Implementation of PID Based Controller Tuned by Evolutionary Algorithm for Double Link Flexible Robotic Manipulator

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Implementation of PID based controller tuned by Evolutionary Algorithm for Double Link Flexible Robotic Manipulator

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***Abstract*—The paper investigates the development of intelligent hybrid collocated and non-collocated PID controller for hub motion and end point vibration suppression of double-link flexible robotic manipulator. The system was modeled using multi-layer perceptron neural network structure based on Nonlinear Autoregressive Exogenous (NARX) model. The hybrid controllers are incorporated with optimization algorithm that is ABC and PSO to find out the parameters of the PID controllers. Numerical simulation was carried out in MATLAB/Simulink to evaluate the system in term of tracking capability and vibration suppression for both links. Performance of the controllers are compared with the hybrid PID-PID Ziegler Nichols (ZN) controller in term of input tracking and vibration suppression. The results show that PSO revealed the superiority over ABC in controlling the system. The system managed to reach desired angle for both hub at lower overshoot using proposed method. Meanwhile, the vibration reduction shows great improvement for both link 1 and 2. This signifies that, the PSO algorithm is very effective in optimizing the PID parameters.**

Keywords—Flexible Manipulator, Neural Network, Particle Swarm Optimization, Artificial Bees Algoritmn, Vibration suppression

I. INTRODUCTION

Despite various advantages shown by flexible manipulator such as offers cost reduction, lower power consumption, improved dexterity, better maneuverability, safer operation and light-weight, the undesirable vibration is the common shortcoming occurred in the structure. In order to satisfy the conflicting requirements, number of researches on improving the control methods have been carried out.

Among available wide range controllers, PID controller is still the most widely used in the industrial environment for MIMO systems because they are capable of providing a satisfactory performance in spite of their simple structure and intuitiveness. The main issue of PID controllers is to tune the gains. Other than that, PID controller is still significant because of its robustness performance in a wide range of operating condition and easy to implement.

There is few researches that consider double link flexible robotic manipulator (DLFR) using PID controller. The decentralized PI-PID controller for DLFR have been proposed in [1-2] by employing manual tuning for both PD and PID whereby the parameters of the first link was carried out followed by the second link. The overall system performance has been improved by introducing ILC and adaptive control respectively which were proven in the simulation. Another tuning method that has been implemented in flexible manipulator is simultaneous equation solving method. The Linear matrix inequalities (LMI) based PID control of a nonlinear DLFR incorporating payload have been presented in [3]. Another researcher proposed a class of stabilizing decentralized proportional integral derivative (PID) controller by incorporating bounding parameters of interconnection terms in LMI formulation for an *n*-link robot manipulator system [4]. Meanwhile, Neural Network (NN) is being utilized to approximate the ZN-PID for each link of DLFR in [5] which can be categorized under Independent method.

Evolutionary Algorithms have been used in various areas including in developing tuning method of PID controller for flexible manipulator. For instance, hybrid PD-PD/Iterative learning Algorithm (ILA) tuned by Genetic Algorithm for single-link flexible manipulator (SLFM) is presented in [6], a multi-objective optimization using Differential Evolution (MODE) for PID controller of SLFM studied in [7], an improved Bacterial Foraging Algorithms (BFA) to tune the PID controller of SLFM is proposed in [8], Bee Algorithm is used to optimize the hierarchical PID parameter of SLFM in [9] and particle swarm optimization (PSO) algorithm to tune parameter of one PID controller of SLFM in [10].

In this paper, a hybrid PID-PID controller is developed for double link flexible robotic manipulator (DLFR) based on the NARX model plant as elaborated in [11]. The global search of ABC and PSO are utilized to optimize all the PID controllers' gains.

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