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HUMAN FACTORS EXPERIMENT DESIGN PROCESS IN THE CONTEXT OF DEEP SPACE HABITAT MAINTENANCE OPERATIONS WITH AUTONOMOUS AGENTS

Abstract

Maintenance operations in space, such as those performed on the International Space Station, require a team effort between astronauts onboard and mission controllers on Earth. Astronauts onboard the space station are responsible for completing physical tasks, while mission controllers remotely assist them in real-time, thanks to low-latency communication. This collaboration enables the team to effectively address any issues that arise during maintenance operations, ensuring the safety and reliability of the space station. As interest grows in establishing deep space habitats for Moon and Mars missions, the involvement of mission control in real-time will become practically impossible due to increasing communication delays over long distances. To achieve safe and reliable Earth-independent operations, deep space habitats will require autonomous agents or systems taking the role of mission control for maintenance and other tasks. This means that we expect the teaming to shift from human-human, as seen between astronauts and mission controllers, to human-autonomy, involving astronauts and onboard autonomous agents. These autonomous agents are expected to provide assistance— or task execution support —in the form of guidance and oversight, decision support, and problem-solving. With this new type of teaming, it is crucial to understand team dynamics in experimental settings before implementation in future space habitats. Specifically, we need to assess human performance, self-confidence, and workload, as well as humans' trust and Human Factors Respect (HF Respect) levels for their autonomous agent teammates. HF Respect is a newly proposed construct to assess the willingness of humans to assist their autonomous agent teammates. This paper presents a design process for human factors experiments, including subject selection methods, task implementation, data collection methods, data analysis methods, and lessons learned. The design process is relevant for experiments with participants performing hands-on actions (e.g., disassembly, inspection, and assembly) while teaming up with an autonomous agent (e.g., a Large Language Model-based AI) that can answer questions and offer feedback/suggestions based on participants' requests.