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漂浮基空间机器人捕获卫星过程动力学模拟及捕获后混合体运动的RBF神经网络控制

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Dynamics Modeling for Free-floating Space-based Robot During Satellite Capture and RBF Neural Network Control for Compound Body Stable Movement

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摘要

讨论了漂浮基空间机器人在轨捕获目标卫星过程的碰撞动力学建模,以及捕获操作结束后空间机器人与卫星混合体的稳定控制问题。首先采用多刚体动力学建模方法并结合空间机器人捕获目标卫星过程中的碰撞动力学特性,建立了漂浮基空间机器人在轨捕获漂浮卫星过程的动力学模型,并在此基础上计算出完成捕获操作后空间机器人与目标卫星混合体关节的运动速度。然后针对卫星及空间机器人系统惯性参数均是未知的复杂情况,应用上述模型、神经网络控制理论和Lyapunov稳定性理论,设计了空间机器人与卫星混合体在捕获过程碰撞冲击影响下稳定运动的高斯径向基函数神经网络控制方案,以达到对捕获卫星的有效控制。此外,高斯径向基函数神经网络控制方案具有不需要测量和反馈载体位置、移动速度与加速度的显著优点。系统数值仿真证实了上述控制方案的有效性。

关键词: 漂浮基空间机器人 在轨捕获卫星 碰撞动力学建模 稳定运动 高斯径向基函数 神经网络

Abstract:

This paper discusses the collision dynamics modeling of a free-floating space-based robot in the process of on-orbit satellite capturing, and it also analyzes the stability control for the compounded body of the space-based robot and target after the capturing operation is completed. First the method of multibody system dynamics modeling is employed in combination with the characteristics of collision dynamics of the space-based robot while it captures the target satellite to set up a dynamics model for the free-floating space-based robot during its on-orbit capture of the floating satellite. Based on it, the movement speed for the compounded body of the space-based robot and target is calculated. In view of the fact that for the inertia parameters of both the satellite and the space-based robot system are unknown, the model and the theory of neural network control and Lyapunov stability theory are used to design a Gaussian radial basis function neural network control scheme for the compounded body to move stably under the influence of collision and impact during the capturing process. Thus, the effective control is realized for capturing a target satellite. The Gaussian radial basis function neural network control scheme has the obvious advantages of requiring no feedback and measurement of the position,velocity,acceleration,attitude angle velocity and attitude angle acceleration of the floating base. Finally, the validity and applicability of the control scheme are manifested by system numerical simulation.

Keywords: free-floating space-based robot on-orbit capture satellite collision dynamics modeling stable movement Gaussian radial basis function neural networks

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