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A REVIEW ON VIBRATION CONTROL USING FUZZY LOGIC AND NEURAL NETWORKING

Srishti Srivastava[1], Sankha Bhaduri[2]

[1]P.G. Research Scholar, Dept. of Mechanical Engineering, BIT Mesra, Jharkhand, India
[2] Assistant Professor, Dept. of Mechanical Engineering, BIT Mesra, Jharkhand, India

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Abstract*: The computational intelligent technique is frequently used by different authors to design the control part of active vibration control system to minimize the vibration of different structures. The purpose of this review paper is to collect different research papers on vibration control method using modern computation intelligent techniques such as Fuzzy logic technique and neural network technique. Magnetic and piezoelectric actuators have been extensively used for vibration excitation and control of structures. In this survey the main focus is given on the vibration control of structures using smart materials and magnetic actuators with the help of Fuzzy logic and neural network technique.*

Keywords: Neural Network, Fuzzy logic, Vibration control, piezoelectric actuator.

INTRODUCTION:

Vibration had an adverse effect on machines so it is necessary to control the vibration. We can control the vibration using two different methods one is active and the other one is passive. Passive vibration control is less effective and has some limits to their effectiveness. Nowadays the active vibration control is more familiar and there are many methods that are available for active vibration control and one of them is soft computing. Different smart materials and magnetic materials are extensively used by different authors to minimize the vibration of structures. Different modern soft computing control system such as fuzzy logic and neural network techniques are frequently applied by the authors in the vibration engineering domain. Therefore the present attempt is to collect different papers on vibration control using the modern artificial intelligent techniques.

Vibration control of smart structures:-

The neural network control system has been applied by different authors to control the vibration of smart structures. In 1997 Yang and Lee [1] implemented the neural network technique to smart structure for system identification & vibration suppression. Smart structure with build in PZT actuator and sensor was used for vibration control. Here three neural networks were implemented one for the system identification second one for on-line state estimation and the third one for vibration suppression. They had shown the successful application of their technique both experimentally and analytically.

Lin and Chang [2] improved the performance and practicability of neural network controller by introducing a hybrid controller where repetitive controller was added with NN controller for active vibration control of smart structure. Back propagation algorithm was used in neural network controller for performance evaluation .Authors had experimentally demonstrated the effectiveness of the control system considering a smart cantilever beam where PVDF was used as sensor and piezoelectric patch as actuator.

Non linear active vibration control:-

In 1999 the neural network for non linear active control of vibration was studied by Bouchard et al. [3] developed a new algorithm which has faster convergence speed and lower computational load. The study of non linear control system is important where the actuator used in active control but having non linear characteristics & another important case where the structure exhibit non linear behavior. Previously non linear active control method was used which was based on back propagation algorithm but now in this paper author used multi layer perceptron neural network based control system &author also used a new heuristical algorithm and the result of the change led to the improvement in learning rate of neural network control system.

Again the same study was done by Martin bouchard [4] on non linear active vibration control on advanced techniques where the technique had been used previously. Here they used two multi layer neural networks in which one is for

non linear controller and other is for non linear plant model. Algorithm based on two distinct gradient approaches was used in training of controller network. These two gradient approaches were also known as filter-x and adjoint approach. By using these approaches Recursive -Least-Square algorithm was generated. Using this new algorithm a better performance was achieved as compared to previous one.

Vibration control has been the topic of research in recent years. Wenzhong et al [5] published a paper on active vibration control using fuzzy control method in year 2004. A very popular and simplest filtering algorithm i.e. filtered-x LMS algorithm was used because of low computational load. But that algorithm was applicable to linear control problem that used feed forward techniques. In this paper fuzzy control system with adaptive algorithm has been used for driving non linear feed forward active vibration control. This type of non linear fuzzy control method was used in two kind of active vibration problems i.e.
*A fuzzy system was used to suppress the primary disturbance and to approximate a non linear sensor path function.
*A fuzzy logic system used to control active control with non linear piezoelectric active actuators.

Small amplitude vibration control:-

Small amplitude vibration control had also become the important topic for research. Although the vibration was small in magnitude but it had very adverse effect on the system. To overcome this disadvantage Bai & Lin [6] researched on small amplitude vibration control. Here the researcher used an active vibration control system for suppressing the vibration of small amplitude in flexible beam. In this study piezoelectric (PZT) ceramics was used as an actuator and piezoelectric plastic (PVDF) was used as a sensor. ARX which is a parametric modeling method was used to identify the characteristics of system. The controller was designed on the basis of LQG (linear quadric Gaussian) algorithm and the floating point digital signal processor was used to implement the controller. They controlled the vibration successfully experimentally.

Vibration control of suspension system:-

In 2004 Yildirim [7] worked on vibration control of bus suspension system using neural network. The system of tiers, tier airs, springs, shock absorber and linkages that connect a vehicle to its wheel and allows relative motion between them is known as suspension. So for proper functioning of vehicle we need to control the vibration of suspension system. In this study researcher designed a quarter bus models for the suspension system. He used different type of controllers like PID, PD, PI for comparing with the proposed neural networking technique and he proved the better performance of this control system over the traditional PID or PI.

