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AERODYNAMIC SHAPE OPTIMIZATION OF A 3D WING VIA VOLUMETRIC B-SPLINES

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In shape optimization techniques, the goal is to minimize a suitable cost or objective function, as aerodynamic drag, through surface deformations by means of a selected geometry parameterization. The use of non-rational uniform b-splines (NURBS) has been demonstrated as a suitable technique for wing design in a previous work [1]. NURBS is a parameterization frequently employed by CAD applications to represent surfaces. Another viable technique is free-form deformation (FFD), which encloses the geometry in a volumetric parallelepiped, commonly referred as *control box* or *control lattice*. This can be seen as a transparent rubber box that deforms the space by the manipulation of control points. The most common mathematical definition for FFD are the trivariate Bernstein polynomials, which provide the advantage that the parametric coordinates are directly obtained from the Cartesian vertex coordinates of the computational grid. While both techniques have its advantages and disadvantages [2], more crucial is the ability to handle geometric restrictions, as the thickness of a wing profile. The methodology proposed in this paper unifies both parameterization techniques, by the use of the mathematical definition of the *control box*:

$$N(u\ v\ w)=\sum_i\sum_j\sum_k B_i(u)B_j(v)B_k(w)C_{ijk}$$

where C_{ijk} are the control points and B_i, B_j, B_k, are three parametric basis functions, one for each dimension.

The selected test case is the DPW-W1 three-dimensional wing, from the 3rd AIAA CFD Drag Prediction Workshop [3], as can be observed in Fig. 1. The parameterization is a control box with 3 sections at the root, mid-span, and tip, 12 control points in each section, and beam constrains at 20% and 75% of the chord. The design variables are the vertical displacements of the control points, which are initially placed on the aerodynamic surface.

In this work, two basis functions are tested and compared: uniform b-splines (the same employed by surface NURBS) and Bezier splines, as displayed in Fig. 2. With the control box approach, the design variables (control points) are set up strategically for having a certain degree of control of the restrictions. Conclusions on the advantages of this parameterization when handling geometric constraints will be summarized, and the shape optimization results using different basis functions will be compared.

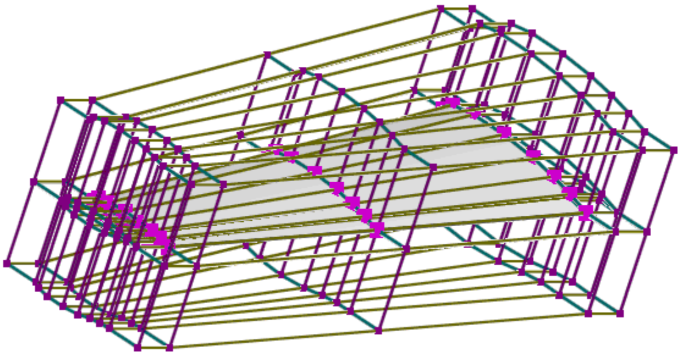

Fig1. Selected test case: DPW-W1 wing and control box parameterization.

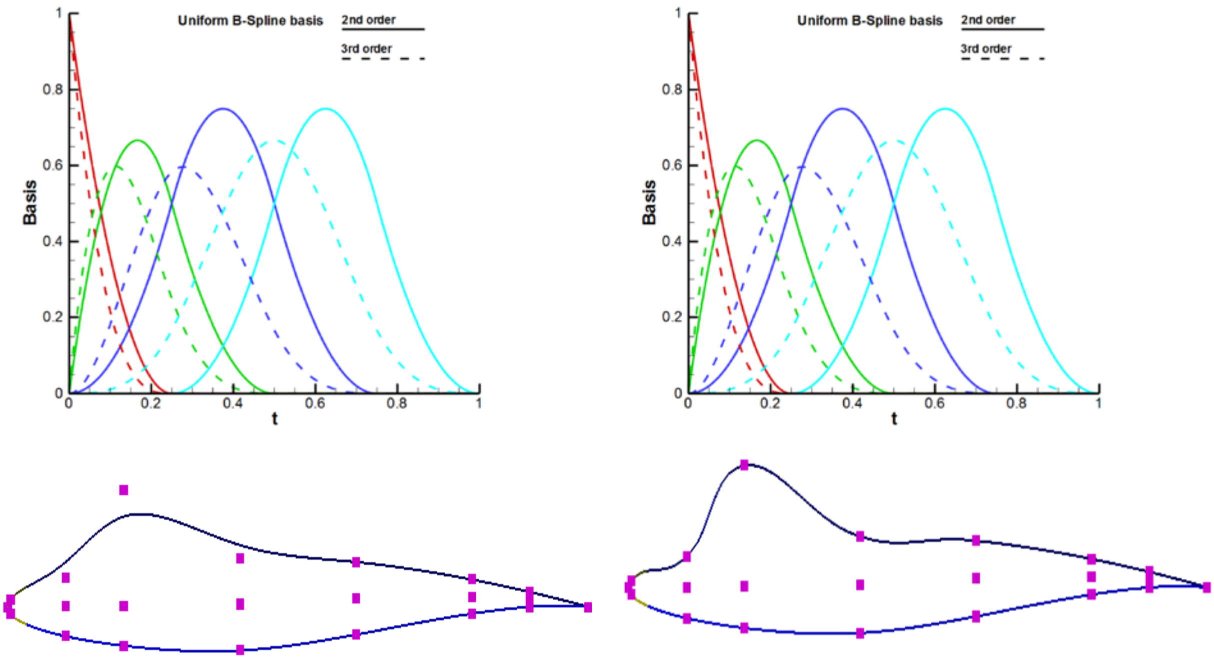

Fig 2. Basis functions employed: uniform b-spline (left) and bezier splines (right)

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