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# A new two-stage online method for identification and control of structures

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**Abstract**
An online method for identification and active control of shear type frames with unknown stiffness parameters is presented. The proposed method is composed of two stages. The estimation of the unknown parameters and blind vibration control of the structure take place at the first stage in a relatively short duration. The estimated parameters from the first stage are utilized to enhance the performance of the LQR vibration control algorithm. As a result, the vibration control method is able to tune its internal parameters and improve its performance in the second stage.
**Keywords: Online structural identification, Active control, Smart structures, Uncertain systems, Parameter estimation**

## 1. INTRODUCTION

Online structural parameters identification methods play a prominent role in the structural engineering research. It is worthwhile to mention that several vibration control methods require parameter information. For instance, a recursive least squares (RLS) algorithm is employed in [1] to identify structural parameters in real time and the identification scheme was evaluated through an experimental test. However, without enough frequency content, the identified parameters do not converge to their real values necessarily. It is worthwhile to mention that several vibration control methods require parameter information. [2]

Adaptive control methods employ a technique to accomplish a control objective despite uncertainties in the system model. A recently developed adaptive update scheme is Concurrent Learning (CL) which guarantee parameter convergence without requiring persistent excitation. However, this technique requires state derivatives which are not usually available. As a result, a new Integral Concurrent Learning (ICL) method is developed in [3] which maintains the parameter convergence while the need for state derivatives is removed.[4]

Recently, a new online identification method called virtual synchronization method (VSM) is introduced in [5]. In this method a virtual system is designed which follows the actual structural system, by employing system synchronization technique and adaptive control theory. As a result of the synchronization procedure and under a specific condition, the estimated parameters converge to their real values.

On the other hand, several vibration control algorithms require the parameters of the system, in order to perform appropriately. Linear quadratic regulator (LQR) is a known linear control algorithm. The definition of the weighting matrices can greatly affect the performance of the LQR method. A rational formulation for the weighting matrices of LQR is to define the weighting matrices as a function of structural properties (mass and stiffness matrix). As it can be noted, the aforementioned formulation requires known parameters, and the uncertainty in those parameters will undermine the performance of the LQR method.[6, 7]

In this paper, the new VSM identification method introduced in [5] is integrated with a specific LQR based vibration control method. This integrated method is performed in two stages and estimates the unknown parameter at the first stage. Additionally, the estimated stiffness parameters are employed to improve the performance of the LQR vibration control method at the second stage.

This paper has the following structure: Section 2 presents the mathematical model of the smart structure, a brief elaboration on the virtual synchronization method and an introduction to the proposed two-stage identification-control method. Next, the numerical examples are presented in Section 3. Lastly, Section 4 establishes the conclusions of this paper.