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SE(3)上一般力学控制系统的运动描述与飞行器建模

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Kinematic Description of a General Mechanical Control System on SE(3) and Aircraft Modeling

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摘要 与Lie群上的简单力学控制系统不同,Lie群上的一般力学控制系统需要考虑势能在位形空间中的变化,故其Lagrange算子不再是左不变的,这意味着根据定义Euler-Poincaré方程不能直接应用于此类系统。为此,本文首先建立矩阵Lie群SE(3)上的一般力学控制系统的数学描述,重新定义Lagrange算子为左不变动能减势能;然后基于连续Lagrange-d’Alembert法则推导得到了含有势能函数的Euler-Poincaré方程,用来刻画SE(3)上一般力学控制系统的动态;最后给出了四旋翼无人直升机和无人飞艇建模的应用实例。

关键词： 一般力学控制系统 矩阵Lie群 左不变 Euler-Poincaré方程 四旋翼直升机 飞艇

Abstract： Unlike simple mechanical control systems on a Lie group, a general mechanical control system on a Lie group includes a variable potential in configuration space, which makes it impossible for the Lagrangian of such a system to be left-invariant. This means, by definition, that the Euler-Poincaré equation cannot be applied directly to such a system. This paper first introduces the mathematical definitions of a general mechanical control system on matrix Lie group SE (3). Secondly, by redefining the Lagrangian of left-invariant kinematic energy minus potential energy, a modified Euler-Poincaré equation involving a potential function is deduced and obtained based on the continuous Lagrange-d’Alembert principle to describe the dynamics of the general mechanical control systems on SE(3). Finally, two applications of modeling an unmanned quadrotor and an unmanned airship are presented to verify the proposed approach.

Keywords： general mechanical control system matrix Lie group left-invariant Euler-Poincar? equation quadrotor airships

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