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

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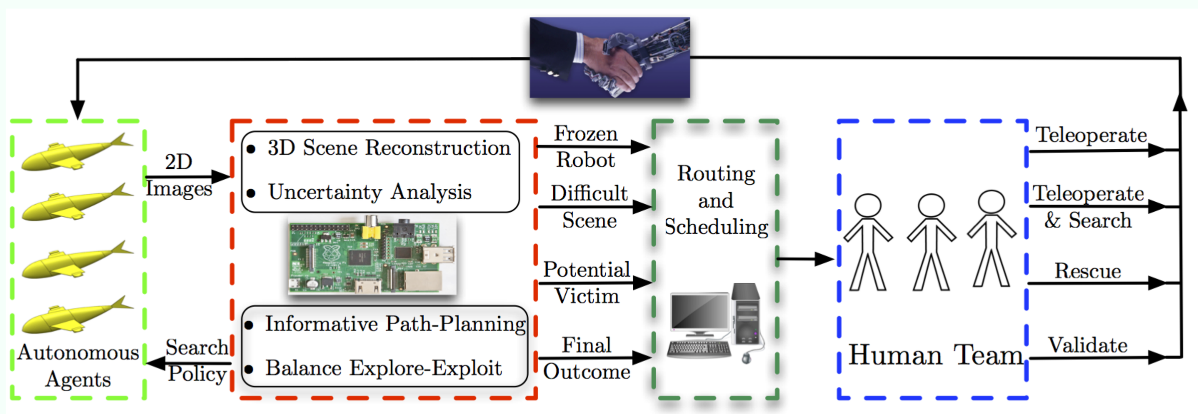
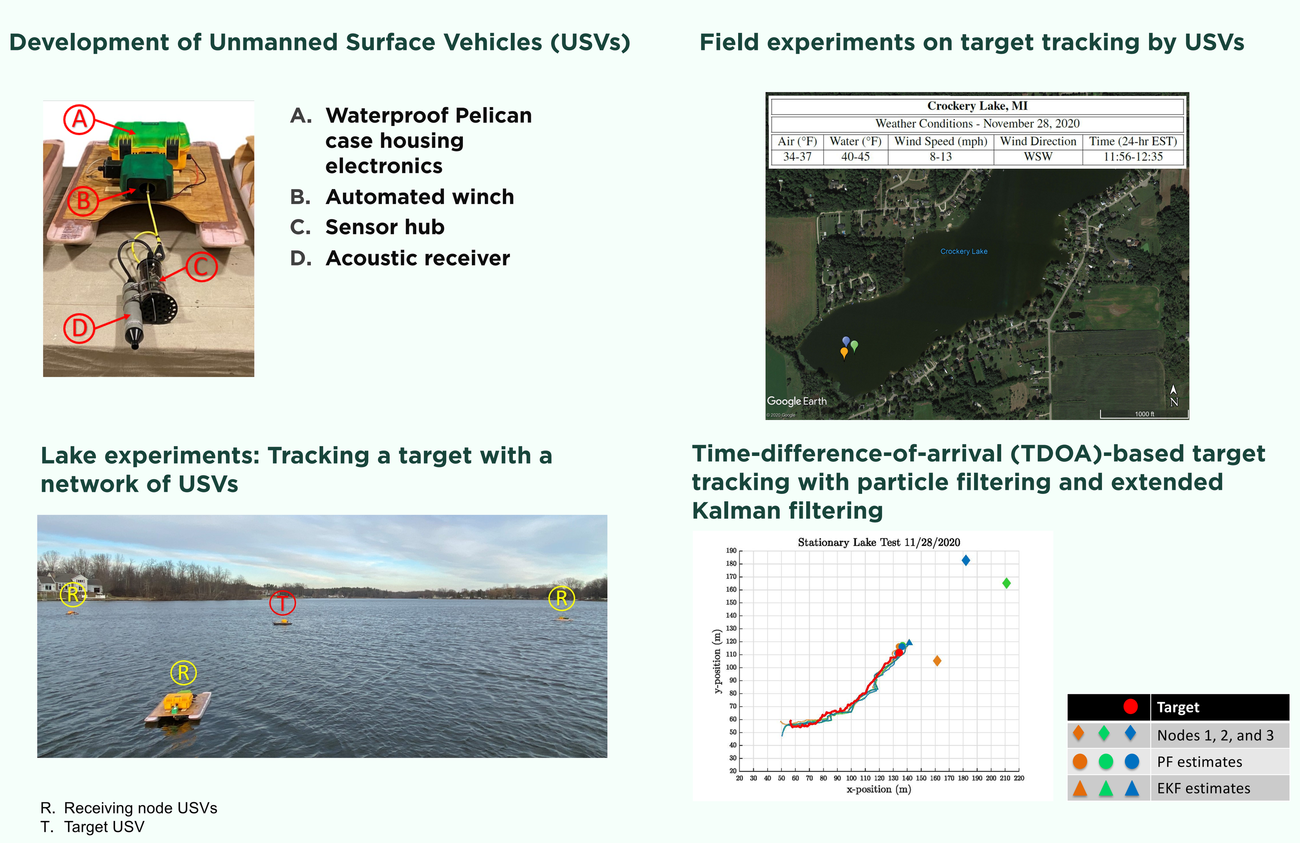
Project Objectives



