Spacecraft Simulator Manual Control Using Reaction Wheels and Immersive Virtual Environments

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March 1, 2004

Tracking control laws are applied to spacecraft simulators to study the effect of immersive virtual environments on the ability of a human operator to perform manual attitude control tasks. The three degree of freedom (DOF) spacecraft simulator, located in the Virginia Tech Space Systems Simulation Laboratory (SSSL), consists of a test-bed mounted on a low friction, hemispherical air-bearing, allowing full rotational freedom about one axis and constrained rotation about two axes. Actuation of the simulator is achieved with momentum exchange by using three rigid, axisymmetric wheels controlled by axial torques. Solid-state rate gyros are used to estimate the attitude of the spacecraft simulator. The human operator controls the simulation while viewing a visual interface from within the Virginia Tech Cave Automatic Virtual Environment (VT-CAVE). The operator uses the motion of a six DOF tracked input device to specify the torque level to apply to a reference body, in this case an ideal rigid body making up the spacecraft simulator. Modified Rodriquez Parameters (MRPs) are used to describe the attitude kinematics. The nonlinear tracking control law computes the axial motor torques needed to track the motion of the reference body with the spacecraft simulator, using the angular velocity error and MRP error. The overall effectiveness of the system is evaluated and recommendations given for future improvements.