National Grid NG SINGAPORE

Duct Parameterization & Optimization using POD

Project Introduction

Objectives
To carry out optimization using Proper Orthogonal Decomposition (POD).

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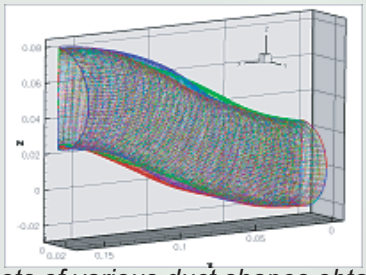
Abstract
POD is a powerful technique for reduced-order modeling. It can speed up the computational time by several orders. However it requires the generation of a set of database which is the computationally expensive part.

Project Details

Description
The method of analysis at the core of this project appears in various guises and is known by several different names—depending on its area of application. In image processing, it is known as the Hotelling transform. In pattern recognition it goes by the title principal component analysis. And for statistical and econometrical purposes, the Karhunen-Loève method is commonplace.

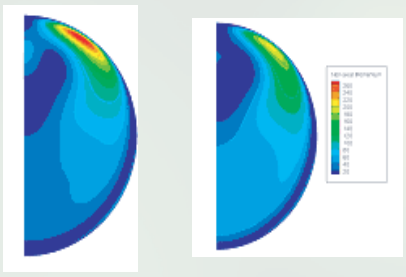
Another name for this method is proper orthogonal decomposition (POD), proposed by Lumley in 1967, when he used it for fluid flow analysis. He suggested that POD could be used to provide an unbiased identification of coherent structures in turbulent flow. Since then, many researchers and practitioners have applied POD techniques to various applications in the domain of fluid and aerodynamics. Regardless of the monikers that the method goes by, it is essentially based on second-order statistical properties which result in a linear invertible transformation such that the eigenfunctions yielded would optimally represent the data. Optimal in this sense, refers to the fact that for any given orthonormal bases, the POD eigenfunctions bases ensure it is the best bases, and that the two-norm or L2-norm error between the original and reconstructed data is minimum.

It is important to parameterize the duct with a small number of parameters which will permit exploring a reasonable family of ducts and yet keep the problem tractable.



Snapshots of various duct shapes obtained by varying the parameters obtained via gappy POD

With the duct properly parameterized, we seek to optimize it for aerodynamic performance by changing its geometry. The M2129 duct was used as the test case.



(a) *(b)*

Duct optimized for non-axial momentum, (a) Original M2129 duct, (b) re-designed duct