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The Proper Generalised Decomposition for interactive aerodynamic design

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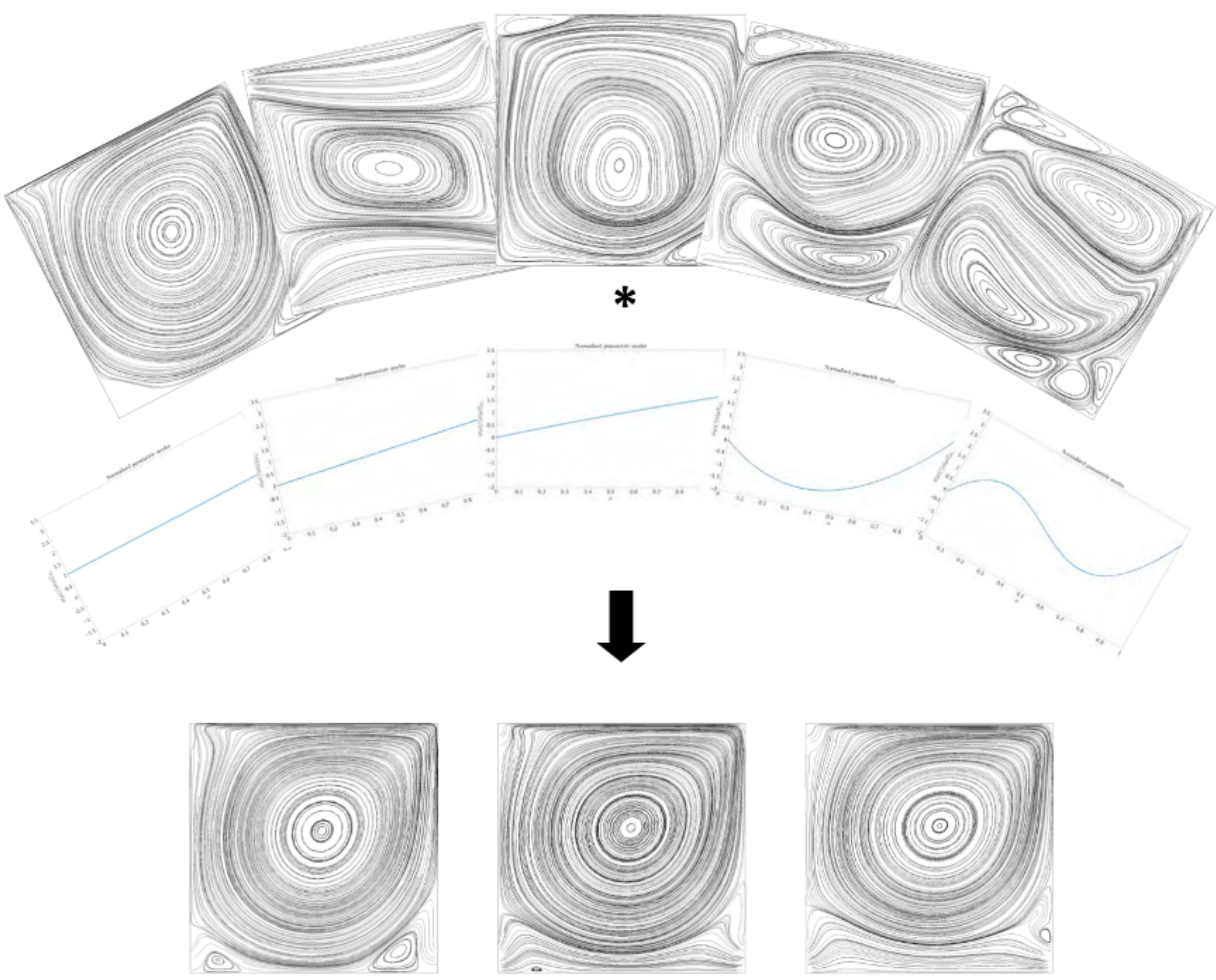
1. Motivation and Objectives

The exploration of parametric solutions for flow problems is an essential part of the design pipeline in the automotive industry. In such problems, where a large number of solutions are required, the use of conventional computational fluid dynamics (CFD) techniques is unfeasible.

Reduced order modeling (ROM) techniques provide an efficient approach to the solution of parametric problems. This research is aimed to the development of a Proper Generalised Decomposition (PGD) methodology and its seamless implementation in the CFD software OpenFOAM.

Experimental set-up and digital model of VW UP for flow control tests. [Source: Dr. Robin Placzek, VWAG]



Visual representation of the PGD rationale using the lid-driven cavity case with parametrised flow-control.

2. The Proper Generalised Decomposition

The main concept of PGD is separation:

- Consider parameters of interest as extra dimensions.
- Break down complex solution to simpler and easier-to-compute parts.
- Combine these parts to get an accurate approximation in real-time.

Main issue is the intrusive nature of PGD.

3. Contributions

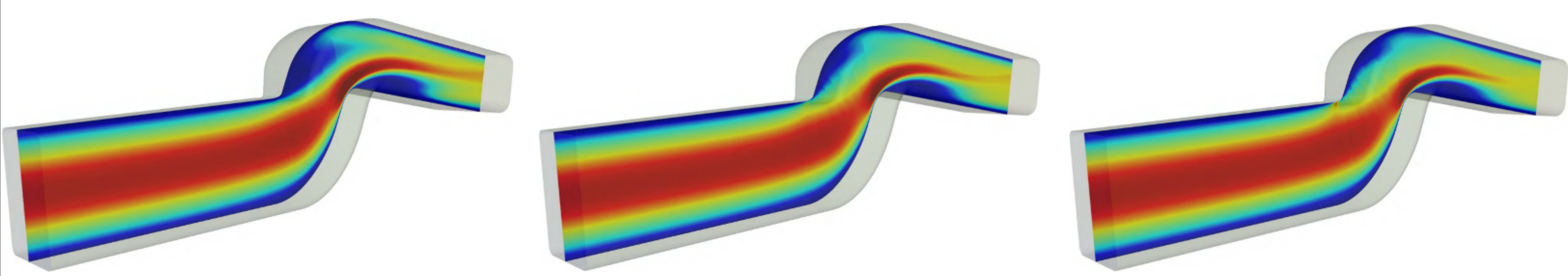
The main contributions include:

- **First** non-intrusive implementation of PGD for flow problems.
- Development of methodology for the **first** application of PGD in parameter-dependent turbulence.

4. Example with parametrised flow control

In an industrial environment where large number of designs need to be tested, **compacting the optimisation pipeline in a black box** offers great possibilities to the developer. Coupling that with the main advantage of PGD, its ability to **build and correct itself**, we get a more streamlined and care-free design environment.

The case below requires **12 core-hours** to solve, but can be approximated in **less than 1 second**.



Different design possibilities of an air conditioning duct section produced in real-time using PGD.