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ON THE DESIGN OF A NEURAL NETWORK BASED PID CONTROLLER FOR A TWO-LINK FLEXIBLE ROBOT MANIPULATOR INCORPORATING PAYLOAD

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Abstract

This paper presents investigations into the development of a neural network (NN) based PID control of a two-link flexible robot manipulator incorporating payload. A dynamic model of the system is derived using a combined Euler-Lagrange and assumed mode methods (AMM). The controller based PID design is reduced to a nonlinearities problem that can be efficiently solved using NN.

To study the effectiveness of the controller, initially a PID control is developed for two-link flexible manipulator incorporating payloads. The system responses namely hub angular position and deflection responses and end-point acceleration at both links are obtained and analysed. The performances of the controllers are assessed in terms of the input tracking controller capability of the system as compared to the responses with PID control. Moreover, the robustness of the NN based PID control schemes is discussed. Finally, a comparative assessment of the control strategies is presented. The results show that NN based PID controller performs give increasing profiles.

Keywords: *AMM, neural network, two-link flexible robot manipulator.*

1. INTRODUCTION

Flexible manipulators have several advantages over rigid robots: they require less material, are lighter in weight, consume less power, require smaller actuators, are more manoeuvrable and transportable, have less overall cost and higher payload to robot weight ratio.

The main goal of modelling of a two-link flexible manipulator is to achieve an accurate model representing the actual system behaviour. It is important to recognise the flexible nature and dynamic characteristics of the system and construct a suitable mathematical framework. Previous study utilising the assumed mode method (AMM) for modelling of a single-link flexible manipulator has shown that the first two modes are sufficient to identify the dynamic of flexible manipulators. A good agreement between theory and experiments has been achieved [1]. However, the complexity of the modelling process increases dramatically as compared to the case of a single-link flexible manipulator. Dogan and Istefanopulos [2] have developed the finite element models to describe the deflection of a planar two-link flexible robot manipulator. De Luca and Siciliano [3] have utilised the AMM to derive a dynamic model of multilink flexible robot arms limiting to the case of planar manipulators with no torsional effects. Subudhi and Morris [4] have also presented a systematic approach for deriving the dynamic equations for n-link manipulator where two-homogenous transformation matrices are used to describe the rigid and flexible motions respectively.

There is a great interest in the development of control strategies for use with a two link flexible manipulators at present. The difficulties of flexible manipulator control are exacerbated by the fact that control inputs as well as external disturbances induce flexural vibrations in the manipulator structures. A number of control methods have been proposed for control of a two-link flexible manipulators.

A PD controller was also designed by Shengping, *et. al.* [5], whose purpose is to maintain stabilization of the robot system after the capture of the object. The dynamical simulations are carried out in two cases: the robot system is uncontrolled and controlled after impact. Payo et al [6] proposed a PID controller for force and constrained motions of the flexible manipulator. A combined PD control for vibration control of a single-link

flexible manipulator using an array of fiber optic curvature sensors and PZT actuators have also been proposed [7].

4. CONCLUSION

The development of dynamic model and robust control of a two-link flexible manipulator with varying payload has been presented. A PID controller has, initially, been developed for control of a two-link flexible manipulator with varying payloads. The NN based PID controller is universal and can be adapted for any a nonlinear system. A NN based PID controller has been implemented for input tracking control of the two-link flexible manipulator. Performances of the control schemes have been evaluated in terms of the input tracking capability of the system with compared PID controller. Simulations of the dynamic model and NN based PID control have been carried out in the time domains where the system responses including angular positions, deflection and end-point acceleration are studied. In term of input tracking, NN based PID has been shown to be more effective technique. These results will be verified on the hardware experimental work for future work.

Comparison with PID controller, using NN has been made the overshoot decreases by 83 % and 81 % for link-1 and link-2 respectively for system without load. The settling time decreases for both links by 41 % and 28 % for link-1 and link-2 respectively. Otherwise with payload 0.3 kg, the overshoot decreases by 82 % and 83 % for link-1 and link-2 respectively. On the other hand, the settling time decreases for both link with NN control by 42 % and 42 % for link-1 and link-2 respectively.

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