SPACE OPERATIONS SYMPOSIUM (B6)
Human Spaceflight Operations (1)

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A HYBRID DYNAMICAL SYSTEM METHOD FOR MODELING ASTRONAUTS' COMPLEX OPERATIONS DURING EXTRAVEHICULAR ACTIVITY

Abstract

Special study about astronaut's behavior during Extravehicular Activity (EVA) must be carried out in order to assure safety and effectiveness of crews and success of manned space missions. However, it is very difficult to analyze the astronaut's behavior during EVA in detail. Physical experiments can only represent one or several aspects of the space context but shade some important information. Traditional models based dynamical equations are only applicable for continuous systems, which lack information about the astronaut's ability to control his body and interact with objects during his operations. Fortunately, development of theory of the Hybrid Dynamical System (HDS) and associated methodology brings a chance for us to model the astronauts' behavior in an integrated framework, which means we can represent the complex process of the astronaut's active control along with dynamical models. In general, a HDS can be viewed as a dynamical system whose evolution depends on a coupling between variables that take values in a continuum and variables that take values in a finite or countable set. In the HDS model, kinematics and dynamics of the astronauts' motion can be described by continuous dynamics equations as usual, and active control from the astronauts can be describes by discrete events, then by integrating the two portions the astronauts' complex behavior model can be constructed with many advantages, for example, we can give the astronauts more advices for EVA operations and design detailed training to help them more accustomed to the microgravity environment and more skillful in the heavy EVA space suit. The HDS method in the paper is based on our previous work for several years, which includes a structure model of the astronaut in space suit with the backpack, a coupled forward-inverse dynamics model, and a sensor-actor model to describe the torque on the joints of the astronaut's body. A centralized-distributed control model is developed to describe the control behavior of the astronaut. Then these models are integrated into the HDS framework. Finally, in order to show the effectiveness and feasibility of the method, a simple example of payload operation during EVA is presented.