Hub Angle Control of Double Link Flexible Robotic Arm Manipulator Using PID Controller Tuned by Bacterial Foraging Optimization Algorithm

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***Abstract*—Robotic manipulator with a multi-link structure has a significant role in the majority of today's industries. Controlling the motion of a multi-link manipulator, on the other hand, has proven to be a difficult task, especially when a flexible structure is used. This is due to the complexity of their structures, which causes excessive vibration, resulting in system failure. The goal of this research is to eliminate excessive vibrations produced in order to maintain its efficiency and extend the life of the system. This can be accomplished by developing an intelligent controller for a double-link flexible robotics manipulator (DLFRM) using a proportional integral derivative (PID) controller approach and bacterial foraging optimization algorithm (BFOA) to tune the PID control parameters. BFOA is a new swarm intelligence optimization algorithm based on *E. Coli*'s foraging behavior. The BFOA is utilised to tune the PID controller parameters via simulation to achieve the optimum angle for both links present in the DLFRM using MATLAB/Simulink software. Not only that, the BFOA performance is analyzed and compared with conventional method (Ziegler-Nichols) in optimizing the PID controller used to control the hub angle of the manipulator. It is noticed that the PID controller tuned by BFOA exhibited reduced settling time, overshoot, raising time, and steady state error for both hub angles of the manipulator at link 1 and link 2. Then, the system robustness was tested using different types of sinusoidal disturbance and its durability is demonstrated by the fact that it can effectively reduce vibration when the drawback is moved under different disturbances.**

Keywords*—*double link flexible manipulator, PID controller, bacterial foraging algorithm, intelligent controller, Ziegler Nichols

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I. Introduction

Robotic manipulator arm systems are becoming increasingly popular not only in large industries but also in small and medium-sized businesses industries, ranging from basic pick and place tasks to important tasks [1]. This system was designed to be used for standard, repetitive and complex tasks in order to enhance the performance and maximize efficiency [2]. As a result of market demand, the physical structures and functionalities of a robot have changed, for which the material itself is lightweight and the link structure is much longer and thinner.

The flexibility of the manipulator thus confers numerous advantages over rigid manipulators including its ability to eliminate gearing, reducing power consumption, secure operation due to lower inertia, a minimum level of installation strength and rigidity, a safe structure, a much less bulky structure, and requiring only a small actuator [3]. These advantages allow the flexible manipulator to have such a great potential in a variety of applications such as intelligent remote controlled (robotic) helper for the disabled, lowering space launch costs in space manipulators, and handling waste products in potentially dangerous plants at which underground storage access is limited [4-6].

However, because of its flexibility, the oscillation response of a flexible manipulator system throughout its operating conditions requires great consideration. It is of paramount importance to reduce the vibration of the flexible robot manipulator. The vibration upon that system weakens its performance and efficiency, causing longer idle time between operations, tracking errors, and devaluing accuracy, efficiency and safety [7].