Utilizing P-Type ILA in tuning Hybrid PID Controller for Double Link Flexible Robotic Manipulator

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***Abstract*— The usage of robotic manipulator with multi-link structure has a great influence in most of the current industries. However, controlling the motion of multi-link manipulator has become a challenging task especially when the flexible structure is used. Currently, the system utilizes the complex mathematics to solve desired hub angle with the coupling effect and vibration in the system. Thus, this research aims to develop the controller for double-link flexible robotics manipulator (DLFRM) with the improvement on hub angle position and vibration suppression. The research utilized DLFRM modeling based on NARX model structure estimated by neural network. In the controllers' development, this research focuses on adaptive controller. P-Type iterative learning algorithm (ILA) control scheme is implemented to adapt the controller parameters to meet the desired performances when there are changes to the system. The hybrid PID-PID controller is developed for hub motion and end point vibration suppression of each link respectively. The controllers are tested in MATLAB/Simulink simulation environment. The performance of the controller is compared with the fixed hybrid PID-PID controller in term of input tracking and vibration suppression. The results indicate that the proposed controller is effective to move the double-link flexible robotic manipulator to the desired position with suppression of the vibration at the end of the double-link flexible robotic manipulator structure.**

Keywords—robotic manipulator, flexible, Iterative learning algoritmn , vibration suppression

I. INTRODUCTION

The advancements in various field of life inclusive of domestic and industries create a great demand for flexible robot manipulator. Many robot manipulator applications are categorized as multiple-input-multiple-output (MIMO) systems due to multi-link structure. The design and tuning of multi-loop controllers to meet certain specifications are often the pullback factor because there are interactions between the controllers. The system must be decoupled first to minimize the interaction or to make the system diagonally dominant. Moreover, the reduction of vibration on flexible structure of robot manipulator must be treated at the same time. The continuous stress produced by the vibration can lead to structural deterioration, fatigue, instability and performance degradation. Thus, the reduction of vibration on flexible structure of robot manipulator is of paramount importance. Though many researchers have successfully produced the controllers for multi-link flexible manipulator, the control scheme developed involves complex mathematics to solve the coupling effect and vibration simultaneously. As a result, it consumes a lot of time in numerical computation which leads to higher computational cost. Thus, the drawback received substantial attention to cater recent industries demand in various applications. On-going researches focused on improving the control methods to fulfill all the conflicting requirements.

The study of adaptive controller in flexible manipulator remained until today due to its significant contribution in actual plant. Among them, a new Nonlinear Adaptive Modal Predictive Controller on two link flexible manipulator with various payload was carried out [1]. The controller could generate appropriate adaptive torque to control tip trajectory tracking and fast suppression of tip deflection. Besides, indirect control of Self-Tuning PI controller of two link flexible manipulator tune by Neural Network was proposed [2]. Simulation results showed that the tuning parameters obtain could suppress the vibration and track the desired joint angles effectively. E. Pereira et al. have investigated the use of adaptive input shaping using an algebraic identification for single-link flexible manipulators with various payloads [3]. Experiment results proved that the proposed control managed to follow tip trajectories in shorter time. Another research on adaptive controller was comprised of a fast on-line closed-loop identification method combined with an output-feedback controller for single link flexible manipulators [4]. Experimental results showed that the controller manage to follow the trajectory tracking.

Another type of adaptive controller that is iterative learning algorithm (ILA) has been implemented in different control

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