Effectiveness of a direct adaptive control algorithm

In this research, the authors study the effectiveness of applying a direct adaptive control algorithm for both vibration suppression and damage detection. Combining vibration suppression and damage detection in civil engineering structures allows the implementation of a more effective control system since the model reference represents more accurately the real structure. The adaptive algorithm chosen in this study is the sliding mode and model reference control algorithm, with an online identification procedure based on tracking error. In order to test the effectiveness of the method, a numerical investigation is presented, performed to a MDOF shear building. The study successfully uses the adaptive control algorithm to damage detection and vibration suppression of the MDOF shear-type structure aforementioned.

The study first presents the governing relations of a general structural system, such as the equations of motion and its state space representation. Then, it presents the control canonical forms and the transformations that are useful to the application of the model reference adaptive control. These canonical form allow the separation from assignable dynamics and internal dynamics that are not affected from control input, and are applicable to both SISO and MIMO cases. It shows that a correct selection of a reduced measure of the state variables can guarantee exact output reference tracking. After this, the control strategy via sliding mode control and model reference control are presented. The reference model is defined in a way that the system response approaches or tracks the desired reference response. The slide mode control objective is to make the output to track a desired behavior, which means that the output error zero. This goal is achieved by

sliding along a line, defined by a weighting parameter that defines the convergence rate. The control law is therefore defined in a way that the states in canonical form match the “ sliding line”. In this study, the online identification procedure is based on the asymptotic convergence to zero of the tracking errors and the stability of the method is proved by showing asymptotic stability convergence based on Lyapunov function. The numerical investigation performed in a 3DOF shear type structure. The reference model and the actual model differ in damping ratio values. Not much detail is given regarding the tools used during the numerical investigation.

In the numerical investigation it is evaluated the performance of collocated and noncollocated control cases. It is concluded that the model reference control is accurate in the output tracking and is successful in suppressing the excessive vibrations, and is effective in the identification of changes in the model, showing it can deal with changes in the plant due to damage. The numerical stability of the method is verified, and the on-line identification effectiveness is evaluated. It is concluded that large control efforts are required during abrupt changes in the plant parameters. The results are not compared to any other adaptive algorithm, so it is difficult to measure its effectiveness.

The research is important in the sense that brings the concept of adaptive control by applying model reference adaptive algorithm with sliding mode control to civil engineering structures. It confirms the effectiveness of the method in tracking the system parameters, even after abrupt changes happen, and it is successful in controlling the response while remaining numerical stable. However, that are some weaknesses in this paper, such as:

the loading type/duration/scheme applied to the structure is not presented. Therefore, the results of the research are difficult to be reproduced in order to expand the knowledge in the area. The results obtained by this algorithm implementation are not compared to others non-adaptive and adaptive methods. Consequently, it is difficult to assess the extent of the effectiveness of the method. The model reference adaptive control and the sliding mode control theoretical aspect is somehow confusing and lacking completeness, with too many direct citations that introduce a fragmentation in the text.