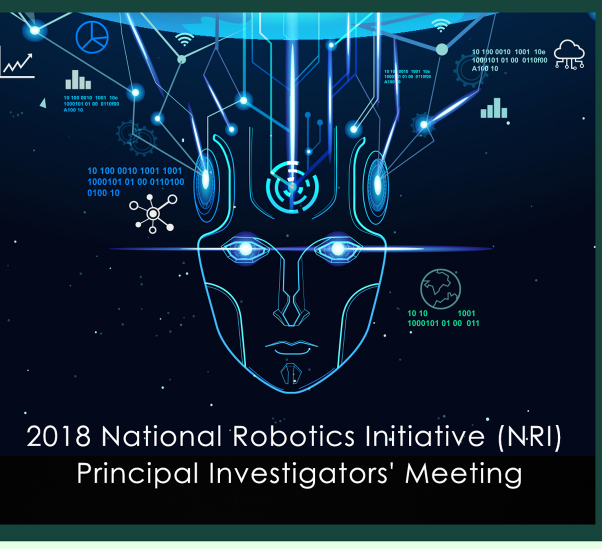

NRI-FND: Human-Team-Supervised Autonomy with Application to Underwater Search and Rescue

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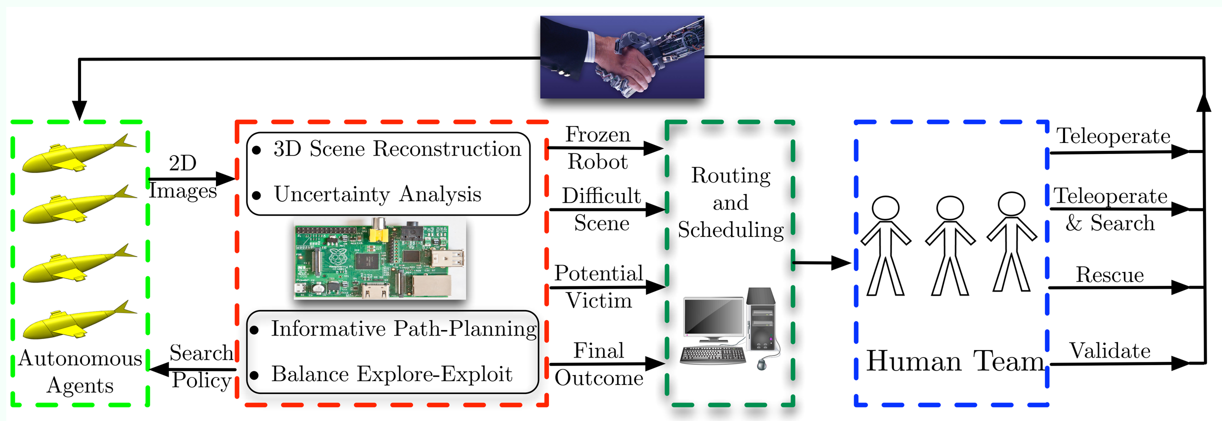
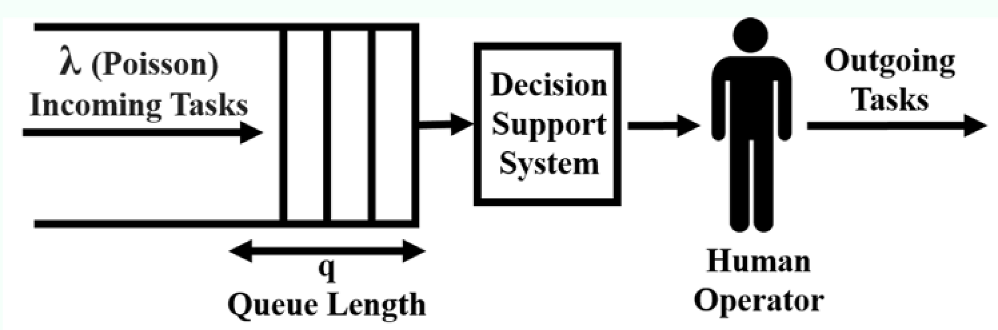
Project Objectives



