Accepted Manuscript

Geometrically consistent static aeroelastic simulation using isogeometric analysis

E. Gillebaart, R. De Breuker

PII: S0045-7825(18)30277-9
DOI: https://doi.org/10.1016/j.cma.2018.05.033
Reference: CMA 11934

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 30 August 2017
Revised date : 8 April 2018
Accepted date : 27 May 2018

Geometrically consistent static aeroelastic simulation using isogeometric analysis

E. Gillebaart[a,*], R. De Breuker[a]

[a] Department of Aerospace Structures and Materials, Faculty of Aerospace Engineering, Delft University of Technology

Abstract

In conventional aeroelastic analysis and optimisation methods for wing design, different geometries are used for the different steps in the process. Generally, a parametrised model is used to describe the shape of the geometry for the optimisation process. Subsequently, this model is converted into a structural and aerodynamic model for analysis purposes. These steps increase the computational effort and introduce geometrical errors. In this work, a geometrically consistent static aeroelastic analysis framework is presented. By using isogeometric analysis, the exact geometry is used in both the structural and aerodynamic models, preventing any additional computational effort for meshing and geometry retrieval steps and avoiding the introduction of geometrical errors due to the discretisation of the geometry. The separate components of the framework are described and verified, and the complete framework is demonstrated through the analysis of the realistic wing model.

Keywords: Isogeometric analysis, Aeroelasticity

1. Introduction

With the trend of aircraft wings becoming more slender and flexible, the need for multidisciplinary analysis and optimisation is becoming more and more essential. The two main disciplines, aerodynamic and structural analysis, should be taken into account simultaneously to enable crucial trade-offs between the two disciplines. This will allow for improved overall performance of the future aircraft. Furthermore, goals set out by European programs like Flightpath 2050 [1] are challenging to achieve with current aircraft configurations. Deviation of the well-known "wing and tube" configuration will render large portions of the empirical data and knowledge currently used in aircraft design obsolete. Physics-based models can be used to bridge this gap and enable the design of new aircraft concepts.

The benefit of combining aerodynamics and structures in the analysis and optimisation of aircraft wings has been explored extensively in the last 40 years. An overview of earlier work can be found in the review article by Sobieszczanski-Sobieski and Haftka [2]. In more recent years there has been more emphasis on including high-fidelity models in the aerostructural optimisation routines. Kenway and Martins [3] used large-scale parallel computational power to perform aerostructural optimisation using an Euler aerodynamic model and a finite element shell structural model. The free form deformation (FFD) method was used to generate a parametrisation for the geometry. A similar level of fidelity was used in the work of Zhang et al. [4], who demonstrated a different way of parametrising the geometry using B-spline surface patches. The FFD parametrisation was also used by Brooks et al. [5] who increased the fidelity of the aerodynamic analysis to a Reynolds-averaged Navier-Stokes (RANS) model to perform aerostructural optimisation of a tow-steered composite wing.

*Corresponding author.
Address: Kluyverweg 1, 2629 HS Delft, The Netherlands.
Email address: e.gillebaart@tudelft.nl