# Adaptive hierarchical B-spline refinement of stereo-DIC

**Pieter van Zuijlen*[1], John-Eric Dufour[2] and Clemens Verhoosel[1]**

[1] Department of Mechanical Engineering
Eindhoven University of Technology
PO Box 513, 5600 MB Eindhoven, The Netherlands
e-mail: p.h.v.zuijlen@student.tue.nl

[2] Departement of Civil Engineering and Architecture
University of Pavia
via Ferrata 3, 27100 Pavia, Italy
e-mail: johnericpierre.dufour@unipv.it

## ABSTRACT

The commonly used refinement techniques for multivariate B-spline bases are often suboptimal. The tensor product structure of these bases does not allow for local refinements. Therefore, most refinement methods result in an unnecessary high number of degrees of freedom on the global level. The hierarchical B-spline refinement structure has been developed to tackle this issue [1], using different levels of nested B-spline spaces. B-spline functions are then expressed as a linear combination of functions of a higher level [2], resulting in a locally enriched function space. To maintain the essential B-spline properties, truncated hierarchical B-splines are commonly used as an alternative method [2].

The present work implements this refinement strategy in a global approach to isogeometric stereo-DIC [3],[4]. This 3D surface measurement technique allows the representation of both the geometry and displacement fields with the same B-spline basis, expressing displacement fields as a transformation of the control points. This basis is adaptively refined based on the residual error given by the DIC algorithm, such that refinements are carried out during the calculation process. Using this method, the number of degrees of freedom required to approximate complex fields or shapes remains very low since the influence of the tensor product structure is kept minimal, and the flexibility of the isogeometric stereo-DIC algorithm is significantly improved.

**Keywords** Hierarchical B-splines, stereo-DIC, isogeometric analysis

## REFERENCES

[1] Davide D'Angella, Stefan Kollmannsberger, Ernst Rank, Alessandro Reali *Multi-level Bézier extraction for hierarchical local refinement of Isogeometric Analysis.* Computer Methods in Applied Mechanics and Engineering, Volume 328, 2018, pp. 147-174

[2] E. M. Garau, R. Vázquez *Algorithms for the implementation of adaptive isogeometric methods using hierarchical splines.* Applied Numerical Mathematics, Volume 123, January 2018, Pages 58-87

[3] John-Eric Dufour, François Hild, Stéphane Roux. *Shape, displacement and mechanical properties from isogeometric multiview stereocorrelation* The Journal of Strain Analysis for Engineering Design, 50(7): 470 - 487, 2015.

[4] Kleinendorst, S. M., Hoefnagels, J. P. M., Verhoosel, C. V., and Ruybalid, A. P. *On the use of adaptive refinement in isogeometric digital image correlation.* International Journal for Numerical Methods in Engineering, 104(10), 944-962, 2015.