

MULTIBODY BASED DIGITAL ASTRONAUT DYNAMICS SIMULATION

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BACKGROUND:

This study provides the Software, Robotics, & Simulation Division at the NASA Johnson Space Center with a verification tool for multibody dynamics simulation requiring human motion. The motivation stems from current studies of several Vibration Isolation & Stabilization (VIS) system designs that attenuate the moments and forces which would be transmitted to a spacecraft during an exercise. A multibody dynamics model for a proposed VIS was available previously [1], therefore modeling of the VIS was not needed for this work. The interest here is in creating the multibody dynamics model of an astronaut in motion which may be utilized independently or while attached to a mechanism. An existing simulation [2] that utilizes OpenSim [3,4] and an in-house multibody dynamics package (MBDyn) [5] is used in order to verify the astronaut model. The main advantage this model will have over the existing simulation is that everything will be processed in one tool.

METHODS AND RESULTS:

Creating the simulation required; estimation of Body Segment Inertial Parameters (BSIP), a multibody model of the human-VIS system, joint acceleration profiles, and input files for MBDyn, which is used for this analysis. The scaling factors provided by Dumas et al. [6] are utilized in estimating the BSIP. Anthropometric data are used for estimating these parameters, the Anthropometric Survey of US Army Personnel (ANSUR II) [7] was the source. The astronaut model consists of 15 bodies, 14 joints and 32 degrees of freedom, with the dynamics topology generated using the center of mass locations and anthropometric data. MBDyn has an option for prescribed joint motion (PJM), which requires joint acceleration data as input. The joint angle data is first obtained from a motion capture system and then processed through code that has been created to generate approximate joint acceleration profiles.

The topology tree for the astronaut model begins at the right foot up to the pelvis where there is one branch for going down the left leg and another for the torso. The torso branch leads to branches for the arms and a leaf body for the head/neck segment. For attachment to the VIS, the heel of the right foot is connected to the VIS platform through a fixed joint, resembling a foot restraint. The left foot does not attach to the platform in order to prevent a system with a closed loop. Topology and symmetry of the astronaut model were verified through kinematic analysis. Further verification of the forces and moments transmitted to the VIS were verified against the existing simulation. There was a satisfactory level of agreement when testing a simple motion, for example, rocking back and forth. Full exercise motions are to be tested soon.

The main outcome has been a novel application of MBDyn for biomechanics modeling that is now available for dynamic simulations involving human motion. The estimation of BSIP was another useful result of this study, requiring only 15 inputs for generating mass properties of a theoretical astronaut model. Expansion on this work is possible by going through an alternative route in obtaining the joint motion data. Instead of high-tech and often expensive motion capture systems, an individual may watch videos with high focus and at a slow motion for each individual segment in order to determine the initial and final time and angle for that specific degree of freedom. Synthetic trajectories may also be created if there is no video reference available.

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