Taxonomy of a Design Process

In a sophisticated design process, such as for instance used in an aircraft aerodynamic design, a four dimensional design problem is specified in terms of an objective function and constraints, which require an expensive three-dimensional unstructured Euler method evaluation.

The problem to be solved is specified as follows:

\[ \text{Minimise } C_{\text{D},\text{M}} = 0.85 \]

(With \( C_{\text{D}} \) being the drag coefficient and \( M \) the Mach Number) by varying the design variables: angle of attack (\( \alpha \)), wing twist angle (\( \theta \)), flap deflection angle (\( \delta \)) and camber, such that straight and level flight must be achievable:

\[ C_{\text{L,\text{Total}}} = C_{\text{L,\text{Wing}}} \geq 0.1994 \]

where \( C_{\text{L,\text{Wing}}} \) is the pitching moment about the wing leading edge, \( c \) is the wing chord and \( h \) is the distance from the aerodynamic centre to the centre of gravity.

Here a response surface model (RSM) is used for each of the objective and constraints (alternatively constituents of these, \( C_{\text{L}}, C_{\text{D}}, C_{\text{M,l.e}} \) could be modelled and the objective and constraints constructed from these). We determine how many evaluations can be afforded and exactly where in the design space these are going to be placed (we specify a Latin hypercube design of experiments, DoE). In our case one evaluation provides the objective and constraints, although this may not necessarily be the case. Here, 200 evaluations were performed across 9 computers in parallel in an overnight run. The next thing to determine is which RSM to use.

The next step in this work will be to increase the dimensionality of the problem to incorporate variables related to planform area.

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