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APPLIED MATHEMATICS seminar

DATA-DRIVEN METHODS BASED ON SVD AND DMD AND DEEP LEARNING IN FLUID DYNAMICS

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ABSTRACT: Complex flows are found modeling a wide range of industrial and biological applications. Although these flows have been studied for decades, in a large quantity of relevant cases, to elucidate their spatio-temporal structure is still considered as an open topic due to their high complexity. Thus, the deep study and understanding of complex flow behavior, such as transitional or turbulent flows, is a research topic of high interest.
In this talk we will introduce a method suitable to detect spatio-temporal patterns in complex non-linear dynamics. This is an extension of the well-known technique dynamic mode decomposition (DMD), called as higher order dynamic mode decomposition (HODMD). The method combines singular value decomposition (SVD) with DMD and Takens' delay embedding theorem to approximate the main dynamics describing a signal. HODMD has been successfully applied to study several problems covering from non-linear dynamical systems (i.e.: complex Ginzburg- Landau equation, Lorenz system, ...), to complex fluid dynamic problems (i.e.: analysis of noisy experiments and transitional flows in synthetic jets, turbulent channel flows, etcetera) and has also been applied as a reduced order model for data forecasting in compressible flows and wind turbines. In the second part of the talk, a method known as spatio temporal Koopman decomposition (STKD) will be introduced, presenting a good alternative to perform spatio-temporal DMD analyses in a very efficient way. This method identifies coherent structures as a group of traveling waves. The method will be tested in some examples including the detection of spatio-temporal flow structures describing the wake of a wind turbine or global instabilities in elastoviscoplastic fluids and tuburlent channel flows with anisotropic porous wall.

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