The AstroNet: A Human-Centric Network of Free-Flying Space Co-Robots

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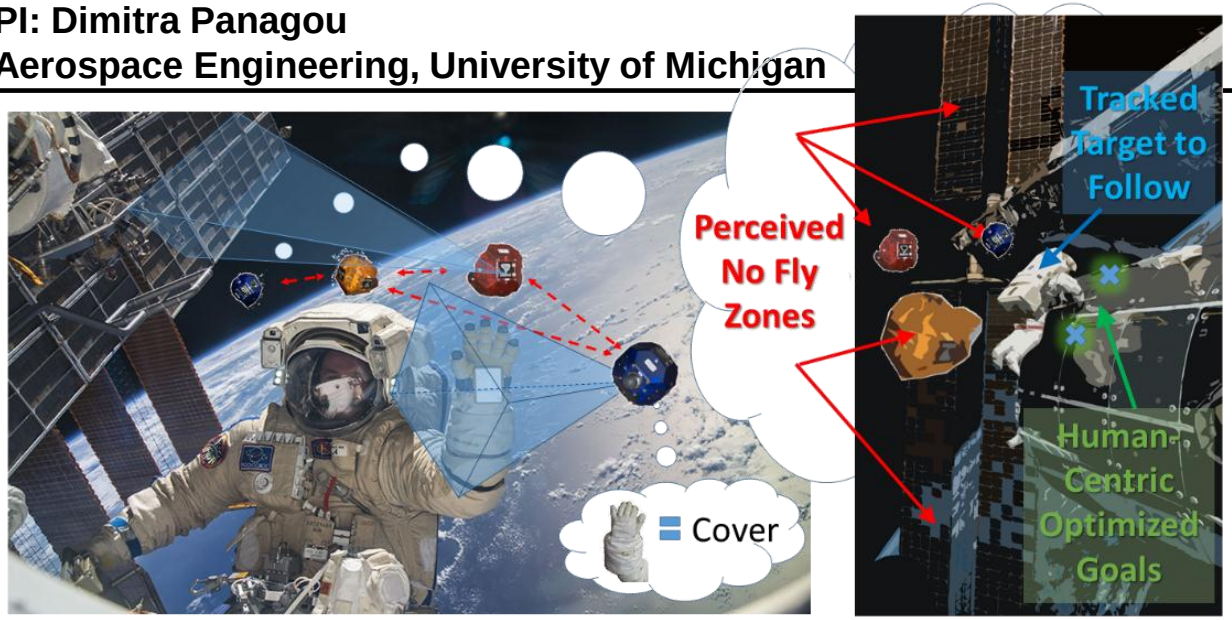

Envisioning the **Astronet**: A human-centric swarm of space co-robots to interact with the astronaut, and assist him/her in inspection and maintenance tasks.

Research Objectives

Motivation: **Assist the astronaut in EVAs** such as inspection and maintenance tasks via the **Astronet***: A human-centric network of free-flying space co-robots*. We will develop:

-- A set of human-centric tasks to be communicated to the Astronet by the human via simple gesture commands.
-- The guidance, navigation and control (GNC) processes for the Astronet so that it dynamically responds to human commands, and executes the assigned tasks in a safe, robust, human-centric manner, under minimal human supervision.
-- The proposed work is of start TRL 1, with projected end TRL 2.

Approach

We will consider **human-centric goals and performance metrics** to improve the conditions for the astronaut in spacewalk (e.g., accessibility of assets, viewpoints beyond line-of-sight, reduced operation time and fatigue).

We will link our **dynamic coverage control and model predictive motion planning** with (i) high-level human inputs, such as gestures, (ii) motion models for the 3D flight of free-floating vehicles, (iii) sensing models on the uncertainty of the on-board sensors of the Astronet, (iv) energy consumption models capturing the limited power resources of the Astronet, and (v) models of the anticipated human motion per task.

The Astronet will **safely surround and interact with the human**, and perform **swarming maneuvers that facilitate both the inspection task in a human-centric manner, as well as its own navigation and guidance**. The results will be validated on our multi-UAV testbed.

Potential Impact

The proposed research will:

-- Advance the GNC systems of human-centric space co-robots.
-- Reduce human fatigue and time-to-task-completion during EVAs.
-- Enable integration with technologies such as computer vision and audio processing, for agent actions driven by higher-level human cues, including complex recognition tasks (e.g., intent).
-- Have impact on other domains such as the active exploration and map building with unmanned vehicles, search-and-rescue robots, and domestic/service/advanced manufacturing robots.

In the short run, the Astronet could be realized via the SPHERES testbed in IVAs. In the longer run, we envision an Astronet of Astrobees in larger-scale, minimally-supervised inspection of the ISS exteriors. In the distant future of space exploration, the AstroNet could be an assistance technology in both unmanned and manned missions for the exploration of Martian surface and cavities.