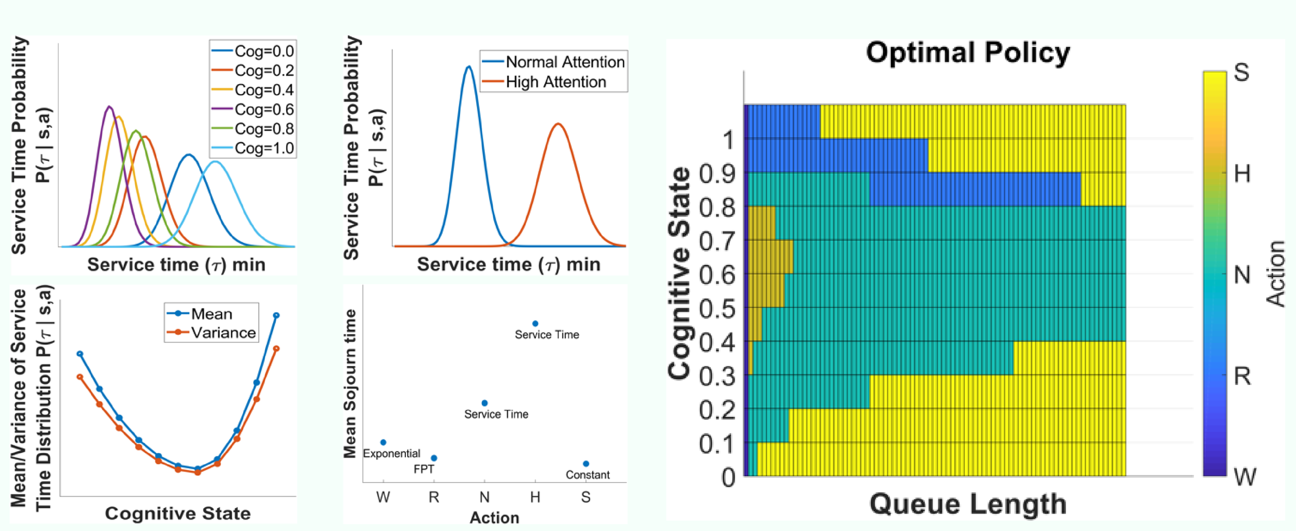
- Development of a principled framework for the design of human-team supervised autonomy
- Optimal task allocation and scheduling for human-team supervision that accommodates stochasticity in cognitive processes and variability among human operators
- Informative path planning that optimally balances the explore-exploit trade-off in the search for targets of interest
- Photogrammetry to enhance human operators' situational awareness in verifying the search outcomes from the robots
- 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

