SPACE OPERATIONS SYMPOSIUM (B6)
Training Relevant for Operations, including Human Spaceflight (3)

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A VIRTUAL ASTRONAUT MODEL AND THE SIMULATION OF EVA

Abstract

The Shenzhou 7 space mission was the first extravehicular activity (EVA) mission of China. Neutral buoyancy training is the basic training of extravehicular activity. However, the difference between the neutral buoyancy and the real space should be thoroughly understood to improve the fidelity of space task training. Since there is no EVA record of Chinese astronaut, the direct comparison between the neutral buoyancy training and the EVA cannot be made. We try to use computer simulation to compare the difference between the real EVA and the neutral buoyancy training. In this study, a multi-body human dynamic model with space suit was developed to study suited human motions in real space and underwater. The model was constructed using the software ADAMS, and depending on the motion of interest, the degrees of freedom can be easily changed, making the model highly versatile. The parameters of the model can be set as the parameters of the real astronaut and the real space suit. The joint constraints are modeled as human joints, and the constraints of suit are also included. For each body of the model, the gravity acts on the mass center and the buoyancy acts on the geometric center. The modified form of Morison's equation was employed to evaluate the hydrodynamic forces. Point masses are set on the torso and limps of the model to simulate the lead weight of the neutral buoyancy training. This model can be easily changed to the model in weightless environment by deactivating the point masses, the hydrodynamic forces, the buoyancy and gravity. This model was used to compare the basic free motion between neutral buoyancy and weightless environment. We have found that the limp motion like swimming should be avoid in underwater training, and the astronaut could not feel conservation of moment of momentum underwater. We have used this model simulating the classic motion of Shenzhou 7 EVA mission, and found some useful results. To perform the same motion underwater and in real space, the astronaut should spent different torques; the value of torque may have a magnitude difference. We also found that some joint torqueses have exceeded the max of human, during underwater motions; however, it can be realized in weightless environment. This model can be used for neutral buoyancy training plan design and evaluation, and also for EVA optimization.