National Aeronautics and Space Administration

Communication-Adaptive Navigation for Autonomous Multi-Robot Systems

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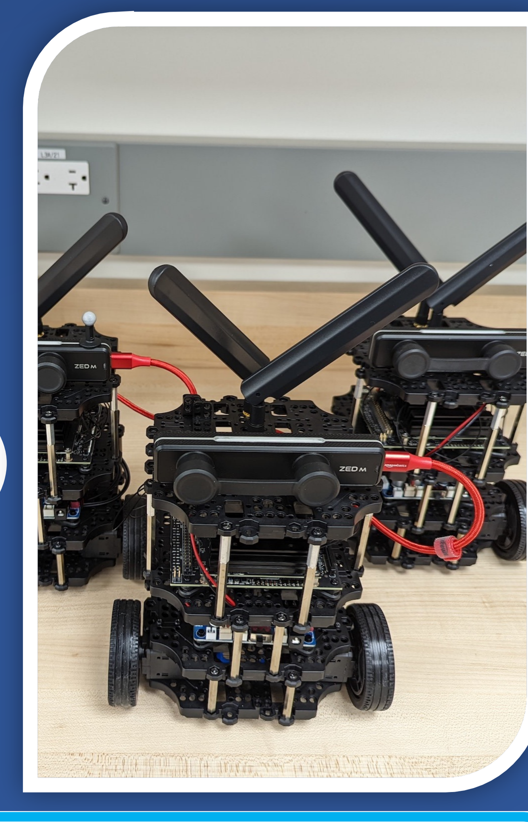
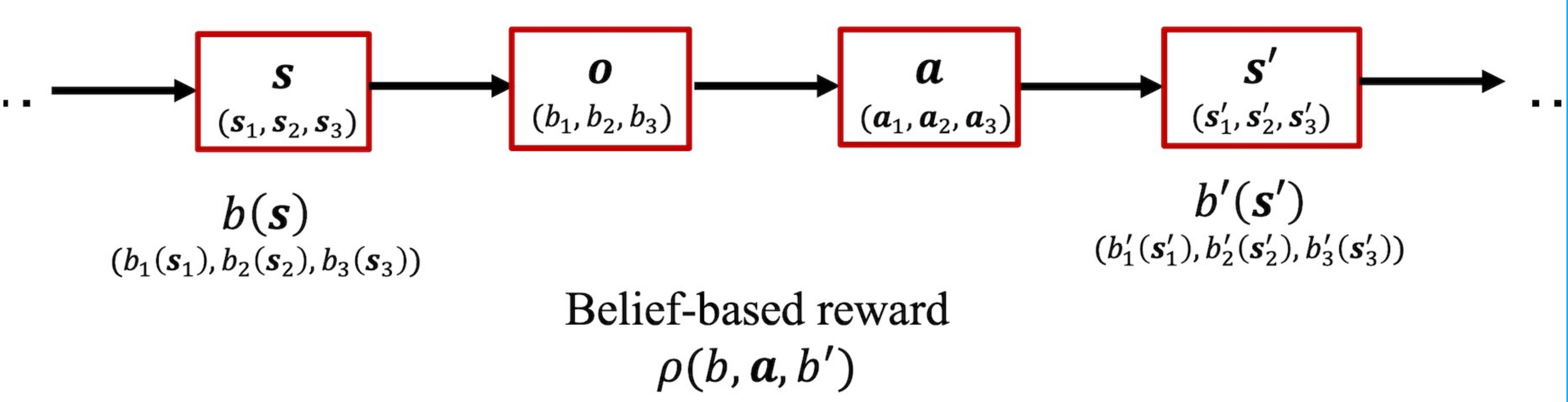
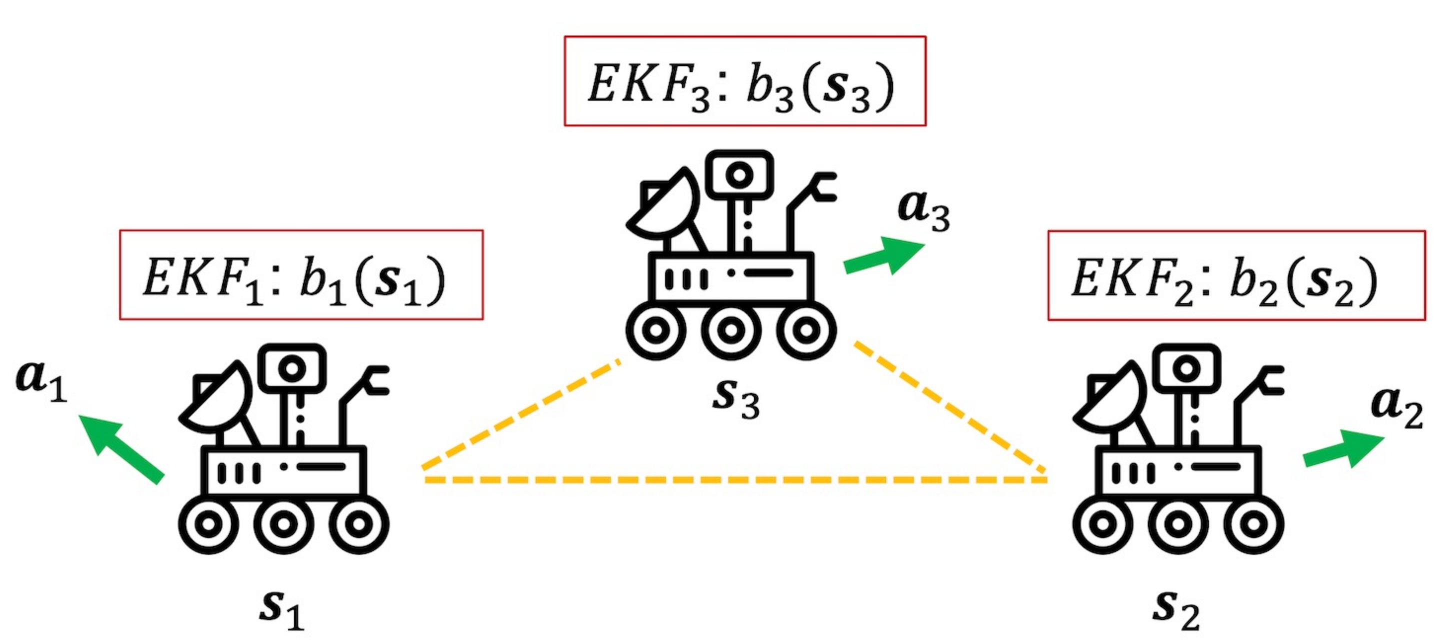
Strategic Focus Area: Multi-robot Teams and In-Space Assembly