Operator Attention Allocation

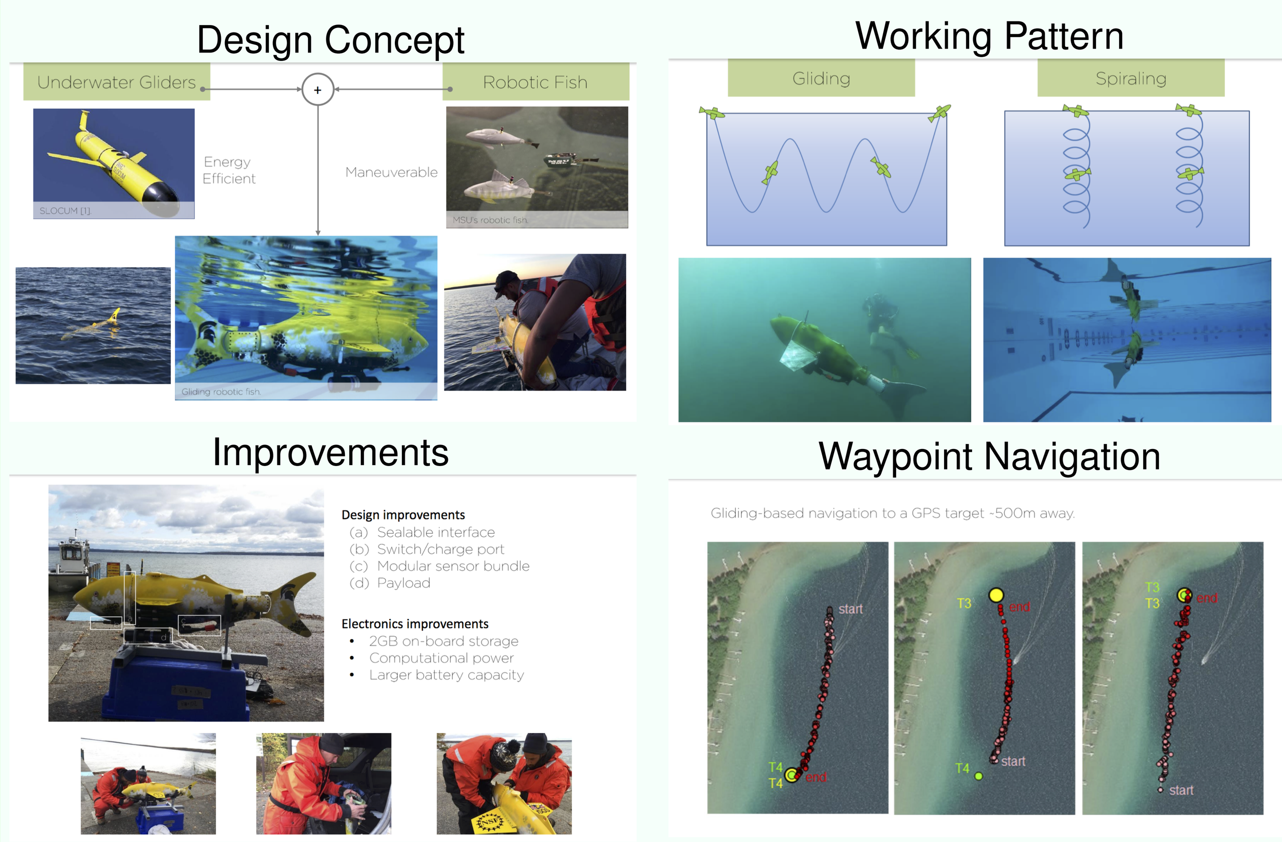
Optimal attention allocation via semi-MDP



- Competing objectives: Optimal cognitive load, high quality service, and stability of queue
- *Actions for operator:* Wait (W), Rest (R), Skip (S), Normal Attention (N), High Attention (H)
- Cognitive state (Cog) modeled as Markov chain decreases (increases) w.h.p. while resting (o/w)
- High (low) reward for action H (N); no reward for W, R and S
- Tasks lose value while waiting in queue



