Contribution ID: **37** Type: **Poster**

Kernel-based Active Subspaces with application to CFD problems using Discontinuous Galerkin method

Wednesday, 29 July 2020 19:30 (1 hour)

The need to devise model order reduction methods is strictly related to the finite nature of the available resources, including the computational budget, the amount of memory at disposal and the limited time, which may range from a life-time to real-time queries. Parametric studies, from optimization tasks to the design of response surfaces, suffer particularly from the curse of dimensionality since they usually scale exponentially with the dimension of the parameter space. A key pre-processing step is therefore reducing the dimension of the space of parameters discovering some notion of low-dimensional structure beneath.

Under mild regularity assumptions on the model function of interest, Active Subspaces have proven to be a versatile and beneficial method in engineering applications: from the shape-optimization of the hull in naval engineering to model order reduction coupled with the reduced basis method for the study of stenosis of the carotid. The procedure involved can be ascribed to gradient-based sufficient dimension reduction methods. In the context of approximation with ridge functions, it finds theoretical validation from the minimization of an upper bound on the approximation error through the application of Poincaré-type inequalities and Singular Value Decomposition (SVD).

We are going to present a possible extension which address especially the linear nature of the Active Subspace in search for a non-linear counterpart. The turning point comes from the theory on Reproducing Kernel Hilbert Spaces (RKHS) which have been fruitfully employed in machine learning to devise non-linear manifold learning algorithms such as Kernel Principal Component Analysis (KPCA). An essential feature of the method that exploits the non-linear Active Subspaces should be the flexibility to account for non-linear behaviours of the model function.

Our implementation is tested on toy-problems designed to exhibit the strengths of the non-linear variant and on a benchmark with heterogeneous parameters for the study of the lift and drag coefficients of a NACA airfoil. The numerical method applied for the approximation is the renowned Discontinuous-Galerkin method. Future directions involve the developement of other nonlinear extensions of the active subspaces method with deep neural networks.

Primary authors: Mr ROMOR, Francesco (SISSA); Mr TEZZELE, Marco (SISSA); Dr LARIO, Andrea (SISSA); Prof. ROZZA, Gianluigi (SISSA)

Presenter: Mr ROMOR, Francesco (SISSA)

Session Classification: Posters 2