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DO YOU SEE WHAT I SEE?: INTERACTIVE VISUALIZATION OF MISSION DESIGN AND NAVIGATION

Abstract

Mission Design and Navigation (MDNav) is an intensive process requiring advanced computational resources, expert human intuition, and many successive human-in-the-loop iterations to hone in on acceptable trajectory designs or navigation solutions. The current bottleneck in MDNav is not the underlying computational algorithms but the human cognitive capacity to prune through a multitude of simulated results to select the few high-value candidates. One approach to alleviate this burden on human operators is through the judicious application of visually interactive environments that allow intuitive human assessment and real-time updates as options are explored. This approach calls for the application of human-centered design principles as well as an iterative prototyping and user feedback strategy to rapidly identify the most critical "pain points" of the MDNav process and generate potential solutions for future software infusion.

In this work, we present three case study visualizations that have the potential to increase human operator efficiency in MDNav, which can be summarized as follows: i) interactive direct manipulation

of the spacecraft trajectory in VR; ii) interactive visual querying of large set of Monte Carlo samples in mission feasibility analysis; and, iii) comparison of model universes and filter parameters, along with the comparison of output propagations to actual observations in navigation control. For each visualization problem, we showcase prototype implementations and discuss significant lessons learned for future software infusion. We identified these three specific cases by studying the larger space of data analysis problems in MDNav, where human input is required for interpretation. Accordingly, we also summarize human-in-the-loop data analyses utilized across various stages of MDNav mission support, starting from initial concept formation, trajectory design and optimization, orbit determination, flight path control, and finally, end-of-life disposal. With this broad survey of our current efforts, we hope to demonstrate the transformative capability of interactive data visualizations in improving mission development and operations, enabling operators to grow intuition, and communicating key concepts across diverse mission teams.