- 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

Advances in Unmanned Surface Vehicles



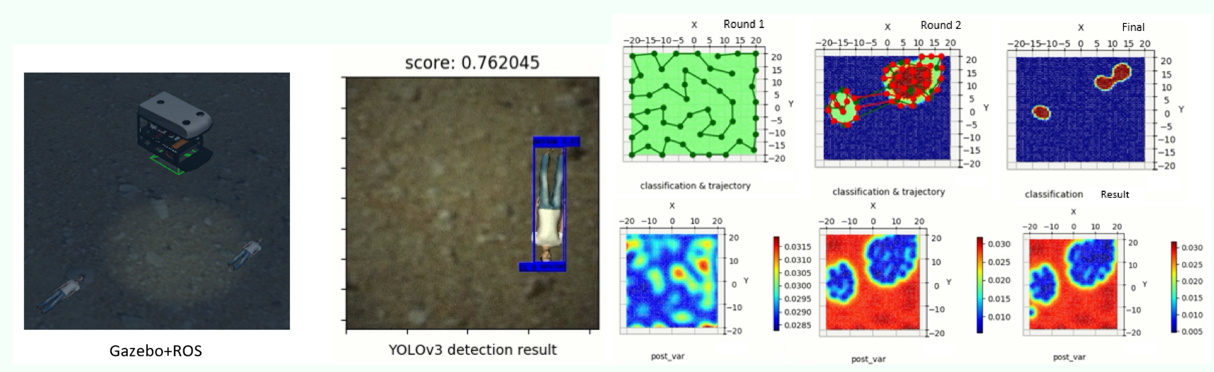
Education and Outreach Activities

- 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

Advances in Underwater Search and Coverage

Multi-fidelity Underwater Search

- 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

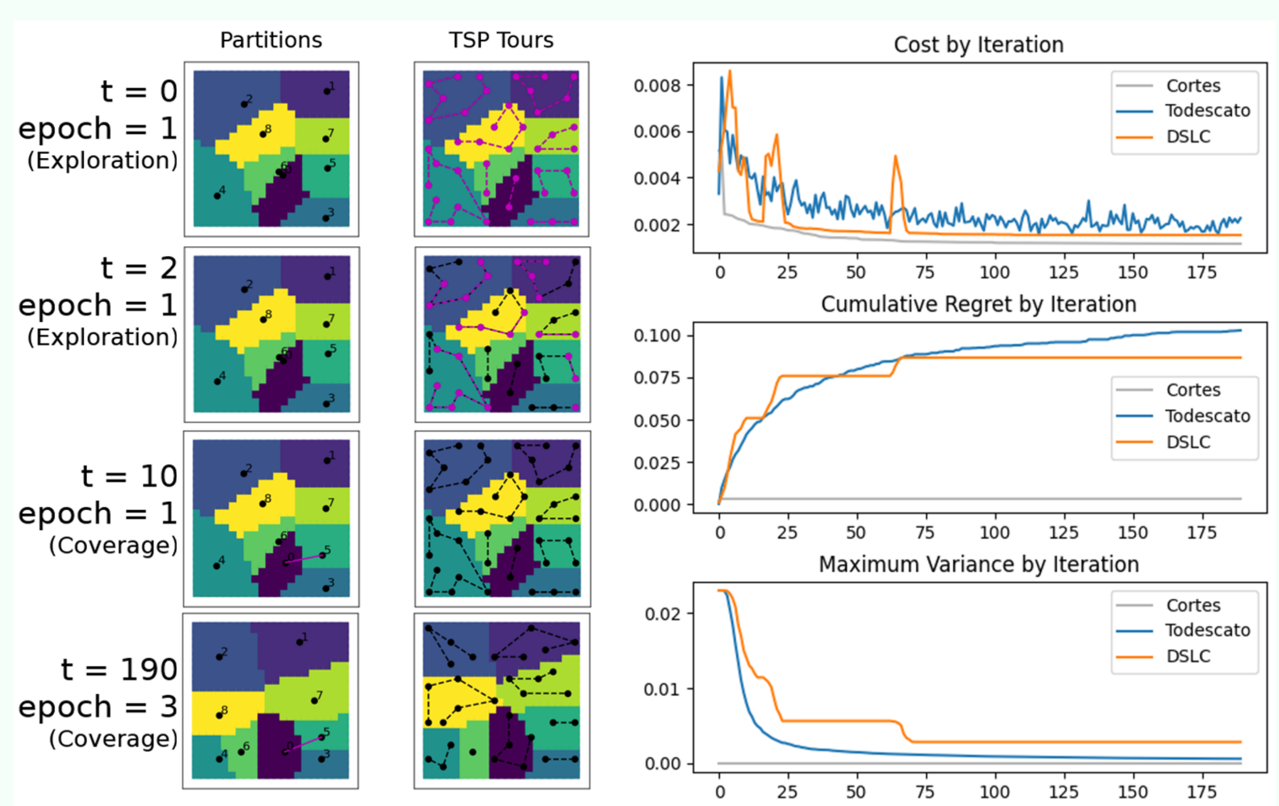


Online Estimation and Coverage

- A group of robots tasked to cover a region
