土木及環境工程學系
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

SEMINAR

SUSPENSION TUNING FOR BRIDGE-FRIENDLY VEHICLES: CHALLENGES AND OPPORTUNITIES

Speaker

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Abstract

About one third of the more than 600,000 bridge structures in the US are rated as deficient and require extensive maintenance and repair, amounting to a 40 billion annual budget for repairs and rehabilitations. Several national initiatives and programs have been launched to accelerate policies that would safeguard and extend the lifetime of these critical infrastructures. As such, significant efforts have been dedicated to research in coupled vehicle-bridge interaction (VBI) dynamical systems, with applications to bridge condition assessment and development of control strategies to mitigate excessive bridge vibration. The control methods are generally grouped into two categories: (1) placement of external devices, such as smart stiffeners or tuned mass dampers (TMDs) on the bridge to improve its safety, or (2) develop bridge-friendly vehicles via tuning of the vehicle suspensions. While the first approach is impractical to retrofit so many bridges, the second approach requires effective government policies and understanding of the complex mechanics and control methodologies of the VBI problem. In this research, a novel theoretical framework for the time-varying displacement transmissibility is developed using a time-frozen technique. The time-frequency characteristics of the transmissibility functions are investigated to gain fundamental understanding and insights of the coupling dynamics in relation to the matching of bridge and vehicle natural frequencies. An important aspect of this time-varying transmissibility formulation is that it leads to the development of physics-based vibration control strategies in the frequency domain. By applying the principle of fixed points from classical vibration absorber designs to the transmissibility functions, optimally tuned vehicle suspensions to mitigate bridge vibration are obtained. Case studies are presented for both passive and semi-active suspensions. It is shown that the tuning strategy depends only on a priori known structural parameters, and thus provides useful guidelines in practice and is shown to be effective in reducing the vibrations of both the moving vehicle and the bridge in simulation results. This work paves a foundation for further research in the design of bridge-friendly vehicles via parameter tuning. Our research also shows that optimal suspension tuning can have significant effects on the frequencies of the coupled vehicle-bridge system, potentially leading to more robust identification techniques for structural health monitoring (SHM) of bridge systems. Novel research directions and opportunities in developing collaborative strategies and policies within the framework of connected and autonomous vehicles (CAV) will also be briefly discussed.

Biography

Professor Chin An Tan graduated from the University of California at Berkeley with B.S. and Ph.D. degrees in Mechanical Engineering, and from California Institute of Technology with a M.Sc. degree in Aeronautics. He is currently a full Professor in the Mechanical Engineering Department of Wayne State University. His research and technical interests lie in the fields of structural dynamics and vibration control, mechatronics, and NVH applications.Current research topics and interests include: structural control; moving vehicles interacting with continuous structures; dynamic modeling and controls with applications to autonomous robotics; machine learning in automotive battery manufacturing; and energy harvesting.

Prof. Tan is a Fellow of the American Society of Mechanical Engineers (ASME). He has served as Associate Editors for several ASME transaction journals and an Associate Dean of Engineering at Wayne State Univ. Recently, he has served as a technical consultant to the electric vehicle battery manufacturing program at the General Motors Research Laboratory.

Prof. Tan has been rated as one of the most outstanding professors in teaching at Wayne State University and has won numerous teaching awards including the University President's Award for Excellence in Teaching — the highest level of recognition for excellence in teaching. He also has a strong interest in global engineering and education.

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