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TUNING CONTROLLER PARAMETERS OF SLIDING MODE CONTROL USING OPTIMIZATION ALGORITHMS FOR UNCERTAIN NONLINEAR SYSTEMS

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Abstract. This paper presents an innovative approach for tuning controller parameters of sliding mode control applied to uncertain nonlinear systems. The proposed methodology leverages the Jaya algorithm, a robust optimization technique, to enhance the efficiency and stability of the control system under varying conditions. Given the complexities and uncertainties inherent in nonlinear systems, precise tuning parameters of the sliding mode control is critical for optimal performance. This study systematically investigates the effects of different parameter configurations on system behavior and stability, employing the Jaya algorithm to effectively search the parameter space and converge on optimal tuning values. Simulation results demonstrate that the sliding mode control optimized by the Jaya algorithm significantly outperforms traditional parameter tuning methods, providing improved tracking performance and robustness against disturbances. The efficacy of the proposed method is supported by a numerical example of an inverted pendulum mounted on a cart.

Introduction. This paper presents a novel approach for tuning the parameters of Sliding Mode Control using the Jaya Algorithm, designed specifically for uncertain nonlinear systems. The author demonstrates how the integration of the Jaya Algorithm with Sliding Mode Control not only enhances the control performance but also ensures adaptability to varying system characteristics and external disturbances. The proposed method is validated through simulation studies, illustrating its effectiveness in optimizing control parameters and improving system response. The results indicate significant performance improvements over traditional parameter tuning methods, thereby offering a practical solution for robust control in uncertain nonlinear environments. The results of Jaya's algorithm are compared with other optimization algorithms to confirm the superiority of this algorithm.

Main part. Tuning Controller Parameters of Sliding Mode Control using Jaya Algorithm for Uncertain Nonlinear Systems is designed as below:

1) Design of Sliding Mode Control of Uncertain Nonlinear Systems [1-3].

In this part, the design of sliding mode control of uncertain nonlinear systems is described. After that, the stability of the system with this control law is proved by using the Lyapunov function.

2) Tuning Controller Parameters of Sliding Mode Control using Jaya Algorithm [4-6].

In this part, the Jaya algorithm is presented. Jaya algorithm is an effective method to find optimal parameters based on an objective function [7-9]. A general schematic diagram describing the proposed method is illustrated.

3) Numerical Example of Inverted Pendulum on Cart [8-9].

In this part, to illustrate the effectiveness of the proposed method, the author gives an example with an inverted pendulum on a cart. This is a complex nonlinear object that includes uncertainties, such as the masses of the cart and pendulum and the unknown disturbances. The results of Jaya's algorithm are compared with other optimization algorithms (TLBO, GA, PSO) to confirm the superiority of this algorithm.

Conclusion. This paper has successfully demonstrated the efficacy of the Jaya Algorithm in tuning controller parameters of Sliding Mode Control for uncertain nonlinear systems. The proposed method not only enhances the robustness and performance of the control system but also effectively addresses the challenges posed by system uncertainties and nonlinearities.

The experimental results reveal that the Jaya Algorithm significantly improves the convergence speed and accuracy of the tuning process compared to traditional methods. By using optimizing parameters, the SMC ensures better trajectory tracking and reduced chattering effects, making it suitable for real-world applications where perturbations and disturbances are prevalent.

Furthermore, the comparative analysis with existing tuning techniques highlights the advantages of the Jaya Algorithm in terms of computational efficiency and solution quality. Future work could explore the integration of this tuning methodology with other advanced control strategies to further enhance performance and applicability across a broader range of systems.

The authors intend to utilize this technique in the future to adjust the coefficients of further intelligent controllers for uncertain nonlinear systems impacted by unknown disturbances.

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