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Abstract #
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Title
Prediction of Aerodynamic Coefficients for Multi-Swept Delta Wings via a Hybrid Neuronal Network

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Abstract

High-agility, high-performance aircraft configurations often show opposite aerodynamic challenges along their flight envelope. Being designed for supersonic cruise, such configurations are also required to perform high-agility maneuvers at trans- and subsonic speeds. Low speed performance demands high lift, which further leads to the need of high angles of attack. To fulfil these requirements such aircraft configurations often consist of low-aspect-ratio wings with medium to high leading edge sweep angle to exploit flow structures such as separated flows, leading edge vortex systems and vortex-to-vortex or vortex-to-shock interactions. [1] Just the possible combinations of angle of attack, angle of sideslip and control surface deflections at a distinct Mach number call for an enormous amount of computational fluid dynamics simulations in the aircraft design phase. Increasing computational power has led to the increased exploration of machine learning techniques for fluid mechanics and aerodynamics. Enormous amounts of existing data from experiments and numerical simulations can be used to better understand flow physics, adopt, improve existing or develop computational models solely based on data [2].

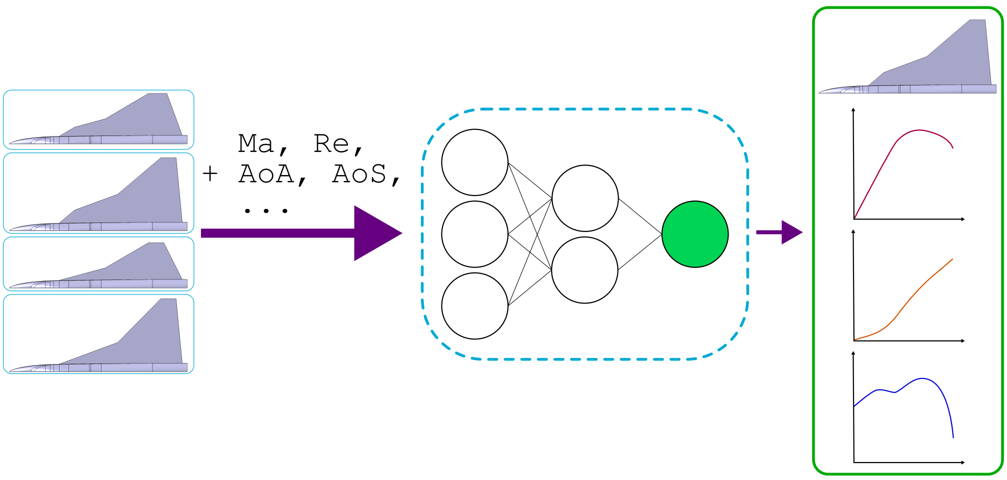

Figure 1: Schematic flow diagram of preliminary design selection.

In this study, the prediction capabilities, with respect to integral aerodynamic coefficients, of a hybrid neuronal network consisting of a conventional feed forward neuronal network (FNN) and a convolutional neuronal network (CNN) are investigated. In Figure 1 a schematic flow diagram for this coefficient-prediction-framework is depicted. LeCun et al. showed, that a CNN can classify high-dimensional patterns with minimal preprocessing by outperforming all other available techniques [3]. This image recognition feature enables the hybrid neuronal network to be independent of the input configuration, since important parameters such as number of delta wing segments or sweep angle(s) can be identified as pattern rather than be hardcoded in the system. The results of wind-tunnel experiments of multiple swept delta wing configurations with a sharp leading edge serve as trainings data for the neuronal network. These datasets contain angle of attack slopes for the basic configurations, as well as measurements with deflected control surfaces and an applied side slip angle. In Figure 2 an exemplary double delta wing configuration and the result of the lift coefficient prediction is shown. The comparison with the wind tunnel results shows, that the lift coefficient trends match perfectly, while the maximum deviation of the neuronal network predictions is well below 10%.
The proposed network is trained to predict integral aerodynamic coefficients and the results will be discussed with respect to accuracy and repeatability. Additionally, a hyperparameter optimization is conducted, where the influence of the most important hyperparameters will be highlighted. To cut cost and time in the preliminary aircraft design phase this prediction tool shall help identify promising aircraft configurations regarding the aerodynamic coefficient slopes and derivatives.

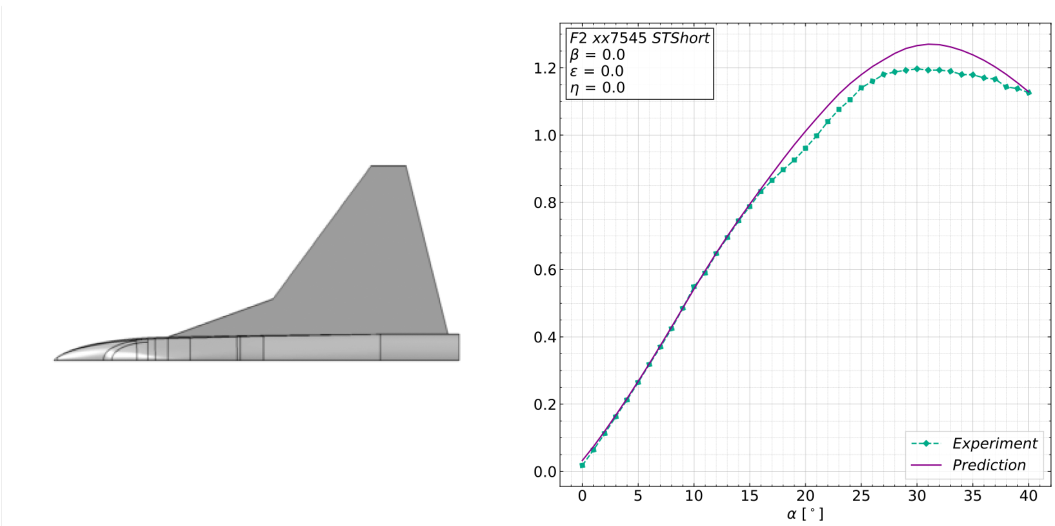

Figure 2: Exemplary result of the predicted lift coefficient of a double delta wing configuration at zero sideslip angle and no deflected control surfaces.

References

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