- A discretized region as graph $G = (V, E)$
- Unknown sensory function $\phi : V \to \mathbb{R}_{\geq 0}$ denotes the needs of robotic service at location $v \in V$
- $\phi(v_i)$ can be measured by sample $y = \phi(v_i) + \epsilon$
- Achieve a configuration $\eta \in V^N$ minimizing cost

$$\sum_{v' \in V} \min_{i \in \{1,\dots,N\}} d(\eta_i, v')\phi(v')$$

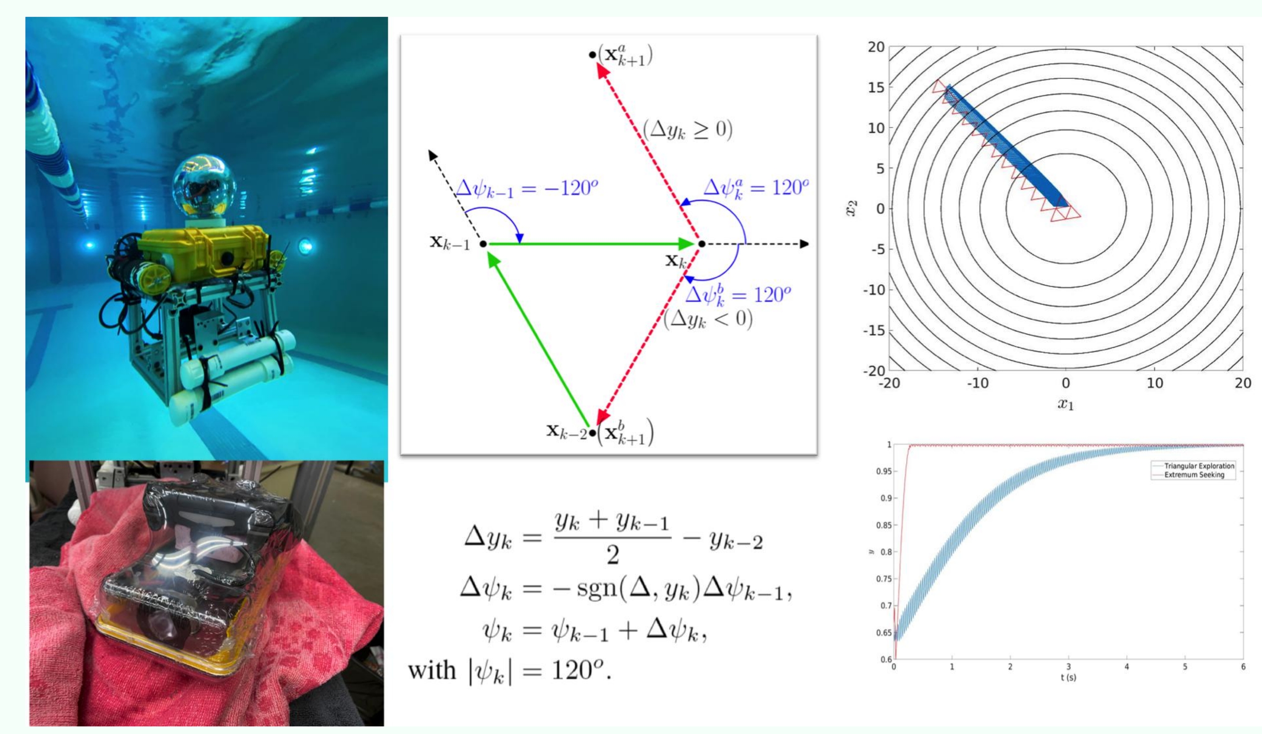
- An adaptive coverage algorithm DSLC balance the exploration-exploitation trade-off.



