Evolutionary Identification of Dynamics and Fuzzy Self Adaptive Model Based Control of a Seven-Link Manipulator.

Background
One major problem often encountered in the identification of dynamics of multi-link industrial manipulators is the lack of knowledge of necessary data such as input joint torques or the gains of the servo controllers. Identification of inertia parameters using the least-squares algorithm has been investigated in conventional methods. Yet these methods need the input information of joint torque which needs special hardware changes in an industrial manipulator. Identification of dynamics using artificial neural networks (NN) can be found in the literature. These methods suffer from several drawbacks: one is the tendency of backpropagation algorithms to converge to local minima, another is that in some of these methods the trained NN depends on the sampling time width of the training data and the other is that these methods do not make use of the inherent structure of the dynamics of manipulators.

Motivation
The motivation of this research has been to find solutions to the following challenging problems:

• Developing a method to identify the dynamics of a multi-link manipulator that needs only the basic reference input of joint angle and its velocity, and their output data to suite a real industrial application.
• Constructing a model that does not depend on the sampling time width.
• Developing a model with an ability to grasp the structure of the dynamics of a manipulator so that the properties of dynamics are clearly reflected in the identified model.
• Developing a method such that a parameter searching in the identification model converges to a global optimum.

Methodology
The proposed method uses Runge-Kutta-Gill neural networks (RKGNNs), which is an extension version of Runge-Kutta neural networks (RKNNs), for the identification of the dynamics, because RKNNs are capable of identifying the changing rates of the states accurately due to the state space interpolation between one sampling interval. Furthermore, this method only needs one state information to predict the next state and the trained NN of the function is independent of the sampling time width unlike in direct mapping NNs (DMNNs). In the RKGNNs, a function NN has been constructed to identify an ordinary differential equation (ODE) of the dynamics of a robotic manipulator. The proposed method synthesizes a function NN consisting of sub-networks, so that the sub-networks represent the components of the dynamics of the manipulator. Radial Basis Function (RBF) NNs are used for each sub-network.

Evolutionary Computation Application
Due to the complex structure of the dynamics of a manipulator, the number of weights of the total NN system demands for efficient optimization techniques to train the NNs. Therefore optimization of weights
using a new evolutionary optimization algorithm has been proposed by using a Chaotic mutation and a concept of strategic moves. Due to the property of monotonically reducing standard deviation of mutation, the convergence rate is fast in the evolutionary algorithm. In the proposed algorithm, sustaining adequate standard deviation of mutation throughout the optimization process guarantees the convergence to a global optimality.

Fuzzy Self Adaptive Controller

Using the dynamics identified employing the above method, a fuzzy self-adaptive controller is also designed closely following the features of human cognition to adaptively fuse pre-learnt experiences to deal with a new problem. Recently artificial intelligence literature can be found that has endeavored the task of imitating this property of human mind to deal with complex control tasks of modern engineering applications. The proposed method has been implemented experimentally using a seven-link industrial manipulator called PA-10, manufactured by Mitsubishi Heavy Industries Ltd. The reference input of joint angle, its velocity, and their output data obtained from the experiments are used for the system identification studies.

Results

- Control results for a new trajectory using the fuzzy self-adaptive controller