

## GA-OPTIMIZED SEMI-ACTIVE FUZZY BASED CONTROLLER FOR SEISMIC VIBRATION REDUCTION OF A 3DOF STRUCTURE WITH VELOCITY FEEDBACK

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### ABSTRACT

This paper aims to evaluate the effectiveness of a semi-active fuzzy logic based controller (FLC) with velocity feedback to reduce the response of a three degree-of-freedom (DOF) system representing a three floor shear building frame under seismic excitation. The proposed FLC controller uses the first and third floor velocity measurements to determine the desired control signal to command a MR damper. In this study the actuator is rigidly attached between the first floor of the structure and ground. The membership functions of the FLC were optimized using a genetic algorithm (GA) in order to obtain the best relationship between the controller inputs and output according with a predefined training data. The comparison between the uncontrolled and the controlled structural responses is used to assess the performance of the proposed semi-active FLC controller.

**Keywords:** structural control, genetic algorithms, semi-active control devices, MR damper.

### INTRODUCTION

The study is based on the results of numerical simulations carried out on a three-story building subjected to an earthquake ground motion with an MR damper located between the first floor and the ground as shown in Fig. 1. The MR damper representing the actuator (control force in Fig. 1) can be used in a passive dissipation mode with constant operating current, i.e., no change in the control signal, or in a semi-active control mode in which the operating current is determined by a controller in accordance with the system response to improve the behavior and performance of the structure.

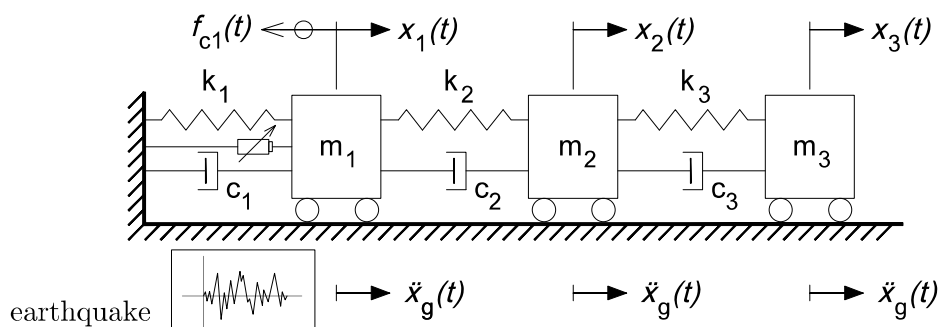


Fig. 1 - Schematic representation of a 3DOFs system under earthquake excitation. Semi-active control with a MR damper at the first floor.

It is well-known that semi-active controller requires a properly designed control algorithm that can deal with the inherent non-linearities of the system as well as take full advantage of the controllable properties of the actuator. Thus, fuzzy logic control approach seems to be adequate for this purpose since they offer a systematic way to deal with non-linear systems. The main problem in fuzzy controller design is the construction of an initial rule base or to define the parameters of the fuzzy system. Intelligent or learning searching/optimization techniques such as ANFIS and GA can be used to improve the performance of this type of controllers and simplify the rule base procedure.

Hence, a fuzzy controller was designed by using a GA-optimized procedure to find the membership function properties that ensure the best expected response of the control system in accordance with a predefined training data. In this study, the FLC was optimized based on the numerical results of a LQG controller. The surface of the proposed GA-optimized FLC is shown in Fig. 2. Velocity feedback is used to design the fuzzy controller since viscous damping can be directly related with velocity measurements.

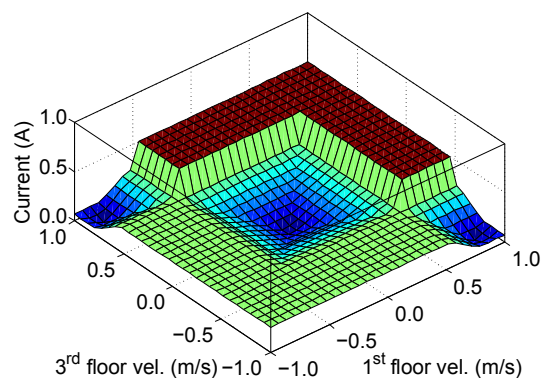


Fig. 2 - Surface of the GA-optimized FLC

## RESULTS AND CONCLUSIONS

The effectiveness of the semi-active GA-optimized FLC with velocity feedback for vibration control of a three-story building structure equipped with a MR damper was verified. The results indicate that the proposed control system was effective in reducing the response of the structure to dynamic loading.

## REFERENCES

- [1]-Dyke S.J., Spencer Jr B.F. A comparison of semi-active control strategies for the MR damper, Proceedings of the IASTED International Conference, Intelligent information Systems, 1997, p. 580-584.
- [2]-Ali Sk.F., Ramaswamy A. GA optimized FLC driven semi-active control for phase II smart nonlinear base isolated benchmark building, Structural Control & Health Monitoring, 2008, 15, 5, p. 797-820.
- [3]-Byrne, J.P. GA-optimization of a fuzzy logic controller, Master's Thesis, School of Electronic Engineering, Dublin City University, 2003.