Unobtrusive Monitoring of Sensorimotor Performance in Ground-Based Functional Tasks

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Astronauts returning from long-duration exposure to microgravity frequently exhibit alterations in sensorimotor function leading to postural imbalance, impaired locomotion, and operational challenges to manual control. Mission duration often influences the severity of performance decrements, however individual responses vary as manifested by diverse adaptation timelines. Postflight disruptions during functional tasks are often detected through body-worn inertial measurement unit (IMU) devices. While IMU sensors are relatively compact, the long-term wear may lead to discomfort, displacement of the sensors on the body, and restrictions in movement or crew behavior. Although IMU data offers valuable insights from a research standpoint, interpreting changes in pre- and post-flight measures can be difficult for crew support personnel beyond the research domain, which can hinder the application to medical assessments and rehabilitation. Finally, the availability of inertial sensors in-flight is limited. There is a need for unobtrusive monitoring tools to improve our ability to monitor adaptation following gravitational transitions in various postflight evaluations and rehabilitation settings. Markerless motion capture is an evolving unobtrusive technology that builds upon decades of research with marker-based motion capture systems to provide three-dimensional human pose estimation from multiple synchronized two-dimensional camera views using deep learning algorithms. Markerless technology can revolutionize how data is captured pre- and post-flight and potentially in-flight during intravehicular activity by enabling pose estimation of multiple crew members from onboard camera hardware. The following paper presents the initial evaluation of a state-of-the-art commercial-off-the-shelf markerless motion capture system, Theia Markerless, compared to traditional IMU devices during various ground-based functional tasks and environmental conditions. Synchronous functional data collected using both motion capture and IMUs are analyzed for six subjects, four male and two female subjects of varying anthropometry. The analysis includes limited assessments of clothing, capture volumes, and the tool's sensitivity to detecting performance changes after a spaceflight analog centrifuge exposure. Results demonstrate comparable root mean square error to existing literature comparing markerless and marker-based motion capture systems. The development of visualization tools to enhance the application of the pose estimation output is also presented. These tools offer effective methods for anonymizing sensitive crew data, facilitating numerous applications across research, medical, and rehabilitation groups. The following work lays the foundation for future implementation leveraging markerless motion capture to assess the time course of recovery to baseline performance and provide insight for rehabilitation protocols to enhance crew readiness for the resumption of daily activities.

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