The 9th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2024
3-–7 June 2024, Lisbon, Portugal

MACHINE LEARNING-BASED SURROGATES FOR UNCERTAINTY QUANTIFICATION AND DESIGN UNDER UNCERTAINTIES

Varvara G. Asouti[1,2], Marina G. Kontou[2] and Kyriakos C. Giannakoglou[2]

[1] FOSS: Flow & Optimization, Software & Services, Piraeus, Greece
e-mail: vasouti@fossgp.com
[2]Parallel CFD & Optimization Unit, School of Mechanical Engineering
National Technical University of Athens, Athens, Greece
e-mail: mkontou@mail.ntua.gr, kgianna@mail.ntua.gr

Keywords: *Machine Learning, Surrogates, Uncertainty Quantification, Design Under Uncertainties*

This paper discusses the use of surrogate models based on Machine Learning (ML) methods for Uncertainty Quantification (UQ) and design under uncertainties. Emphasis is laid on the ability of the ML-based surrogates to accurately predict the Quantities of Interest (QoI) as well as on the computational cost reduction both of the UQ and the design under uncertainties turnaround time. Deep Neural Networks (DNNs) are used as surrogates to support UQ using the Monte Carlo, as well as, the non-intrusive, Gauss Quadrature and regression-based Polynomial Chaos Expansion (PCE) methods, [1]. For the latter, the DNNs may predict only the values of the QoIs as well as their gradients with respect to the uncertain variables to be used for gradient-assisted regression-based PCE.

The NACA16-103 airfoil is used to quantify uncertainties associated both with the flow conditions and geometric imperfections. The QoIs are the lift and drag coefficient as well as their ratio (lift over drag). The computational cost from the use of the DNN-based surrogates will be compared with that of the same UQ methods using CFD computations and the obtained gain will be quantified. Then, in shape optimization problems under uncertainties, solved either by gradient-free or gradient-based methods, the DNN-based surrogates are used to compute statistical moments of the objective function. Applications in 2D and 3D external flows will be presented in the full paper.

This work is part of the NEXTAIR project funded by the European Union under Grant Agreement No. 101056732. The views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the REA can be held responsible for them.

REFERENCES

[1] E.M. Papoutsis-Kiachagias, V.G. Asouti and K.C. Giannakoglou. Assessment of variants of the method of moments and polynomial chaos approaches to aerodynamic uncertainty quantification. 4th Conference on Uncertainty Quantification in Computational Sciences and Engineering, Athens, Greece, June 28-30, 2021.