Improvements to Gliding Robotic Fish



ROV Platform and Robotic Boat

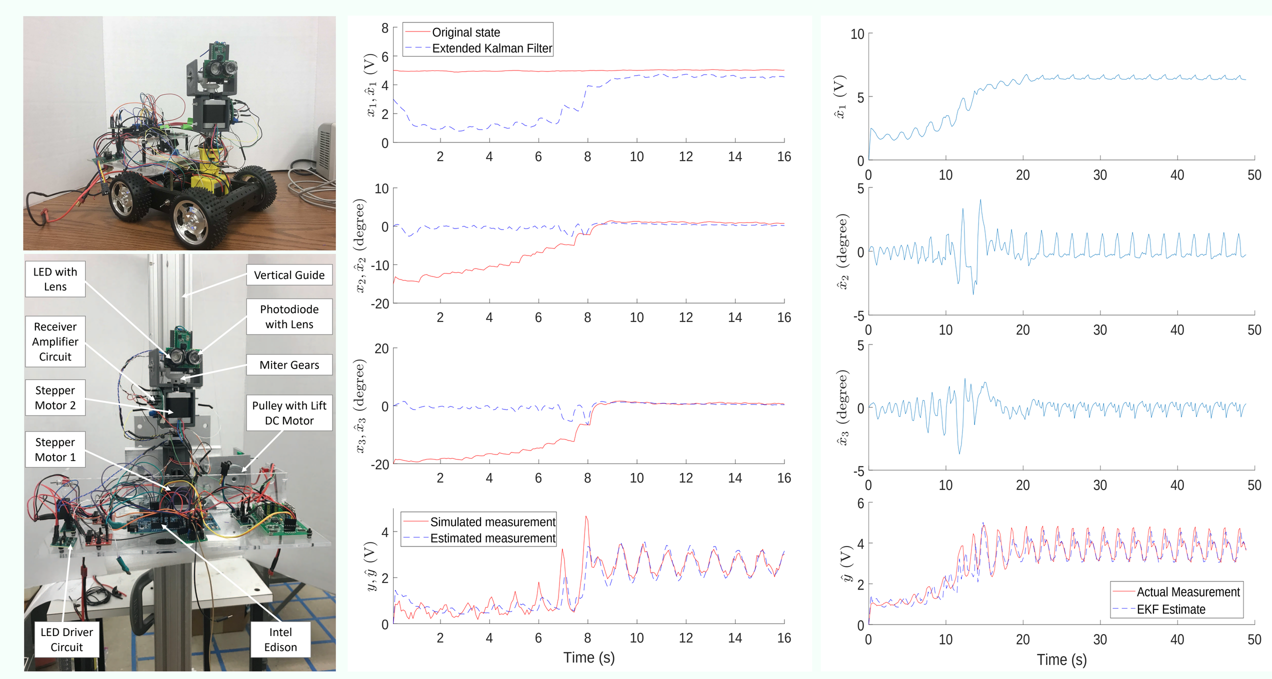
ROV | Robotic boat | Side-scan Sonar

- 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

LED-based Communication and Localization

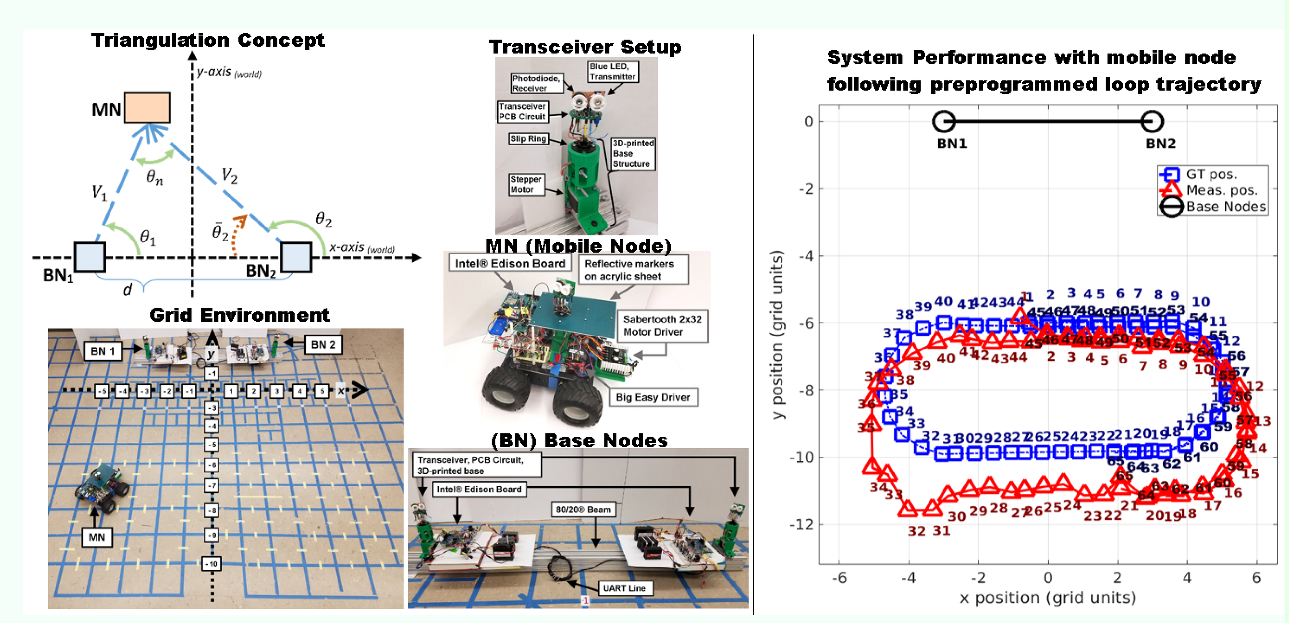
Alignment Control for Optical Communication