LED-based Communication and Localization

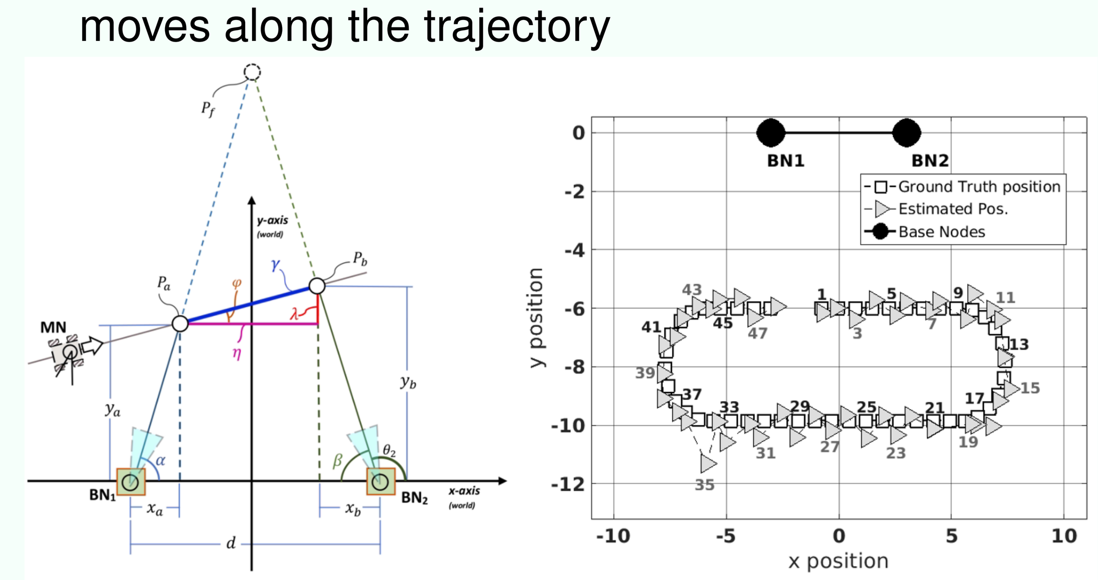
Alignment Control for Optical Communication

- 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



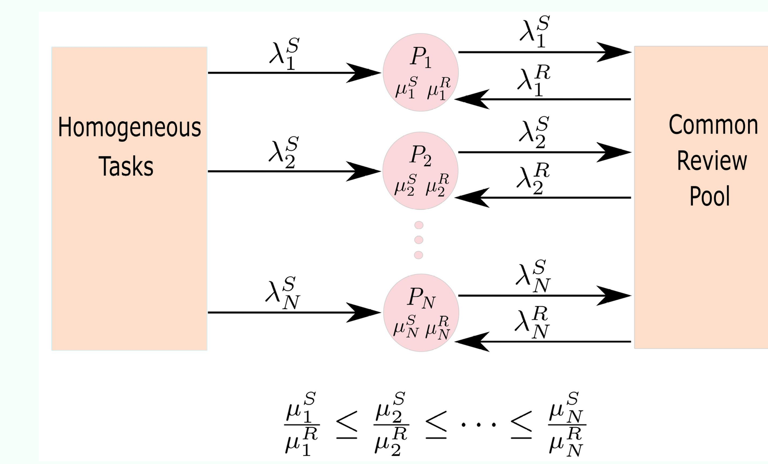
LED based Localization

- 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°
- Mobile Robot's predicted velocity used to estimate the robot's position
  - Mobile Robot measures the bearing angles while it moves along the trajectory



