INVESITIGATION OF TWO NEURAL NETWORK BASED CONTROLLERS TO CONTROL A PLANT WITH UNKNOWN DYNAMICS

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Introduction

PID controllers have played an important role in control engineering and still continue to do so. These PID controllers are implemented by usually analysing the plant dynamics, which should be known as *a priori*. On the other hand, NNs have also been used in many control applications even with PID controllers (Cho,2005) to tune them as adaptive systems.

This paper focuses on an attempt to develop two NN-based controllers whereby the dynamics of the system is **not required as *a priori***. The main concept is to develop a controller where the plant is a 'black-box' as far as the dynamics are concerned. Two different NN topologies are developed and investigated. The developed NN-based controllers simulate a simple plant with unknown dynamics, and examine the performance by comparing it with a conventional PID controller.

NN-based Controller Topologies

The main basis here is to utilize the robustness and flexibility of a NN and combine it with the concept of the time-tested PID controller to form a novel NN-based controller which would perform superior to a conventional PID controller. Two different architectures are developed.

(i) Two-parallel NN controller

This controller utilizes 2 parallel NNs, each with 1 hidden layer of 3 neurons, where NN-1 uses the reference input (r) as its input and NN-2 uses the error of the output (r-y) as its input. The output of NN-1 is considered as the main actuator input (u) whilst NN-2 is made to produce a corrective action to the plant input (Δu) by considering the error of the plant output (r-y).

(ii) PIDNN

A three layered NN is formed as shown in Fig. 1, where the two input neurons receive the reference input (r) and the output of the system (y) as its inputs. The activation functions of the three hidden neurons, N_P, N_I and N_D, are different and are formulated to be comparable with Proportional, Integral and Derivative action, as in a conventional PID controller.

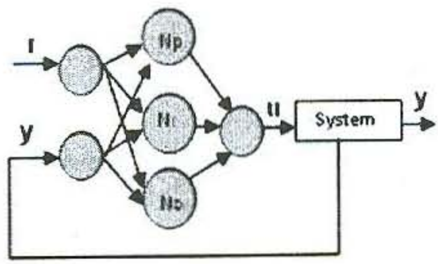

Fig.1. PIDNN

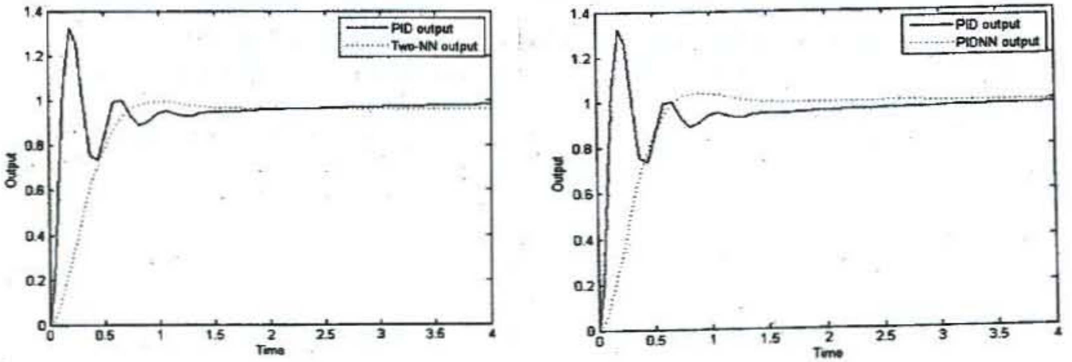

Fig.2 Comparison between the PID controller with two-NN controller and PIDNN controller

Performance Evaluation of Controllers

As mentioned above, the controller dynamics are considered *unknown*. Various inputs are given to the plant and are recorded along with the corresponding outputs. These input-output datasets are used in training the NNs along with the back-propagation algorithm with Levenberg-Marquardt optimization. The performance criterion is the mean square error between the targets and the outputs.

Initially, a simple second-order under-damped system is used to test the performance of the developed controllers and the results are compared with that of a conventional PID controller. Figure 2 gives the performance of the two controllers with a comparison with the conventional PID controller for a unit step input. Figure 3 shows the response in the midst of an extraneous disturbance to the system.

Discussion

The performances of both controllers are superior to that of the conventional PID controller even in the midst of disturbances to the system. The Two-parallel NN controller even performs well in the midst of parameter variations in the system, where as the ***PIDNN*** shows a significant steady state error for larger inputs as well as parameter variations of the system. Two-parallel NN controller seems to mimic the inversion of the plant and needs to be further investigated with non-minimum phase plants as well as higher order plants to verify its effectiveness. Further verification is also necessary for the *PIDNN* controller.

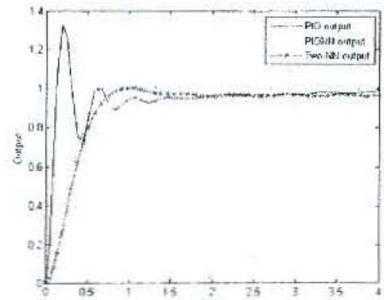

Fig.3 Comparison of the controllers with a disturbance signal

References

Geum-Bae Cho and Pyoung-Ho Kim (2005). A Precise Control of AC Servo Motor Using Neural Network PID controller. Current Science, 89(1), 23-29.