- Two robots with optimal transceivers and relative 3D motion
  - Rover: Moves in a 2D plane
  - Elevator: Moves in vertical direction
- Objective is to achieve Line of Sight between two optical transceivers
- Transceivers can perform yaw and pitch motion
- Received optical signal is used for both communication and feedback control
- EKF is used to estimate and control the relative yaw and pitch angles.



LED based Localization

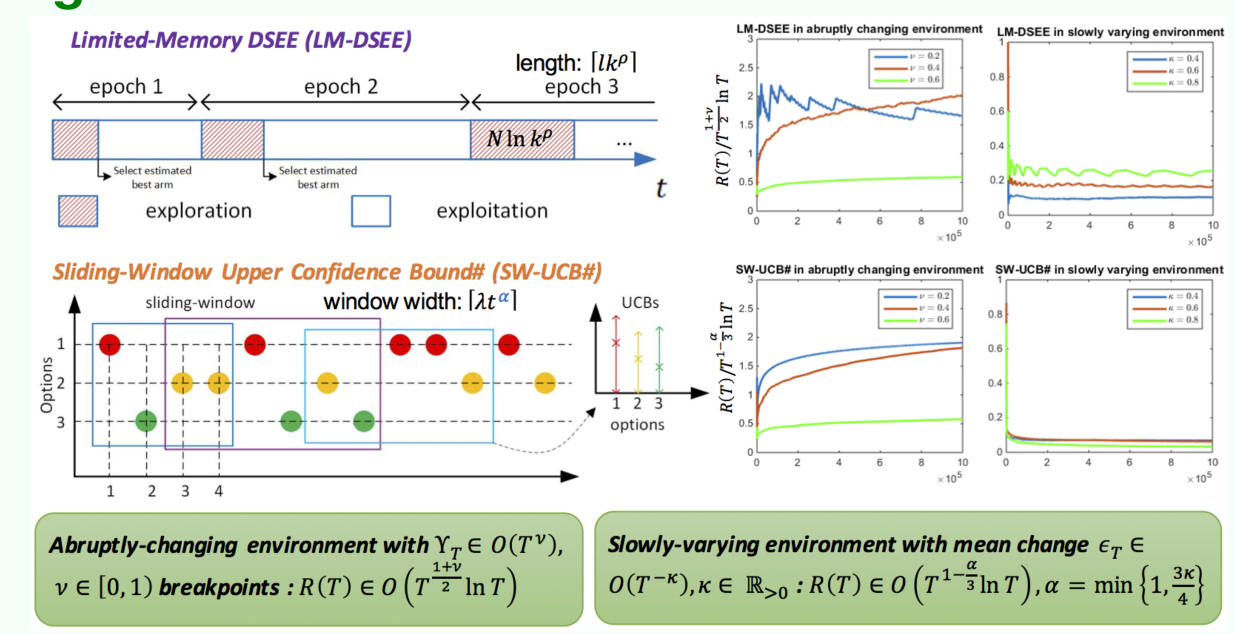
- 2-D space with base and moving nodes
- Each node has LED transmitter and photodiode receiver that rotate 360°
- Two base nodes have fixed positions
- EKF and triangulation with bearing angles used to predict location of mobile target node



