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欠驱动机器人的动力学耦合奇异研究

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Study on Dynamic Coupling Singularity of Underactuated Manipulators

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摘要

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摘要 欠驱动机械臂的运动只能从动力学水平进行控制,从动关节的运动是通过主动关节的动力学耦合间接控制的。主、被动关节之间的动力学耦合特征与机械臂关节空间的位形有关,因此在欠驱动机械臂运动过程中可能发生动力学耦合奇异,某些被动关节的运动变得不可控。从关节空间和操作空间两个角度分析了欠驱动机械臂的动力学耦合问题,给出从以上两种工作空间度量系统动力学耦合的指标。提出一种基于输入变量非线性变换的滑模变结构控制方法,用于实现欠驱动机械臂操作空间中的连续轨迹控制。通过平面二连杆欠驱动机械臂和只有一个主动关节的平面三连杆欠驱动机械臂进行了仿真,仿真结果证明提出的控制方法是可行的。

关键词: 欠驱动 机械臂 动力学奇异 非线性控制 非完整约束

Abstract: The motion control of an underactuated manipulator can be realized on dynamic level only, and the motion of the passive joint is controlled by the actuated joint indirectly. The controllability of the underactuated manipulator depends on the dynamic coupling between the actuated joint and the passive one. Ulteriorly, the dynamic coupling of the system is related to the configuration of the manipulator in joint space. Therefore, the dynamic singularity could be happen in the motion of the system, where some passive joints are uncontrollable. In this paper, the dynamic singularity of the underactuated manipulators is analyzed form two points of views, the joint space and task space. Two measures of the dynamic coupling singularity are proposed according to the two aspects. Furthermore, a sliding mode control method based on the nonlinear transformation on inputs is suggested for the continuous trace-tracking task of the underactuated manipulator system. A planar three joint manipulator, which has one actuated joint, is utilized to simulate thes conclusions and to test the suggested control method. The simulation result shows the method is feasible.

Keywords: underactuated manipulators dynamic singularity nonlinear control nonholonomic

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