Wing Movable Layout Parameterisation – From continuous optimised downwash to discrete movables

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ABSTRACT

This paper will present how a continuous movable parameterisation can be converted into a practical set of discrete, distributed movables. In this methodology, the optimised downwash distribution is converted into a discrete set of movables. Furthermore, the effect of different discretisation levels will be presented.

The novel parameterisation methodology [1] has been developed to enable efficient exploration of the movable design space, considering both conventional and shape-morphing movables. Furthermore, as current industrial design processes first size the movable layout for handling qualities, with load alleviation being a secondary function [2], [3]. This can lead to the suboptimal use of control surfaces for load control for all types of wing planforms. Hence, a framework considering handling qualities and load alleviation simultaneously needed to be developed.

The novel parameterisation methodology [1] allows for the optimisation of a movable layout, considering both handling quality and load alleviation (manoeuvre and gust load alleviation) simultaneously. Its output is an optimised downwash distribution described using B-splines, with Figure 1 shows an example of the distribution for manoeuvre load alleviation for a 2.5g pull-up. The optimised downwash distribution is interpretable as the optimal position and corresponding deflection angles of the different movables used for both handling qualities and load alleviation. For example, Figure 1 shows the appearance of an outboard region with upward deflection (in blue) and a downward deflection (in red) in the inboard region. These deflections are used to move the centre of pressure inboard and reduce the root bending moment.

However, the deflections corresponding to the optimised downwash distribution cannot generally be achieved on an aircraft without considering morphing movables. Hence, a method that can convert the continuous downwash into a set of discrete movables needs to be developed.

The idea behind the discretisation process is to utilise the downwash contours that can be extracted from the optimised downwash distributions by specifying the contour interval level. The contour lines are used as indicators of the location of the split between different movables. An example of the optimised downwash distribution with different splits can be seen in Figure 2. To ensure that the splits between the different movables are manufacturable, several constraints must be considered. Examples of such constraints include the maximum angle with respect to the free-stream direction or the maximum spanwise deviation in the chordwise direction.

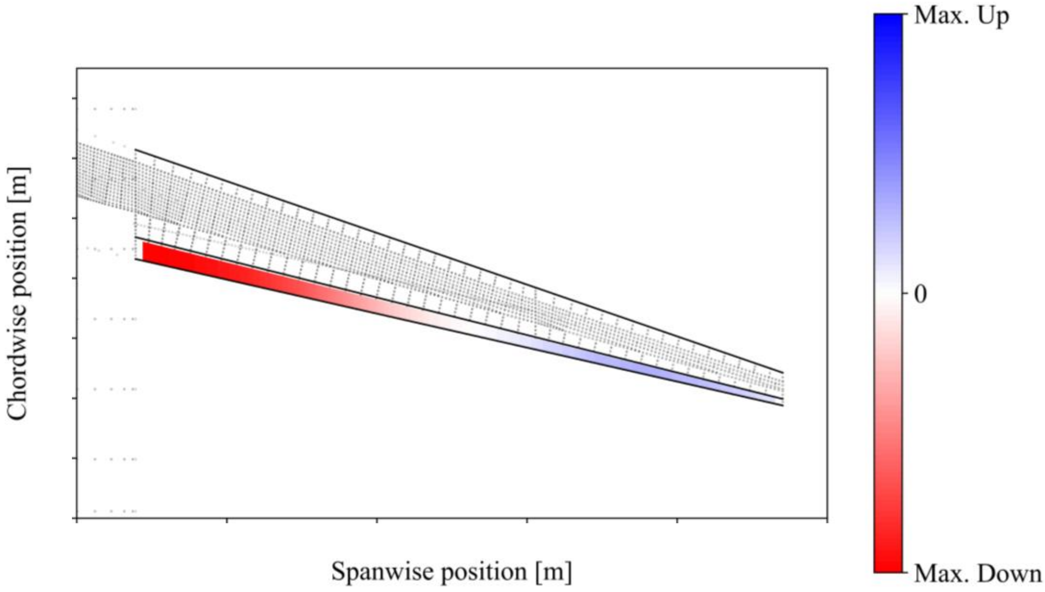

Figure 1: Downwash distribution for manoeuvre load alleviation during Nz = 2.5g

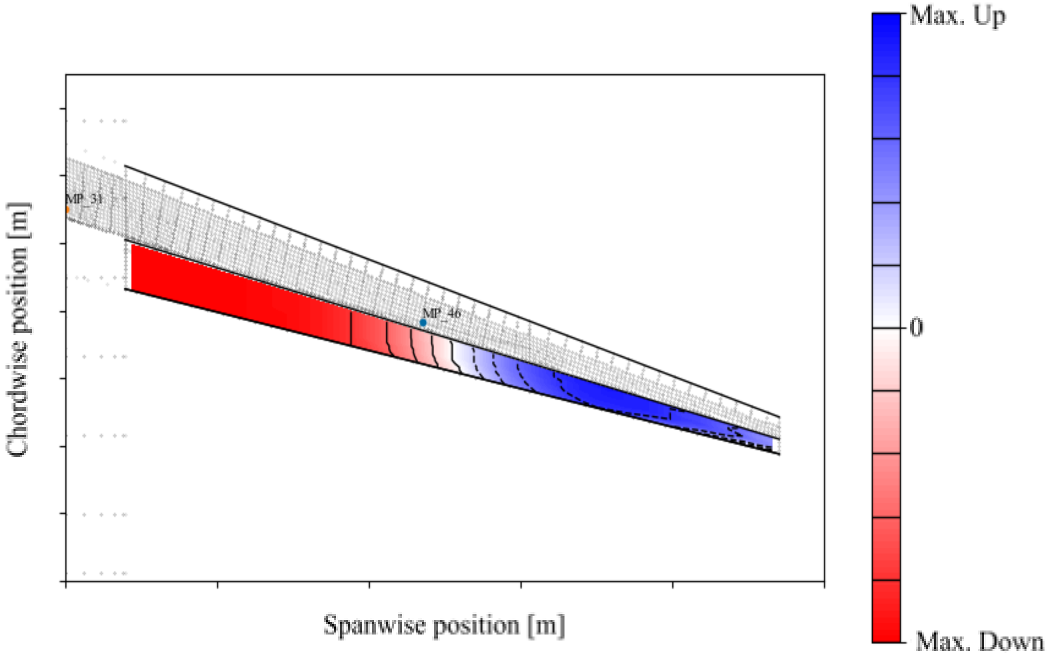

Figure 2: Optimised downwash distribution for manoeuvre load alleviation during Nz = 2.5g of a 40% chord with contour lines

Finally, because the number of contour intervals considered in the contour lines influences the discretisation, the effect of the discretisation level must be investigated, as the number of movables available for load control influences the load alleviation capability of the movable layout [4]. To determine this effect, the movable layout will be discretised using a set of contour line levels, and the handling quality-load alleviation performance will be re-evaluated using the selected set of discrete movables through optimisation of the deflection of each movable. This will be repeated for several discretisation levels, allowing the load alleviation capability and the corresponding discretisation level to be compared.

To summarise, this paper will demonstrate the discretisation of the optimisation output of the continuous movable parameterisation to a set of discrete movables. Furthermore, the effect of the discretisation on the load alleviation performance of the movable layout will be evaluated, and the results of different discretisation levels will be presented.

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