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| **Machine Learning Based Control Algorithm for Active Vibration Suppression of a Mechanical Flexure Hinge** |  |  |
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| ***Moderators: Dr. Ziv Brand,*** ***Dr. Eitan Fischer*** | Daniel Lilienthal |  |
| [Danieli1@ac.sce.ac.il](mailto:Danieli1@ac.sce.ac.il) |  |

**Summary**

Flexible mechanical structures exist in many applications such as aerospace systems, bridges, machining machines, robots, vehicles and more. In many cases, the structures are under dynamic loads generated by vibrations and mechanical shocks. Dynamic loads can accelerate failure mechanisms, such as fatigue and wear damage alongside damage to system functionality and reliability. A common approach to dealing with dynamic loads applied to different systems is to add energy-absorbing components. Today there are methods and approaches to vibration alleviation for example, passive approaches - without adding energy to the system but physically adjusting the system to change its own frequency. Active approaches are about adding controlled energy to the system to suppress the vibrations. This project uses an active approach to vibration suppression using an optimal control approach based on machine learning. The integration of machine learning in control systems has enormous potential in a wide variety of applications. The aim of the project is to learn and develop an optimal control algorithm based on machine learning (genetic algorithm) to suppress vibrations in a mechanical system with one degree of freedom.

The activity in the framework of the project included the development of a mathematical model for a technological demonstrator that simulates a system with a single degree of freedom, a simulation of LQR and PD controllers on this system for the purpose of comparing the performance of these controllers to a machine learning-based controller and developed a dynamic estimator for the full state space. The implementation of the control of the physical system was carried out using the MyRio controller, which receives distance measurement from a proximity sensor and outputs a control signal to current amplifiers that activate electro-magnets on the sides of the beam to stabilize it. Project steps included calibrating a dynamic model, performing experiments with an MLC algorithm while examining parameters such as the number of individuals, genetic actions, probabilities, etc., with the aim of examining their impact on system performance and learning rate.

The results obtained in the experiments show that it is indeed possible to obtain a machine learning-based controller that outperforms an optimal controller after several generations of calculation under certain conditions (settings and parameters) according to the established performance index, since the system is non-linear and there is also parametric uncertainty. If the system was linear, the optimal controller would be the best controller for the system. Later in the activity, the research will deal with the examination of more efficient convergence algorithms and the development of a dynamic MLC-based comprehension.

**Keywords**: Vibration restraint, learning machine, optimal control, dynamic model.