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SCIENTIFIC PHYSICAL AND OPERATIONS CHARACTERIZATION (SPOC) - COMBINING COGNITIVE AND BIOMECHANICAL ANALYSES TO INFORM PLANETARY SCIENCE EXPLORATION

Abstract

Future human planetary spaceflight missions to destinations such as the Moon or Mars aim to promote human scientific exploration, yet outside of the Apollo program, the spaceflight community at large has limited experience performing scientific exploration. An open area of research is designing future human missions to enable exploration in support of scientific goals. One approach to overcome this limited spaceflight experience is to learn from present-day expert scientists performing terrestrial scientific fieldwork. By studying and understanding the intrinsic work demands, constraints, and behaviors that field scientists must overcome and perform to achieve their scientific fieldwork objectives in present-day terrestrial settings, their scientific needs can be better understood within the context of proposed future missions and technologies. This paper presents the research formulation, prototype data capture systems, and preliminary testing results of the Scientific Physical and Operation Characterization (SPOC) project, which aims to better understand the constraints that shape the process of scientific exploration in present-day terrestrial fieldwork as a means to inform future spaceflight planetary exploration concepts of operations. This research employs two complementary methodologies, cognitive work analysis and wearable sensor measurement, to unpack the cognitive and biomechanical constraints that shape scientists' actions in field settings. This paper first describes the methodology associated with simultaneously assessing the cognitive and physical dimensions of field work to illustrate the utility and application of this combined approach. A detailed description is then provided of the data capture system and data processing pipeline used to study science field teams and streamline post hoc analysis. Three field-ready

data collection configurations were designed with combinations of commercial off the shelf audio, video, remote sensing equipment, and wearable inertial measurement units (IMUs), depending on the role of the personnel in the field team (i.e. the scientist, the cognitive researcher, the physical sensors researcher). Finally, this paper presents the cognitive and physical task characterizations of scientists' activities that resulted from incremental proof-of-concept data capture sessions with scientists performing field activities in both laboratory-based and natural environmental settings. By modeling a more complete representation of scientific fieldwork, these testing efforts will contribute to the formulation of necessary scientific capabilities and needs that promote scientific exploration, including informing future mission hardware and software development and mission concept of operations.