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RESEARCH ON ANALYTICAL INVERSE KINEMATICS ALGORITHM FOR SERVO MECHANISM OF SWINGING NOZZLE

Abstract

For the thrust vector control(TVC) servo mechanism of solid rocket driven with a pair of mutually perpendicular servo actuators, in order to overcome the shortcomings of the zero position offset due to the dynamic deflection of its swinging pivot, as well as the coupled motion between the two control channels due to a non-ideal configuration, a three-dimensional rigid body kinematics model is derived using the Euler's rotation theorem, and an analytical inverse-kinematics steering law is given. The definition of the swinging angles used as inputs in this model is consistent with what is used in the linearized dynamics model in control system design, and it can demonstrate the influences on the length of servo actuators and the angle sensors caused by the deflection of swinging pivot and the changes of swinging angle commands, all at the same time. So, its results could be compared directly with the raw data acquired from measurements in the experiments. For a given set of constraints and configuration data, by comparing the results with an existing article using an implicit algorithm, and with a 3D CAD software, all results are matched precisely. This model is derived with definite physical meaning and with a precise and easy-to-use definition of swinging angle. Moreover, its algorithm is in explicit form, so it is appropriate to be used in the real-time software embedded in flight control computers. The proposed algorithm has been utilized in the process of development of the "Kinetica(Lijian) 1" launch vehicle, and the results from the ground test of the solid rocket motor as well as the flight test have been analyzed.