Developing Principles for Effective Human Collaboration with Free-Flying Robots

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Interfaces that: **generalize** to distal or proximal users and **scale** to multiple robots

Framework to guide the design of at-a-glance signaling of robot state

Research Objectives

Advance fundamental knowledge of human-robot interaction principles that will support deployments of distributed teams consisting of humans and free-flying robots in critical NASA missions.

Two main innovations:
1. Framework for signaling robot status at-a-glance
   A. Novel signaling mechanisms
   B. Communicative planning module that can map robot communication goals to communication mechanisms

1. Novel robot tasking and supervisory interfaces designed for
   A. Scalability - supports operation of multiple robots
   B. Generalizability - supports distal (ground control) and proximal (crew) users
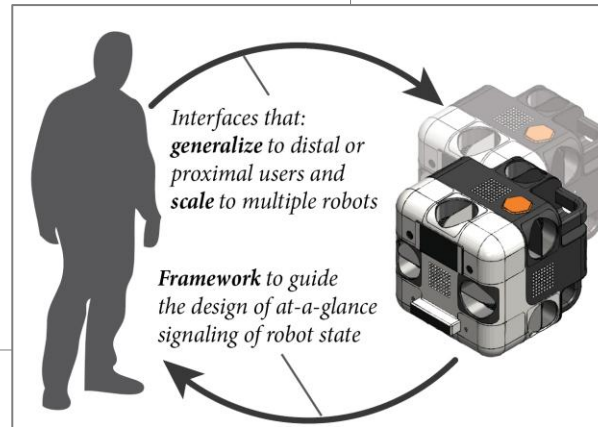
Approach

1. Build human-centered knowledge
   A. Conduct elicitation studies
   B. Model human-human behaviors
2. Prototyping
   A. Develop computational models
   B. Iterative design and continual refinement
3. Evaluation
   A. Validate using controlled laboratory experiments
   B. Two experimental scenarios:
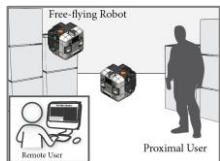
Surveys & Inspections
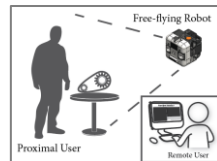
Task Monitoring & Guidance

Potential Impact

- Free-flying robots hold great promise in complementing human space exploration
- This research will radically improve the capabilities for free-flying robots to work in human environments (e.g., the ISS)
- Current TRL: 2 | Anticipated end TRL: 3 Justification: Free-flyers (e.g., Astrobee) are under development but little is known regarding how they can be designed from a human-centered perspective. This research will undertake a comprehensive design, implementation, and evaluation procedure culminating in experimental results that validate key design principles for robot signaling and interface design.
- This work will generate design principles and advance a framework for understanding human interaction with free-flying robots, with applications for both space exploration as well as the use of terrestrial free-flyers