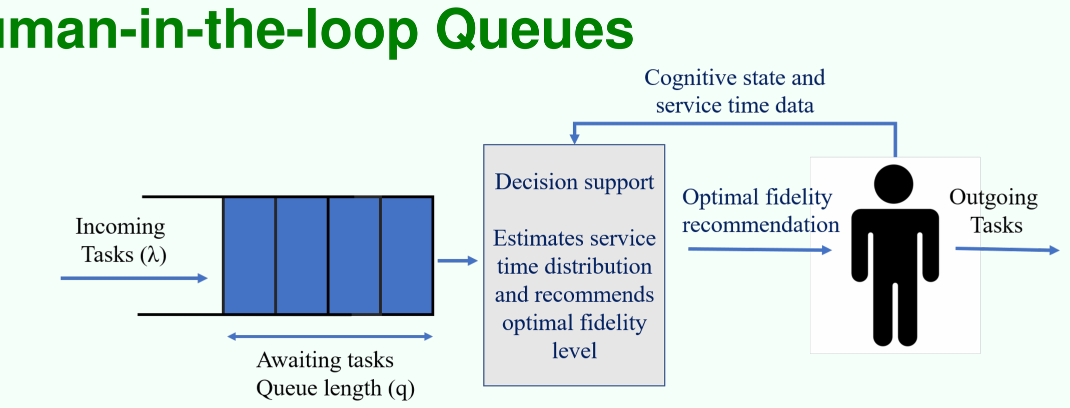
Human-Robot Team Collaboration

Common Pool Resource Games Framework

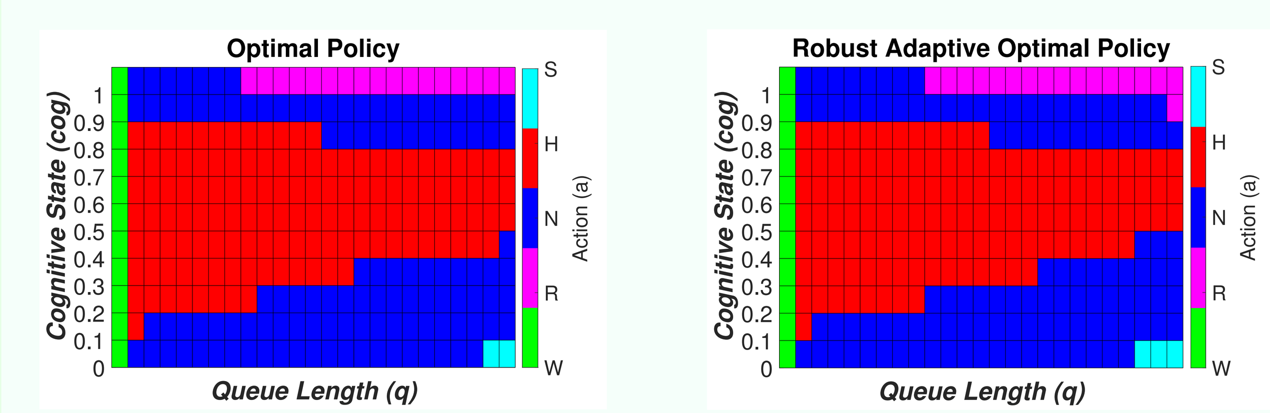


- Team servicing and reviewing (from CPR) tasks
- *Heterogeneity*: Max. serv. (μ_i^S) & rev. (μ_i^R) rate
- *Objective*: Incentivize team collaboration
- Establish existence of unique PNE; $PoA \approx 1$
- Best response dynamics converges unique PNE
- Analytic upper bound on PNE inefficiency
- $POA = 1$ for homogeneous agents

Robust & Adaptive Fidelity Selection for Human-in-the-loop Queues



- human servicing homogeneous tasks with different fidelity levels
- service time distribution is unknown a priori which is learned online through Bayesian estimation
- utilize robust-adaptive semi-Markov decision processes (SMDP) and establish convergence to uncertainty-free SMDP



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