Recursive POD for real time simulations of a ventilated temperature-controlled room

M. Azaïez[1] T. Chacón Rebollo[2] E. Perracchione[3] J.M. Vega[4]

[1] *Bordeaux INP, I2M 16, avenue Pey Berland 33607 Pessac Cedex, France.* azaiez@ipb.fr
[2] *IMUS, University of Sevilla, Avda. Reina Mercedes s/n. 41012 Sevilla, Spain.* chacon@us.es
[3] *University of Padova, Department of Mathematics T. Levi-Civita, Via Trieste 63 PD.* emma@math.unipd.it
[4] *E.T.S.I. Aeronáuticos, UPM, Pza. de Cardenal Cisneros, 3, 28040 Madrid, Spain.* josemanuel.vega@upm.es

The Proper Orthogonal Decomposition (POD) [1], also known as Principal Component Analysis (PCA) in statistics and Singular Value Decomposition (SVD) in linear algebra (see e.g. [4] for a general overview), is an information compression technique. It finds its natural applications in a wide variety of fields, such as in digital image compression, bioinformatics, signal processing and resolution of PDEs, see e.g. [3]. However, it is well suited only for bivariate problems.

Therefore, we extend the POD approximation for multivariate functions with an arbitrary number of parameters [2], for which we prove general error estimates. Furthermore, comparisons with other techniques are also carried out. Having such a versatile method for high dimensions in applications turns out to be meaningful. We thus give an example about the estimation of the thermal resistance coefficients in buildings (refer e.g. to [5]). Such issue is a typical example of multivariate problem for which we need reliable approximations via tensor decomposition techniques.

References

[1] M. Azaïez, F. Ben Belgacem, *Karhunen-Loève's truncation error for bivariate functions*, Computer Methods in Applied Mechanics and Engineering, 290 (2015) 57–72.

[2] M. Azaïez, T. Chacón Rebollo, E. Perracchione, J.M. Vega, *Recursive POD expansion for the advection-diffusion-reaction equation*, to appear on Communications in Computational Physics, 2018.

[3] G. Berkooz, P. Holmes, J.L. Lumley, *The proper orthogonal decomposition in the analysis of turbulent flows*, Annual Review of Fluid Mechanics, 25 (1993) 539–575.

[4] M.M. Loève, *Probability theory*, Van Nostrand, Princeton, NJ, 1988.

[5] A. Rincon Casado, *Modelización CFD para el cálculo de los coeficientes de pelicula convectivos en el interior de espacios. Desarrollo de modelos orientados a la integración en programas de simulación térmica de edificios*, PhD thesis, Universidad de Cádiz, Cádiz, 2014.