

SEMI PLENARY LECTURES

Optimal placement of sensors, actuators and dampers for waves

Enrique Zuazua, BCAM – Basque Center for Applied Mathematics

Monday 9th July, 2.00pm – 3.00pm, Lecture Theatre GM15

In this lecture we address the problem of the optimal placement of sensors, actuators and dampers for wave-like equations, an issue arising in many engineering processes and applications.

We first recall the classical duality principle between controllability and observability considering the toy-model of the 1-dimensional wave equation.

We then discuss the dissipative wave equation where, due to the non-selfadjoint nature of the generator of the dynamics, characterizing the decay rate of solutions as time tends to infinity needs to take into account both spectral properties and the propagation of bicharacteristic rays. We present the state of the art in what concerns the optimal placement of dampers.

We then turn our attention to the conservative wave equation and the optimal placement of sensors and actuators. Using Fourier series representations the problem can be recast as an optimal design one involving all the spectrum of the laplacian. We develop a complete theory allowing to distinguish, depending on the complexity of the data to be observed/controlled, cases in which the solution is a classical set constituted by a finite number of subdomains, from others in which the optimal set is of Cantor type or those when relaxation occurs.

Finally we analyze numerical approximation and simulation issues. We exhibit examples in which the high frequency numerical solutions behave in a pathological manner. This constitutes an important warning about the straightforward use of numerical methods when computing optimal placements.

Most of the work presented in this lecture is part of ongoing research in collaboration with A. Marica (BCAM - Basque Country – Spain), Y. Privat (ENS Cachan, Antenne de Bretagne, France), and E. Trélat (Université Pierre et Marie Curie (Paris 6), Laboratoire Jacques-Louis Lions, Paris, France).



Enrique Zuazua born in Eibar (Basque Country-Spain) in 1961, in September 2008 he was appointed at Ikerbasque, the Basque Foundation for Science, as Research Professor and Scientific Director of the BCAM – Basque Center for Applied Mathematics. He is also an honorary member of Jakiunde, the Basque Academy of Sciences, Letters and Humanities. He holds a degree in mathematics from the "Universidad del País Vasco-Euskal Herriko Unibertsitatea" (Basque Country-Spain), a PhD degree from the same university (1987) and from the "Université Pierre et Marie Curie" in Paris (1988). During the academic year 1987–1988 he was a part-time lecturer at the "Universidad del País Vasco-Euskal Herriko Unibertsitatea" and went on to become a tenured lecturer in Mathematical Analysis at the Universidad Autónoma de Madrid. In 1990 he became Professor of Applied Mathematics at the Universidad Complutense de Madrid. In 2001 he moved to the Universidad Autónoma de Madrid.

He has been a visiting fellow at the Courant Institute in New York and the Universities of Minnesota and Rice in the USA, the Universidade Federal do Rio de Janeiro, the Isaac Newton Institute in Cambridge, the Université Pierre et Marie Curie, Paris-Sud, Versailles, Orleans, Toulouse, Nice and the École Polytechnique de Paris, among others.

He is the editor-in-chief of "ESAIM:COCV", Corresponding Editor of the "SIAM Journal on Control and Optimization" and member of the editorial committee of other magazines and of scientific committees of various centres and agencies, President of the Scientific Committee of CIMPA and Chairs the 2011 Mathematics Panel for Advanced Grants of the European Research Council (ERC).

He has been awarded the Euskadi Prize for Science and Technology 2006 and the National Julio Rey Pastor Prize 2007 in Mathematics and Information and Communication Technology, the Advanced Grant NUMERIWAVES of the ERC in 2010, and more recently the best article prize of Annales de l'IHP for the year 2008 (joint with Th. Duyckaerts and X. Zhang).

With over 204 articles published, his work has had an important impact and he was recognized as a "Highly Cited Researcher" by the ISI Institute (Thomson) in 2004, also he has supervised 20 postdoctoral researchers and 25 PhD students.

His fields of expertise in the area of applied mathematics cover topics related with Partial Differential equations, Systems Control and Numerical Analysis.