Sliding Mode Control of Civil Engineering Structures

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Abstract

In this paper, the application of the sliding mode control (SMC) scheme is discussed in a systematic manner for controlling the vibration of a three story building with a hydraulic actuator installed at the first floor. It's shown that the application of the SMC theory for buildings with hydraulic actuator reduces the amounts of responses in the buildings. In order to investigate the effect of the weighting matirx two different cases are considered. For examining the performance of the proposed control algorithm, three different earthquakes inputs, two near fault and one far fault, are considered. The results indicates that the designed sliding surface is very effective in reducing the responses.

Key words: Sliding mode control, Structural Control, Response Reduction, sliding surface.

1. Introduction

In the SMC framework, a switching surface, known as the sliding surface, is first defined in the state space of the system. The equation of motion for systems with multi degree of freedom can be expressed as the following [1]:

$$[M]_{n\times n}\{\ddot{q}\}_{n\times 1}+[C]_{n\times n}\{\dot{q}\}_{n\times 1}+[K]_{n\times n}\{q\}_{n\times 1}=-[M]_{n\times n}\{f\}_{n\times 1}\ddot{x}_g+[\gamma]_{n\times r}\{u\}_{r\times 1}$$

$[M]$, $[C]$ and $[K]$ are mass, damping and stiffness matrices of the structure. Also $\{\ddot{q}\}$, $\{\dot{q}\}$ and $\{q\}$ are relative acceleration, velocity and displacement vectors. The standard H_∞ state feedback control problem is formulated by state space model like the following [1]:

$$\{\dot{x}\}=[A]\{x\}+[B_1]\{u\}+\{B_2\}\ddot{x}_g$$

$$\{z\}=[C_1]\{x\}+[D_{11}]\{u\}+\{D_{12}\}\ddot{x}_g$$

$$\{y\}=[C_2]\{x\}+[D_{21}]\{u\}+\{D_{22}\}\ddot{x}_g$$

If the formulation in below was stablished the state space formulation of the motion equation is accomplished. The equation of motion is a second order differential equation while the state space system is a first order one and because of this reason solving a state space system is much easier than equation of motion.