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DATA-ASSIMILATION, PARAMETER SPACE REDUCTION AND REDUCED ORDER METHODS IN APPLIED SCIENCES AND ENGINEERING

Outline

Two different pipelines for parameter space reduction using Active Subspaces:

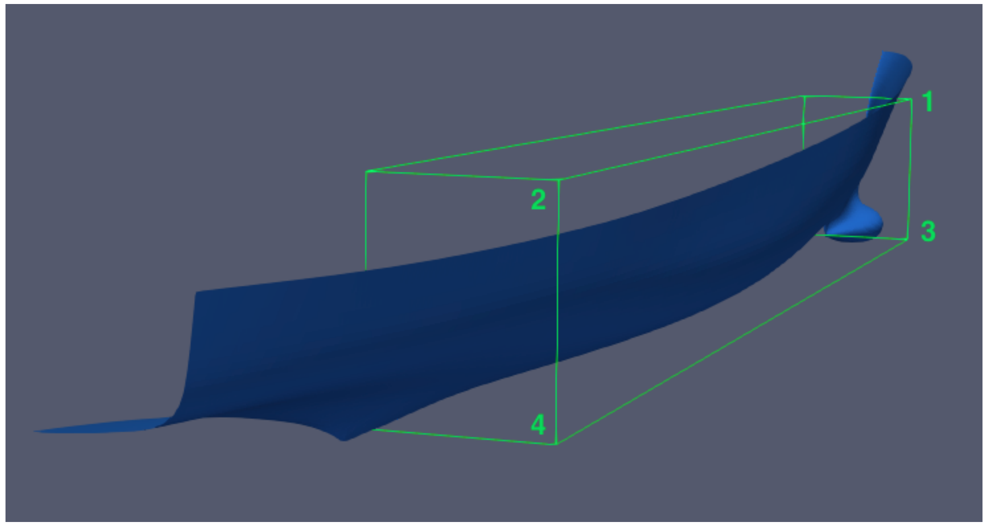
- In the naval engineering problem we used Free Form Deformation to vary the shape of an hull and Response Surface method to make prediction

- In the biomedical problem we used Radial Basis Functions interpolation technique to vary the shape of a carotid and Proper Orthogonal Decomposition method to reduce the model

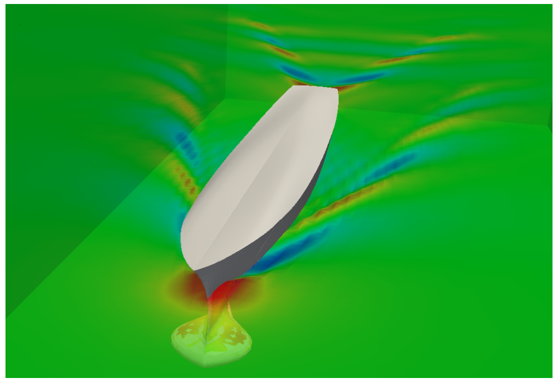
The naval engineering case

- The output is a derived function of the wave resistance of a DTMB hull advancing in calm water at fixed Froude number 0.28 and velocity ~2 m/s
- As parameter inputs we select 8 components of 4 different control points of a FFD lattice over one side wall of the hull. Then we apply the same deformation to the other side. y is the span of the hull, x its length and z its depth

Parameter	Nature	Lower bound	Upper bound
u_1	FFD Point 1 y	-0.2	0.3
u_2	FFD Point 2 y	-0.2	0.3
u_3	FFD Point 3 y	-0.2	0.3
u_4	FFD Point 4 y	-0.2	0.3
u_5	FFD Point 3 z	-0.2	0.5
u_6	FFD Point 4 z	-0.2	0.5
u_7	weight (kg)	500	800
u_8	velocity (m/s)	1.87	2.70



