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一种共轴式直升机操纵机构的运动学建模与分析

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Kinematic Modeling and Analysis of a Coaxial Helicopter's Actuating Mechanism

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摘要

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摘要

共轴式直升机操纵机构的输入/输出运动学关系复杂、非线性严重,不同通道间控制耦合大,其中航向采用全差动的操纵机构最为复杂。为了分析用比例关系简化建模所引起的误差及利用逆运动学进行操纵系统线性化,必须对操纵机构运动学进行精确建模。针对一种航向全差动操纵机构,首先,运用机构学原理,通过去除约束、局部自由度对机构进行简化,计算得到操纵机构自由度;然后,将操纵机构分为3个子模块,通过对每个模块应用空间机构位置分析方法进行正向、逆向运动学推导,建立系统完整的运动学模型;利用光学测量原理设计了测试系统,并通过实验验证了所建模型的正确性;最后给出了所建模型在共轴式直升机建模、操纵解耦及线性化方面的应用方法。

关键词: 直升机 操纵机构 运动学 建模 自由度

Abstract:

The kinematic relationship between the input and output of a coaxial helicopter's actuating mechanism is complicated and seriously nonlinear, and coupled among different channels as well, especially for the mechanism in yaw control which is fully-differential. For the purpose of error analysis on simplified modeling using proportional relationships, and linearization on the actuating system by inverse kinematics, it is necessary to model the actuating mechanism precisely. With regard to a fully-differential actuating mechanism, the over-constraint and local degrees of freedom are firstly eliminated based on the theory of mechanism, to calculate the total degrees of freedom of the actuating mechanism. Next, after dividing the mechanism into three sub-modules, the method of position analysis of spatial mechanisms is applied to derive the forward and inverse kinematic model of each sub-module to establish the complete kinematic model. Then a measurement system is designed based on the principle of optical measurement, and the established model is verified to be correct through experiment. Finally, the method of application with the established model to the modeling, actuating decoupling and linearization of coaxial helicopters is provided.

Keywords: helicopter actuating mechanism kinematics modeling degree of freedom

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