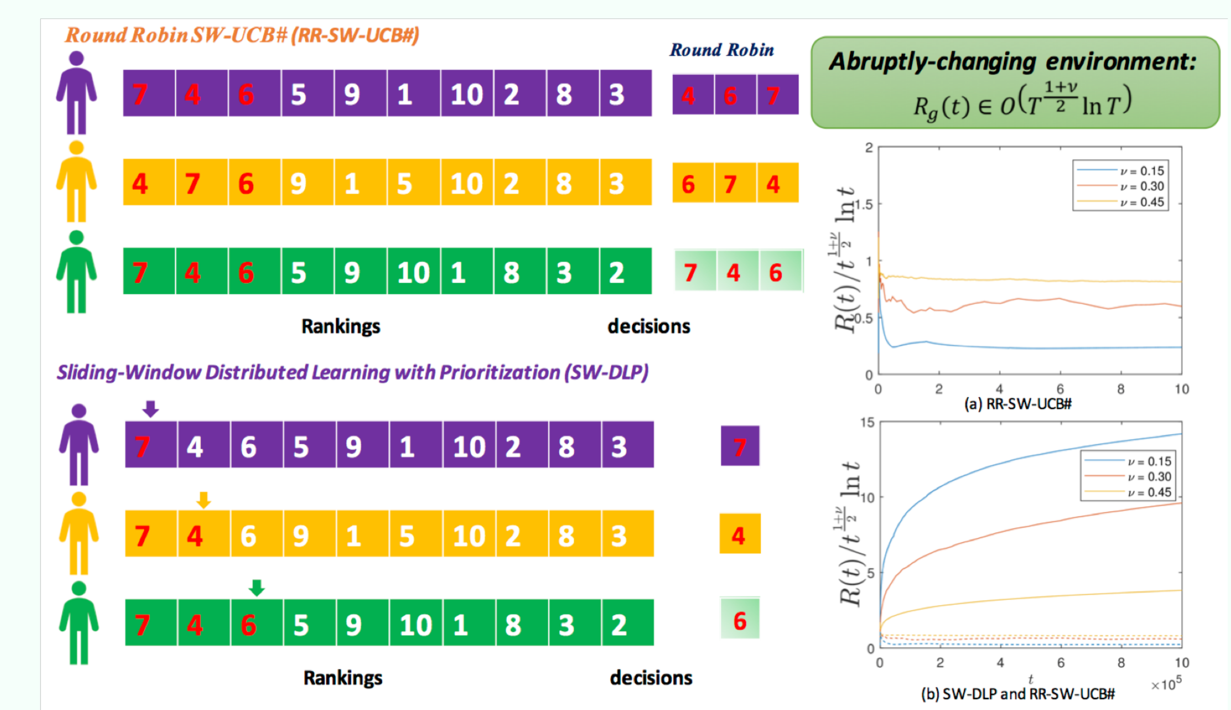
Advances in Underwater Search Algorithms

- A non-stationary multiarmed bandit framework
- M players (robots) searching N regions (arms)
- Minimize cumulative regret: total time spent in uninformative regions
- Abruptly/Slowly varying environment

Algorithmic Advances



Distributed Multiplayer Algorithms



Year 2 Objectives

- Integrating search algorithms in swimming pool experiments
- Algorithms for human-team attention allocation
- Experiments to assess cognitive state and validate attention allocation algorithms
- Photogrammetry using underwater imagery
- LED-based underwater communication system
- Extension of LED-based localization from 2-D space to 3-D space

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