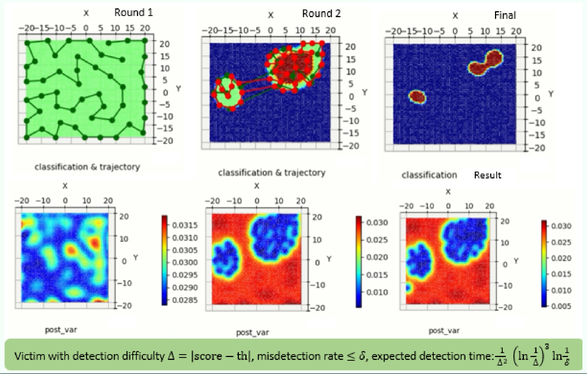
Advances in Underwater Search Algorithms

- An underwater vehicle operated in water
- An unknown number of victims on water-floor
- Sensing at different depth is modeled as multi-fidelity Gaussian processes
- Minimize searching time while meeting the detection accuracy requirement

Simulation Test Environment



Experimental Results

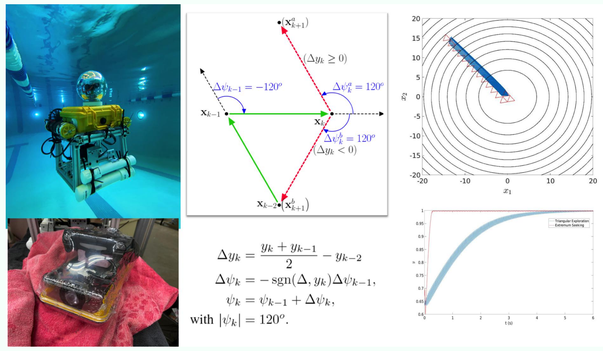


Victim with detection difficulty $\Delta = |\text{score} - \text{th}|$, misdetection rate $\leq \delta$, expected detection time: $\frac{1}{\Delta^2}\left(\ln\frac{1}{\Delta}\right)^3 \ln\frac{1}{\delta}$

LED-based Communication and Localization

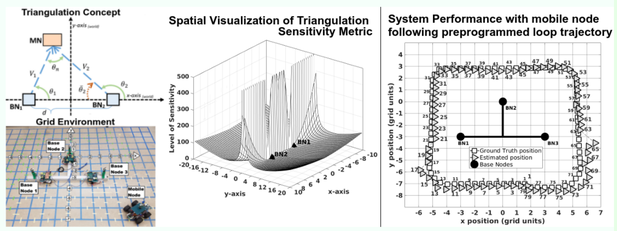
Alignment Control for Optical Communication

- Objective is to achieve Line of Sight (LOS) between two underwater optical transceivers
- Our current work demonstrates establishment and maintenance in a one-sided case.
- A joystick sends command via LED communication to the underwater robot.
- A triangular-exploration based technique is developed for alignment control



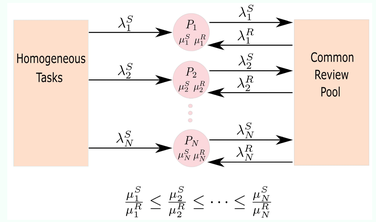
LED based Localization

- 2-D Localization of a mobile robot using bearing angles to triangulate mobile robot's position
  - Bearing angles for establishing LOS between robot and base nodes
  - Each node has LED transmitter and photodiode receiver that rotate 360°
- Sensitivity metric of the triangulation used to determine the most robust base node pairing
  - Sensitivity inversely related to triangulation accuracy

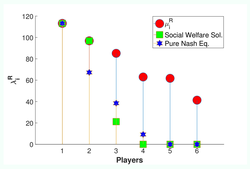


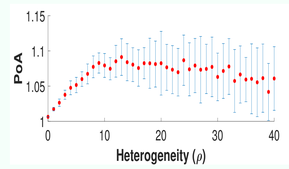
Human-Robot Team Collaboration

Common Pool Resource Games Framework

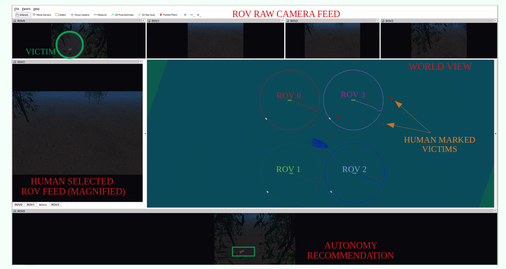


- Team servicing and reviewing (from CPR) tasks
- ***Heterogeneity***: Max. serv. (μ_i^S) & rev. (μ_i^R) rate
- ***Objective***: Incentivize team collaboration
- Establish existence of unique PNE; *PoA* ≈ 1
- Best response dynamics converge to PNE

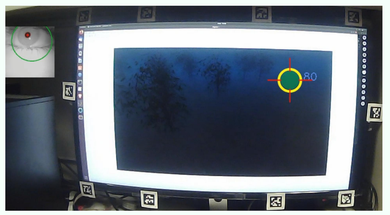




Human-Supervised Underwater Search



- Human supervised victim search & localization
- ROVs operation: Autonomous or Teleoperated
- Autonomy aided human search



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