Modeling and nonlinear energy-based anti-swing control of underactuated dual ship-mounted cranes systems

Die Hu (✉ 202032803009@stu.hebut.edu.cn)

Hebei University of Technology <https://orcid.org/0000-0002-1564-6272>

Yuzhe Qian

Hebei University of Technology <https://orcid.org/0000-0002-9734-2132>

Yongchun Fang

Nankai University

Yuzhu Chen

Hebei University of Technology

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Abstract

As the volume and the mass of the payload increases, it is often necessary to use two ship-mounted cranes to jointly transport huge payloads under marine environment. Compared with a single ship-mounted crane, dual ship-mounted cranes contain more state variables, geometric constraints and coupling dynamics, which bring more challenges in kinematic analysis and controller design for such complicated underactuated systems. In order to solve these problems, the dynamic model of the dual ship-mounted cranes systems are established based on Lagrange's method. Considering different practical requirements, two energy-based nonlinear controllers for dual ship-mounted cranes are developed, including a full state feedback control method and an output feedback control method. More preciously, during the control design process, the saturation constraints of the controllers have been fully considered. Meanwhile, the proposed controllers can achieve accurate positioning of the double-constrained derricks as well as effective elimination of payload swing. The stability of the equilibrium point of the closed-loop system is analyzed by using Lyapunov techniques and Lasalle's invariance principle. As far as we know, the modeling and the output feedback controller design of dual ship-mounted cranes are proposed for the first time in this paper. At the same time, the design and analysis process does not need to linearize the complex nonlinear dynamics equations, while the proposed output feedback control method is robust against the situations when the velocity signals are unknown/unavailable. Finally, a series of experiments are carried out to verify the effectiveness of the proposed nonlinear controllers.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

Figure 1

Illustration for the dual ship-mounted cranes system.

Figure 2

Experiment 1: Full state feedback controller experiment results(blue solid lines: experimental result for the full state feedback controller, red dash lines: desired value).

Figure 3

Experiment 2: Output feedback controller experiment results(blue solid lines: experimental result for the output feedback controller, red dash lines: desired value).

Figure 4

Experiment 3: Experimental results of robustness verification (blue solid lines: experimental result for the full state feedback controller, green solid lines: experimental result for the output feedback controller, red dash lines: desired value).

Figure 5

Experiment 4: Experimental results of wave interference in uence(blue solid lines: experimental result for the full state feedback controller, green solid lines: experimental result for the output feedback controller, red dash lines: desired value).