2834. Intelligent modeling of double link flexible robotic manipulator using artificial neural network

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Abstract. The paper investigates the application of the Artificial Neural Network (ANN) in modeling of double-link flexible robotic manipulator (DLFRM). The system was categorized under multi-input multi-output. In this research, the dynamic models of DLFRM were separated into single-input single-output in the modeling stage. Thus, the characteristics of DLFRM were defined separately in each model and the coupling effect was assumed to be minimized. There are four discrete SISO model of double link flexible manipulator were developed from torque input to the hub angle and from torque input to the end point accelerations of each link. An experimental work was established to collect the input-output data pairs and used in developing the system model. Since the system is highly nonlinear, NARX model was chosen as the model structure because of its simplicity. The nonlinear characteristic of the system was estimated using the ANN whereby multi-layer perceptron (MLP) and ELMAN neural network (ENN) structure were utilized. The implementation of the ANN and its' effectiveness in developing the model of DLFRM was emphasized. The performance of the MLP was compared to ENN based on the validation of the mean-squared error (MSE) and correlation tests of the developed models. The results indicated that the identification of the DLFRM system using the MLP outperformed the ENN with lower mean squared prediction error and unbiased results for all the models. Thus, the MLP provides a good approximation of the DLFRM dynamic model compared to the ENN.

Keywords: double-link flexible manipulator, flexible manipulator, artificial neural network, non-parametric modeling.

1. Introduction

Robotic manipulators are extensively used in a wide range of industries that ranged from simple pick and place task to more complex operations such as those in the field of space exploration, automotive industry, electronic based industry, oil and gas industry and the medical field. They are cost effective and were proven to be more reliable than humans. Previously, robotic manipulator structures were generally large and heavy that resulted in rigid arm and stiff joint designs. Thus, their usage is limited to light loads and their movement is slow. Hence, the conventional design is not favorable in current industries as it is not efficient in term of speed, productivity and power consumption. Moreover, it has become a requirement for any engineering systems to have a lighter structure.

Hitherto, there are several well-established dynamic models of the system ranging from simple model such as the lumped parameters to complex models such as the assumed mode method (AMM) and the finite element method (FEM). Many papers have reported the implementation of AMM and the finite FEM toward designing an efficient controller for flexible manipulator system. They offer better accuracy as compared to lump parameters model. In [1] mentioned that studies on the dynamics modeling of flexible manipulator has been well documented in text books. Recent studies by [2, 3] utilized the Finite Element Method (FEM) when developing the model of two link flexible manipulator. The first model considered the concurrent large deflection in a system