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SURROGATE MODELS FOR SPACECRAFT AERODYNAMIC PROBLEMS

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Airbus Defence and Space, in the frame of the development of various spacecraft vehicles, is producing aerodynamic models. Different kinds of data are used to build these models:

- Experimental results derived from WTT campaigns, with a high level of confidence.
- Numerical data resulting from CFD simulations, with a lower level of confidence, which depends also on the used numerical method (Euler / RANS, flow regime, etc.)

CFD computations and even more WT campaigns are very costly and it is sometimes not conceivable to perform all flight configurations (surfaces deflections, e.g.) on the whole flight range. An inter-extrapolation process is then necessary to build a complete aerodynamic model. With a lot of input parameters (Mach, Angle of Attack, Angle of Sideslip, surfaces deflections, etc.), this process can be quite time consuming and may

lead to inconsistent results with a classical approach. Furthermore available data can constitute anisotropic grids which lead to severely harden the inter-extrapolation process.

The objective is therefore to build a consistent model taking into account all available data, with a fast and rationale method.

Airbus Defence and Space is thus interested by the generation of surrogate models from given spacecraft aerodynamic database. The AErodynamic DataBase (AEDB) provides the aerodynamic coefficients of the vehicle for the different flight conditions and vehicle configurations (notably aerodynamic control surfaces deflections) encountered over the whole mission domain. This type of database is typically included within global vehicle behaviour models. These behaviour models are then used as input to various system studies, such as trajectory and performance analysis, or handling qualities and flight control system analysis.

From a practical standpoint, the AEDB generation process raises the following two fold challenges:

- Multidimensional interpolation/extrapolation: how to cover a prescribed full flight envelope defined in the multidimensional space of flight conditions/vehicle configurations, on the basis of scattered discretized input data?
- Multiple data combination: how to build a consistent and homogeneous aerodynamic database on the basis of multiple input data sets with different levels of fidelity?

The final goal is to obtain a surrogate model that can automatically interpolate multi-dimensional data, union of anisotropic grids with non-uniform data and different level of fidelity, and therefore to build a consistent and homogeneous aerodynamic model that can cover all intermediate points within the flight envelope. Last but not least, the surrogate model shall ensure that the exhibited outputs always remain within realistic limits (i.e. remain meaningful from aerodynamics behaviour standpoint), whatever the input vector content.