Hull in a free surface



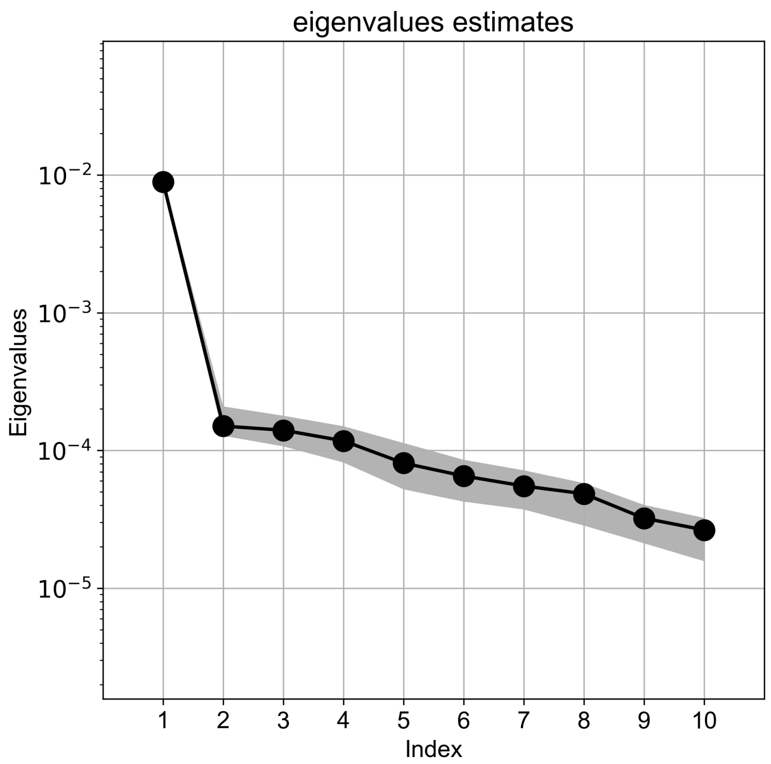
Original DTMB 5415 semi-hull

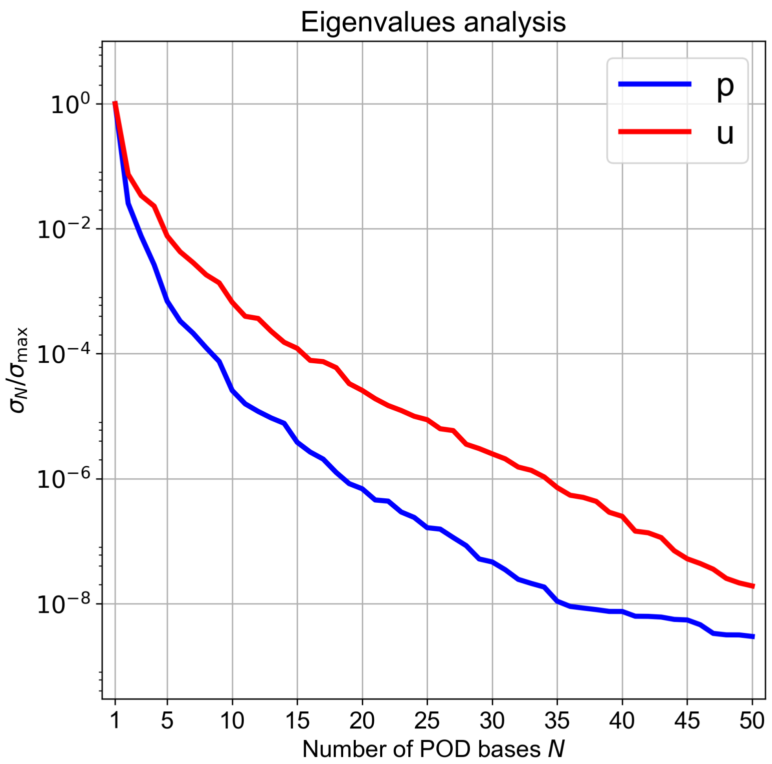
Flow across parametrized carotid bifurcations

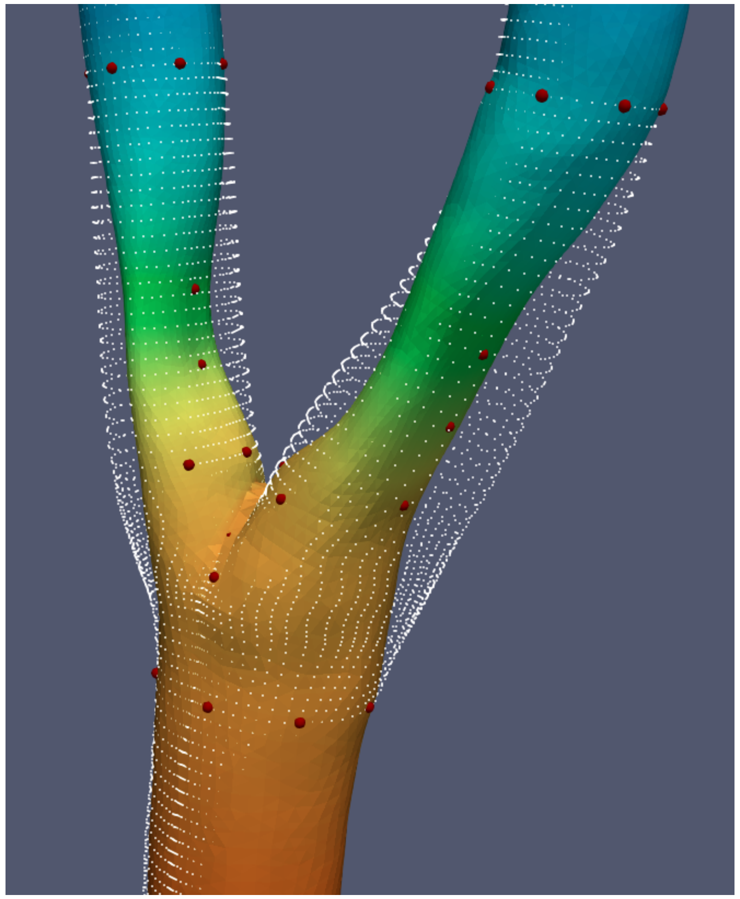
Vessels geometry strongly influences hemodynamics behaviour

Evaluation problem:

$$\begin{cases} -\nu\Delta\mathbf{v} + (\mathbf{v}\cdot\nabla)\mathbf{v} + \nabla p = \mathbf{f} & \text{in } \Omega_o \\ \nabla\cdot\mathbf{v} = 0 & \text{in } \Omega_o \\ \mathbf{v} = \mathbf{v}_g & \text{on } \Gamma^o_w := \partial\Omega_o \setminus \Gamma^o_{out}, \\ -p\cdot\mathbf{n} + \nu\dfrac{\partial\mathbf{v}}{\partial\mathbf{n}} = \mathbf{0} & \text{on } \Gamma^o_{out} \end{cases}$$







Deformed carotid with the deforming control points (red) and the undeformed state (white)