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# Dynamic Analysis of Rotating Structures with Active Constrained Layer Damping treatment by using the PID Neural Network

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## EXTENDED ABSTRACT

The damping performance of active constrained layer damping (ACLD) treatment has been investigated by many scholars. For the vibration suppression of the host structures such as flexible beams or plates, the ACLD treatment is usually installed on the surface of the controlled structures via the full or partial coverage. The controller, as the core of the ACLD treatment, is designed to regulate the input voltage applied on the piezoelectric constrained layer with the control law (e.g., PD control law). Through the active control effect of the controller to increase the shear effect of the viscoelastic material layer of the ACLD treatment, the vibration suppression of the host structure can be achieved [1]. However, the voltage control gains ($K_p$ and $K_d$), used to determine the control voltage applied on the piezoelectric constrained layer of the ACLD treatment, are artificially set in the dynamic and vibration analysis [2-4].

In order to identify the influence on the dynamics responses and vibration characteristics of rotating beam/plate structures covered with ACLD treatment, the machine learning approach is used in this work. Combining the advantages of the PID control laws and the artificial neural network, the PID neural network is employed to real-time determine the control gains with the present state of the dynamic system. The dynamic equations of the hub-beam/plate system are developed by the high-order rigid-flexible coupling dynamic model, and the PD control law is designed to control the input voltage on the piezoelectric constrained layer related to the transverse deformation of the structure. Then the dynamic equations are embedded into the PID neural network. In addition, the control gains are regarded as the designed control variables of this neural network, and the transverse deformation of the hub-beam/plate system is set as the manipulated variable. The PID neural network of the ACLD treatment is shown in Figure 1. The vector $\boldsymbol{r}=\begin{bmatrix} r_1 & r_2 \end{bmatrix}$, $\boldsymbol{y}=\begin{bmatrix} y_1 & y_2 \end{bmatrix}$ and $\boldsymbol{u}=\begin{bmatrix} u_1 & u_2 \end{bmatrix}$ are the expected output vector, the actual output vector and the control variation vector, respectively.

Several typical examples are given in this work, and the simulation results show that the PID neural network can adjust the voltage control gains dynamically. The control gains are more different than those choose artificially in traditional research and the perfect balance between the vibration suppression and the input control voltage in the hub-beam/plate system.

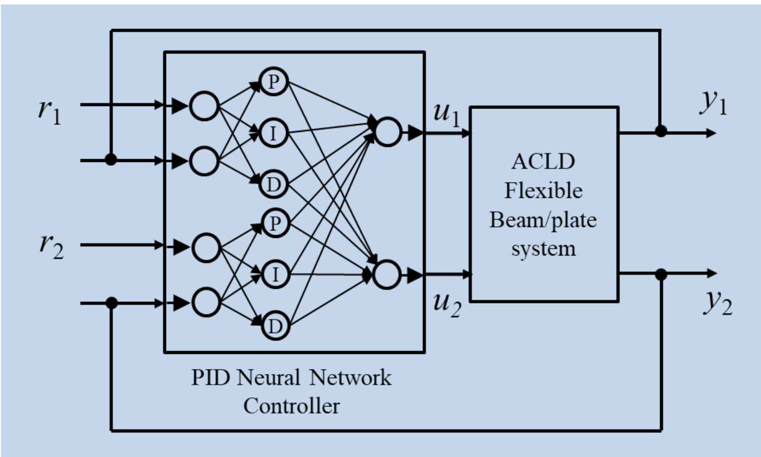


Figure 1: The PIDNN of the flexible beam with ACLD treatment

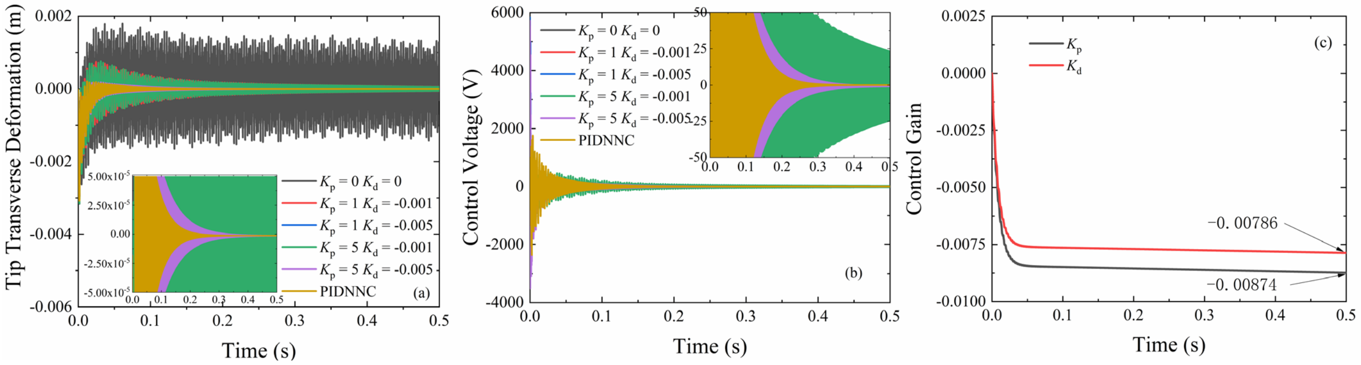


Figure 2: Comparison of the responses between PIDNN and constant control gains


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