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A COMPARATIVE GROUND STUDY OF PROTOTYPE AUGMENTED REALITY TASK GUIDANCE FOR INTERNATIONAL SPACE STATION STOWAGE OPERATIONS

Abstract

Astronauts currently require extensive, near-instantaneous guidance and instruction by ground-based crew to efficiently and successfully conduct flight operations. As missions take astronauts farther away from Earth and real-time communication between spacecraft and earthbound crew becomes impossible, astronauts will need technology that can help them execute flight operations with limited support. While research has shown that Augmented Reality (AR) can feasibly perform as an aid for completing certain flight tasks, there is little evidence that AR can assist in completing entire flight operations or improve flight performance metrics such as completion time.

In this work, we address stowage operations to investigate how AR can impact flight performance. During stowage operations, flight crew members transfer cargo items to and from different spacecraft modules. A recent stowage operation aboard the International Space Station (ISS) took 60 hours to complete with real-time ground crew support. The prolonged duration of stowage operations and the necessity for crewmembers to travel significant distances make it an appropriate domain for this investigation.

We introduce StowageApp, a prototype AR application deployed on Microsoft HoloLens, which we developed to assist astronauts in completing stowage operations. We describe the design of StowageApp and present the results of a user study comparing its performance to that of the current method of delivering stowage instructions on a touchscreen tablet. We are performing this 50-participant between-subject user study in the ISS Node 2 Harmony, Japanese Experiment Module "Kibo," Multi-Purpose Logistics Module "Leonardo," and Columbus mock-ups at National Aeronautics and Space Administration (NASA) Johnson Space Center in Houston, TX, USA. Each participant completes as many of a set of predetermined stowage tasks as they can in 45 minutes in their assigned condition. We measure task completion time, as well as the number of errors attributed to the participant. Participants also complete an unweighted NASA TLX survey and provide their opinions in a free-form exit interview. Eighteen of the participants are Inventory and Stowage Officers (ISOs) who support flight crew. Preliminary results from our ongoing study show that the AR condition produces a mean task completion time of 12.1 min. The experienced ISO who assisted in composing the tasks actively works with ISS crew and has estimated mean task completion time for these tasks using current touchscreen instructions to be about 36.75 minutes in flight (24 minutes on ground).