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Double Pendulum Tower Crane Fuzzy Adaptive Controller Design with Distributed Mass Payload

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Abstract

Tower cranes are a type of very effective transportation gear that are frequently utilised on building sites. The investigation into Distributed Mass Payload (DMP) issues has received increased interest as a result of the volume and mass of payload being delivered rising. However, the majority of the control algorithms now in use, which were created for Concentrated Mass Payloads (CMP), are insufficient to handle the demands of practical production. The fundamental distinction between DMP and CMP is the inability of DMP to adequately reduce the residual payload swing brought on by inertial torque, which creates safety risks. Additionally, due to the variable working environment, it is challenging to collect precise system characteristics (such as mechanical frictions and air frictions), which results in positioning mistakes. We first create a mathematical model of a Double-Pendulum Tower Crane with Distributed Mass Payload (DTCDMP) and do a dynamic analysis to address the aforementioned problems. Then, we suggest a fuzzy adaptive control system that can accomplish precise positioning and efficient anti-swing and has a good tracking effect against external disturbances and parameter uncertainties. The system's stability is then firmly demonstrated using the Lyapunov technique and LaSalle's invariance principle. The effectiveness and robustness of the proposed controller are lastly confirmed through multi-group comparative studies on the basis of tracking the S-shaped trajectories.

Keywords: ***Tower cranes, Under actuated systems, Distributed mass payload***

Introduction

Due to its advantages of having fewer actuators and a straightforward structure, the crane system has been extensively employed with the growth of modern industry in many production departments such as factories, mines, construction sites, etc. However, a crane is an under-actuated system since it has fewer independent inputs than degrees of freedom and typically exhibits strong coupling between system states (jib rotation, trolley movement and cargo swing). This makes it very difficult to eliminate swing angles while maintaining positioning (jib rotation and trolley displacement) during operation. Scholars from several nations have been interested in the crane control issue. Several control techniques, including the input shaping method, trajectory planning method, partial feedback linearization, nonlinear coupling control, adaptive control, sliding mode control, neural network method, and other control algorithms, have also been put forth in this respect. It has been determined after rigorous examination that the literature mentioned above is mostly for the crane system with a single pendulum effect. However, the mass of the hook cannot be disregarded in actual applications. Therefore, throughout the swing phase, it is simpler to demonstrate the double-pendulum effect. We also need to think about things like payload volume and shape. The payload has features of distributed mass. The DMP swing phenomena is more intricate. Because of this, academics have also proposed some useful ideas and produced specific outcomes. For the bridge crane system's payload multi-modal vibration management challenge, Jaafar et al. suggested a model reference command shaping solution. It is more resilient than the derivative zero vibration shaper and the multi-modal zero vibration shaper. For the double-pendulum bridge crane system with variable rope length, Lu et al. developed an increased coupling adaptive control

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approach. Platform experiments were used to confirm the method's efficacy. Ouyang et al. developed a controller based on energy shaping to realize the trolley positioning and payload swing suppression in the double-pendulum bridge crane system.

Conclusion

For the controlling objective of DTCDMP, a fuzzy adaptive controller was created in this study. The adaptive controller and the fuzzy controller are the two components of the suggested controller. In this study, system energy is first expressed. An adaptive controller was created using the proposed scalar function in accordance with the system energy expression. Then, to further enhance its positioning precision and anti-sway function, we introduced fuzzy control while taking into account the real-time control of actual operation. Finally, numerous comparative tests have demonstrated that the suggested controller still performs superbly even in the presence of variable model parameters, non-zero beginning angles, and external disturbances.