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ADAPTIVE TRAINING USING VIRTUAL REALITY FOR ENTRY, DESCENT, AND LANDING DURING LONG DURATION EXPLORATION MISSIONS

Abstract

In long duration exploration missions (LDEM), there is a significant gap in time between when astronauts are trained pre-flight to perform mission-critical tasks, and when they are asked to perform them. This duration, coupled with cognitive changes due to the harsh environment of space[1], can lead to degraded performance that threatens mission success. Virtual reality (VR) has grown, not only as a tool for entertainment, but also for learning. As a low mass, customizable, and off-the-shelf hardware option, VR may be useful as an in-flight training aid for retaining mission-critical skills.

We developed an automated, adaptive VR training simulation of a Mars manually piloted Entry, Descent, and Landing. This trainer requires a user to select a landing site that optimizes proximity to scientific sites, pilot to that landing site using pitch and roll commands, and finally use a descent engine thruster to control vertical descent rate in order to land on the surface. To ensure this trainer is beneficial for individuals across a spectrum of skill levels, we developed a novel training algorithm that adaptively scales difficulty with user-specific skills acquisition. Based on the theory of flow[2], this algorithm uses independent 2-up-1-down staircases for each subtask: landing site selection, manual control, and terminal descent. A lockstep is included in the algorithm to prevent users from neglecting skill development in any one subtask. Through this lockstep, a user's difficult level in one subtask can be no larger than a delta of 1 level away from any other subtask. Simplified, qualitative feedback is provided to the user at the end of each trial to increase engagement and motivation.

To evaluate the efficacy of the adaptive VR trainer, subjects participated in one of three training methods: adaptive virtual reality, static difficulty (non-adaptive) virtual reality, or static difficulty in a non-immersive training environment. The non-immersive training environment involved a 2D, screen-based presentation of training. After training, subject performance was evaluated through a physical cockpit mockup. Skill transfer was evaluated using metrics of efficiency, errors, and human factors assessments of workload, situational awareness, and usability. We hypothesize that this training method will provide a novel approach for using virtual reality technology and adaptive difficulty algorithms to provide a customized solution for skill retention during LDEM.

[1] Strangman, G. E. et al. *Aviat. Space Environ. Med.* 85, 1033–1048 (2014)
[2] Csikszentmihalyi, M. (Harper Row, 1990)