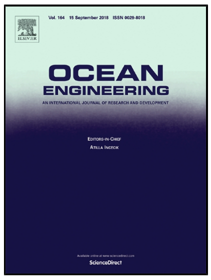
Accepted Manuscript



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PII:	S0029-8018(18)31463-X
DOI:	10.1016/j.oceaneng.2018.08.002
Reference:	OE 5407
To appear in:	*Ocean Engineering*
Received Date:	25 November 2017
Accepted Date:	03 August 2018

The Particle Swarm modified quasi bang-bang controller for seismic vibration control

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Abstract

The frequent occurrence of seismic events results in the damage to the structures. Structural control is one of the popular methods to prevent these damages. In structural control, the main objective is to impart an adequate counterforce. This required counter force is determined by a suitable control algorithm. In this work, an optimized and adaptive control algorithm is proposed based on modified quasi bang-bang control algorithm to generate the adequate counterforce. The constant output weights used in the modified quasi bang-bang controller are optimized for best performance in dynamic loading such as earthquake using the particle swarm optimization (PSO). The proposed optimized controller is then applied to a three storey prototype structure fixed with an MR damper. This structure has been subjected to various seismic events for performance evaluation. The results thus obtained are compared with best performing clipped optimal linear quadratic Gaussian (LQG) controller, quasi bang-bang and modified quasi bang-bang controller. The results establish that the PSO modified quasi bang-bang controller is superior to the other controller in reducing the structural responses i.e. relative displacement, interstorey drift and the absolute accelerations. Further, the voltage comparison shows that the power consumption is less for the proposed controller in attaining better performance

Keywords: PSO, LQG, bang-bang controller, and MR damper

1. Introduction

The seismic vibrations put additional stress on the structure and the vibrations caused are not considered good for its health. Therefore, the need for the technical methods for mitigation of the vibrations arises. One of the popular adopted methods is the structural control. In structural control, the seismic vibrations are reduced by imparting adequate counter force determined by a control law using external actuating devices such as passive, active, hybrid or semi-active (Yu and Thenozhi, 2016). In literature, the structure vibration control can be achieved mainly by three simple methods i.e. passive, active and semi-active control having their merits and demerits (Choi et al., 2016; Saaed et al., 2015; Soong and Spencer, 2000; Spencer and Nagarajaiah, 2003).

The passive control is the simplest method of structural control and used to be very popular among the scientific community due to its many useful features such as it does not require any external power to operate, easy to implement. It also does not alter the stability of the structure. But its inability to adapt to the changes in the external excitation and poor performance at low frequencies makes this control scheme less attractive. To improve upon these disadvantages, the active control scheme came into the existence. The active control scheme was adaptive to the external changes and delivered excellent performance for a range of vibration frequencies, but it relies on the large power source to operate which is very difficult to ensure during the incidence of the earthquake (Datta, 2003; Soong et al., 1991; Yu and Thenozhi, 2016). Additionally, the active control scheme may destabilize structure (Dyke et al., 1996; Ramesh Kumar and Narayanan, 2008).

To overcome these drawbacks a method known as semi-active control scheme came into existence and largely investigated (Huang et al., 2015a; Zapateiro et al., 2012). It requires very less power to operate (a few watts) and shows performance at par with the active control strategy (Dyke et al., 1999; Jansen and Dyke, 2000). It also does not subvert the stability of the structure because the energy of the vibration will only be engrossed without imparting any additional energy to the structure. Thus, the semi-active control methodologies have been the well-thought-out choice for structural control. The semi-active control strategy generally uses the magneto-rheological (MR) dampers. MR dampers vary their physical form proactively with a change in the magnetic