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Structural Dynamics Research in Mechanical Engineering at the University of Sheffield

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Abstract

The Dynamics Research Group (DRG) based in the Department of Mechanical Engineering at the University of Sheffield conducts research into vibrations and the dynamics of structures. The main areas of research are: nonlinear dynamics, structural health monitoring, active and passive vibration control, smart materials and structures and acoustics.

In the field of nonlinear dynamics, the main area of research is concerned with nonlinear system identification, currently centred on Bayesian methods, machine learning and optimisation-based approaches. The group is currently part of an EPSRC Programme Grant consortium on 'Engineering Nonlinearity' – a multi-million pound programme based on a collaboration between researchers in Bristol, Cambridge, Sheffield, Southampton and Swansea. The group also has considerable expertise in analytical nonlinear dynamics and applications of computer algebra in the field, control of nonlinear systems and in uncertainty analysis for nonlinear systems.

Our research into Structural Health Monitoring (SHM) is mostly focused on machine learning and pattern recognition methods - an approach pioneered in Sheffield in collaboration with colleagues from Los Alamos National Laboratory in the US. Both vibration-based and ultrasonic SHM methods are pursued within the group and the dominant applications are currently to civil infrastructure (mainly bridges) and aerospace structures. Recent work has seen an expansion into the field of renewable energy with projects on the condition and health monitoring of wind turbines. Experimental verification and validation is a strong element of the SHM work. Many of the machine learning algorithms are based on biologically-inspired ideas, such as artificial neural networks and evolutionary algorithms

In terms of active and passive vibration control, our main efforts have been in the development of novel material damping technologies and for many years the group hosted a Rolls-Royce UTC on the subject. Technologies developed and extended within the group – like particle dampers – have been successfully adopted by aerospace industry. The group also has expertise in active control applied to manufacturing processes e.g. in the mitigation of 'chatter', a notoriously destructive problem of excessive vibration that can occur in cutting operations. Recent developments in the area of vibration control have successfully incorporated 'hardware-in-the-loop' concepts. A closely related technology to vibration suppression is that of *energy harvesting* and a number of recent projects in this area have been carried out within the DRG; this work has overlapped substantially with the work on nonlinear dynamics.

In the area of smart materials, the group has considerable expertise in piezoelectric actuation, shape memory alloys and Electro- and Magneto-Rheological (ER and MR fluids); applications include automotive and railway damping systems and biomechanical systems. In recent years the MR fluid technology proved very successful in developing mountain bicycle dampers.

Finally, in the field of Acoustics, fundamental research is carried out in the numerical analysis of sound transmission in complex materials and structures and also applied research is carried out in the acoustics of water pipelines; the group is associated with the Pennine Water Group and has a strong link with the Department of Civil and Structural Engineering in the University of Sheffield.

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