Objective

- *Create a multi-robot collaborative navigation algorithm that allows agents to navigate towards goal positions while maintaining low position uncertainty.*
  - Dynamically handle position uncertainty of the multi-robot network by using a combination of inter-robot ranging measurements from ultra-wideband (UWB) ranging radios and vision navigation.
  - Investigate how the robots can adapt planned paths to receive inter-ranging measurements with more optimal geometry.



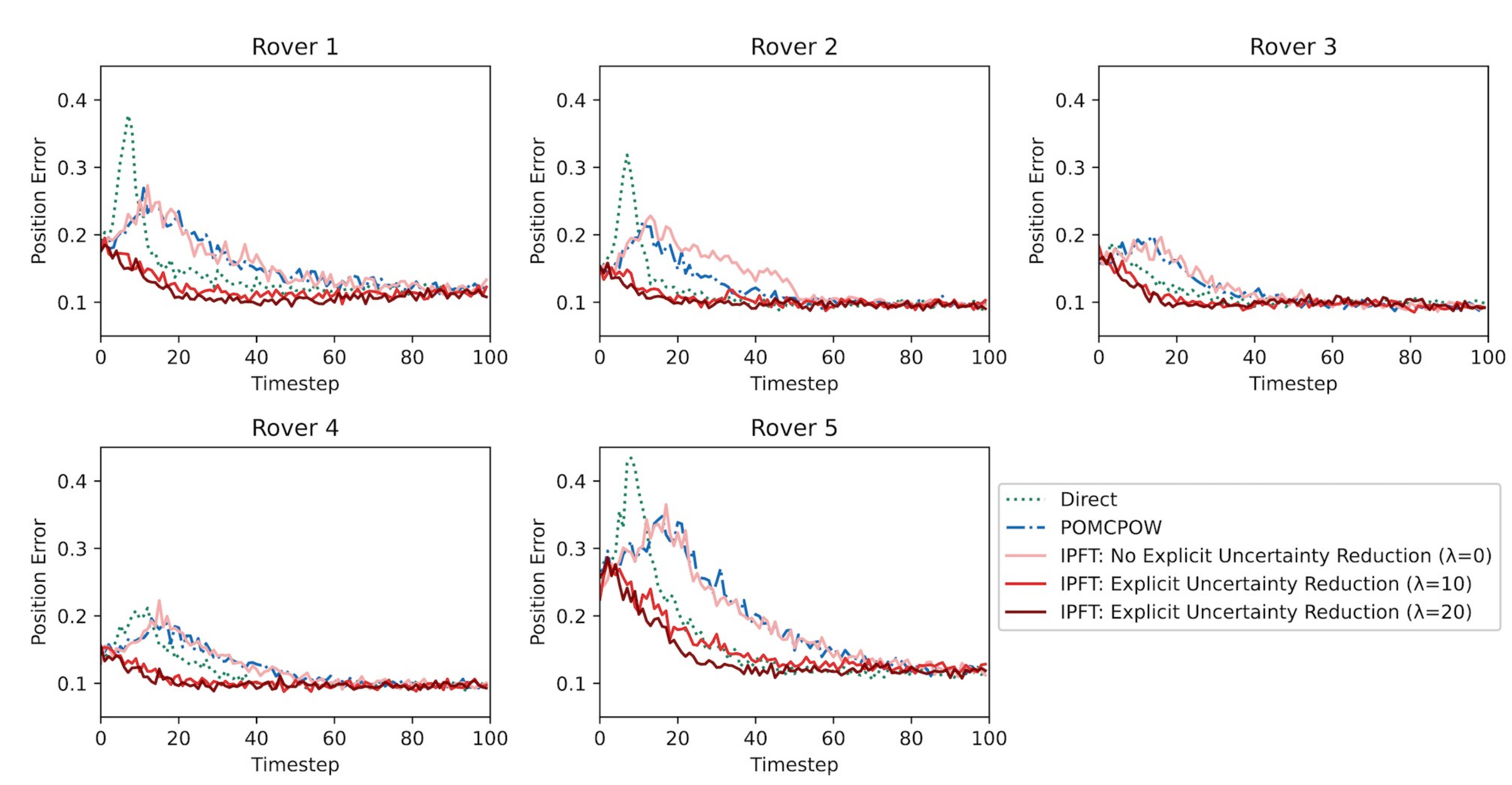


Background

- Position uncertainty can increase while using vision-based navigation when there are rapid changes in lighting, sudden movements, or few visual features in the field of view.
- To take advantage of a multi-robot system, path planning and navigation algorithms must be carefully designed to increase exploration coverage while minimizing positioning and map uncertainty as best as possible.

Approach and Results

- Algorithm creates a control strategy based on partially observable Markov decision processes (POMDPs) which allows the robots to reason about how their control actions will affect the position uncertainty of all robots.
  - The robots plan actions that lower position uncertainty by creating improved geometry for positioning using inter-robot ranging measurements from ultra-wideband (UWB) ranging radios.
  - Each robot deploys an extended Kalman filter (EKF), whose output is used as the observation as well as the belief in the POMDP.
  - To solve the POMDP, adapted the online information particle filter tree algorithm to be compatible with the EKF closed-form output being used as both the observation and belief.
- Shown in simulation to reduce position uncertainty by over 50% over a state-of-the-art sequential decision-making algorithm.



Significance/Benefits to JPL and NASA

- Significant improvement to uncertainty reduction as a result of considering sensing geometry when planning multi-rover paths
- Applicable to future multi-agent missions, such as CADRE or the proposed Mars Sample Return Helicopters, whenever position accuracy is critical.

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Publications:

Alexandros Tzikas*, Derek Knowles*, Grace Gao, and Mykel Kochenderfer, **Multi-robot Navigation using Partially Observable Markov Decision Processes with Belief-based Rewards**, *JAIS: Journal of Aerospace Information Systems.* Submitted.

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