EJIL 2025
6th Meeting of Young Researchers of LAETA
FEUP, Porto, 27-28 October 2025

XFOIL NEURAL NETWORK: A DATA-DRIVEN SURROGATE FOR 2D AIRFOIL AERODYNAMIC ANALYSIS

Francisco Machado [1,2], André C. Marta [2] and Luís Eça [2]

[1] Research and Development, Tekever UAS, 2500-750 Caldas da Rainha, Portugal

[2] IDMEC, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisboa, Portugal

e-mail: francisco.machado@tekever.com, {andre.marta,luis.eca}@tecnico.ulisboa.pt

Keywords: surrogate modeling, machine learning, physics informed neural network, airfoil performance, aerodynamics

Abstract. *Recent advances in physics-informed and physics-aware machine learning have shown great promise in modeling complex physical systems with higher efficiency. These approaches aim to bridge the gap between purely data-driven methods and traditional physics-based solvers by integrating physical principles either through explicit constraints, informed architectures, or training on simulation data. Motivated by this progress, this work introduces XFoil Neural Network, a lightweight deep learning surrogate model trained on XFoil simulations to replicate two-dimensional aerodynamic performance and flow characteristics of airfoils. The model receives as input a compact airfoil parameterization, angle of attack, and Reynolds number, and outputs global aerodynamic coefficients — lift, drag, and pitching moment — as well as local flow features including pressure coefficient (Cp) distribution, boundary layer thickness profile, and transition location on the upper and lower surfaces. The objective is to evaluate the ability of a compact neural network architecture to generalize across a wide variety of airfoil geometries and flow conditions. In addition to assessing predictive accuracy, this study explores the importance of training data quality and hyperparameter tuning in producing physically plausible and reliable results. The model demonstrates strong agreement with XFoil simulations across a range of operating conditions, suggesting its potential for use in rapid design iteration or optimization cycles.*