DEICON
Dynamics & Controls

Neural Network Control of Ram Motion in a Press

Hydraulic presses are used in many forming processing including stamping, forging, and injection molding. The quality of the parts produced by these presses, depend how good the motion of the ram is controlled. As such, it is desirable to have tight control on the ram motion in these presses. An alternative in controlling such system is implementing an open-loop (feedforward) control strategy using the inverse of the plant model as a controller. Such control technique requires a reasonably accurate model for the plant inverse. Considering the complexity of many real-life plants, high-fidelity analytical modeling is not always possible.

Multilayer neural networks (MNN) have been applied successfully in the-model identification and control of complex dynamic systems. The universal approximation capabilities of the multilayer networks make them a suitable choice for modeling nonlinear systems and implementing non-linear controllers. They have the capability to be trained and realized directly from the plant. In other words to use neural networks, one does not have to have an analytical model for the plant as model-based control techniques do.

A 4 layer (two hidden layers, one input layer, and one output layer) NN is trained as the inverse of the plant and used as the controller. The desired displacement, velocity and acceleration trajectories are the MNN inputs, and the output is the force applied to the system. Figure 1 shows the block diagram of this system.

The back-propagation training method was used to model the inverse of the plant. The nonlinearities in the process required nonlinear properties in the controller to be realized in hidden nodes with nonlinear, activation functions.

In the absence of disturbance, the open loop controller provided high performance in terms of command following (tracking). But, in presence of process disturbance (including parameter variations) the tracking performance of the system was inadequate. This is to be expected because in most systems unless the process disturbance is measured and fedforward, the open loop controller has no way of compensating for it.

To remedy the disturbance rejection shortcoming of the feedforward controller a proportional plus integral (PI) feedback controller was added to the compensation system. Figure 2 shows the block diagram of feedforward/feedback controlled system. The PI controller gains were tuned experimentally.

Figure 3 depicts the tracking performance of feedforward/feedback control system in the presence of disturbance; the ram displacement reference input is the combination of two 3rd order polynomials moving the ram from 0 position to its final displacement and back to 0 again. Clear from Figure 3 the tracking performance of the feedforward/feedback controlled system is remarkable; in fact the desired and actual (measured) ram displacements are indistinguishable.

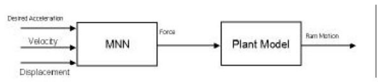

Figure 1. Open-loop control scheme

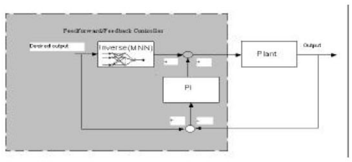

Figure 2. Feedforward/Feedback control scheme

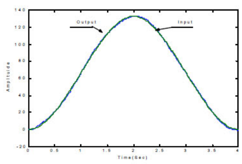

Figure 3. Desired (input) and actual (output) ram displacement trajectories