Zapateiro et al [8] had published a paper in which they deal with neural network to control the vibration of suspension system. Here they used magneto rheological (MR) damper as an actuator. In this paper back stepping technique was used for vibration control of semi active suspension system. Here they developed a neural network which estimate a control voltage input and then this input connects to MR damper which was used for obtaining optimal force predicted by controller in order to reduce vibration.

Yagiz et al [9] published a paper on vibration control of suspension system using fuzzy logic approach. A fuzzy logic controller was used to control the active suspension of a vehicle model which has five degree of freedom with a passenger seat. Three cases were considered for different control applications. Vibrations of the passenger seat in all the three cases due to road bump input were simulated. All the three cases were compared in order to select the best combination for the ride comfort.

Xia and Ghasempoor [10] used neural network for active vibration suppression. In year 2009 they had published a paper in which neural network and digital signal processing techniques were used which automatically detects the sinusoidal waves of vibrations of the cantilever beam and generates a control signal to an actuator which could reduce the vibrations. The generated control signal was based on the neural network calculation and real-time digital processing.

Vibration control of bridge:-
Vibrations may generate from natural calamities, earthquake is one of them. This paper represents and describes how neural network control the non linear vibration bridge system with earthquake excitation. Here Chao et al [11] designed a multi layer neural network with single hidden layer. It is very important for control performance to select the number of hidden neurons. The number of hidden neuron was selected to minimize the performance measures. Here a neural network mitigated the effect of vibration of bridge system that was caused by EI CENTRO earthquake.

The active vibration control of bridge using neural network has already been explained above, now

highlighting the semi active vibration control of bridge using fuzzy logic. In recent years special attention has been drawn towards bridges to control the generated vibrations. For achieving this state, active and semi active type of control methods have been used. In year 2001 Liu et al. [12] studied the semi active control of two span bridge structures. The magneto rheological (MR) fluid has been used as a semi active absorber device. A closed loop was generated using fuzzy logic to control bridge deck suppression under random excitation. The experiment concludes that the relative deck displacement could be reduced by 60% less as compared to passive.

Vibration control of structure using piezoelectric actuator:-

Since controlled structures were going to be the area of interest for future space system. Kwak and Sctuili [13] used decentralized collocated variable structure system control for closed loop stability of decentralized fuzzy control. So in order to control the vibration of controlled structure, fuzzy logic approach was used for this purpose. Where the structure was connected to piezoelectric sensors and actuators. In this paper the comparison have been shown between the variable structure system and fuzzy control system. Accordingly a new fuzzy rule was proposed for vibration suppression of active structure. The drawback of the experiment was that the rule was not producing the satisfactory result in case of multi input and multi output of non collocated system.

Joujou et al [14] in year 2008 presented a paper that shows the analytical and experimental study on elastodynamic control of four-bar mechanism with flexible couple link. They used a piezoelectric sensor actuator pair & fuzzy logic controller (FLC). The main advantage of FLC was that it could be designed without having the model of system controller. In their study they found that FLC was capable to reduce 33% of vibration amplitude, hence they concluded that the FLC in active damping was very effective in vibration control.

The fuzzy logic controller along with electromagnet as an actuator was used for vibration control of flexible structures. The paper was published by Mahfoud and Hagopian [15] in year 2011.They used fuzzy logic control technique with displacement and velocity as an input. Fuzzy Control was used because of its effectiveness in the presence of non linearity and uncertainties. By using an electromagnetic actuator they investigated numerically as well as experimentally the possibility of controlling vibration of flexible beam. The result was effective to control the vibration of flexible beam.

Bhaduri & Ranjan [16] used fuzzy logic approach, to minimize the vibration of cantilever beam. A non contact damper that was made up of an electromagnet has been used to minimize the vibration of beam. The arrangement consists an electromagnet that was placed at free end of cantilever beam, apart of this a non contact displacement sensor was used to measure the displacement of the beam. Further they applied the measured amount of force to the beam and obtained output was in the form of displacement and velocity. This resultant output was connected to fuzzy logic controller to control the current through electromagnet coils. After setting this arrangement it was observed that during upward displacement of the beam above the static equilibrium position the electromagnet was switched ON which gives the magnetic force in opposite direction of motion of the beam. During downward movement of the beam the electromagnet was switched OFF. In this study they had successfully minimized the amplitude of vibration under the action of step excitation and swept sine excitations.

CONCLUSION:

Soft computation is one of the most important topics of this decade. The application of the soft computation has been observed in the field of mechanical engineering. The applications of fuzzy logic and artificial neural networking system are observed frequently in the filed of vibration control. The vibration control of beam is considered as an important engineering problem because it will enhance the stability of the system. In this paper a review is conducted on the active vibration control method of beam using soft computing technique. Different control methodologies have been discussed based on fuzzy logic and artificial neural networking techniques. This survey will give an introduction to a new researcher in this field to different published papers at a single glance.

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