Deep Learning Based Aerodynamic Dataset Generation for Combat Aircraft

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In order to represent the aerodynamics of a combat aircraft configuration within the entire flight envelope, an aerodynamic dataset is necessary. This dataset is mandatory for the design of the flight control system as well as for performance and load estimation. Due to the coupled dependencies between flow parameters, control surface deflections and geometric parameters, the dataset needs to be designed in order to cover a large, multidimensional parameter space. Therefore, for the generation of the dataset, extensive numerical and experimental investigations are required, which leads to the necessity of reducing computational time and costs in the overall dataset design process.

In the present study, the focus is on the application of an artificial neural network (ANN) for the prediction of the stability and control (S&C) aerodynamic dataset of a very agile state-of-the-art combat aircraft. The ANN architecture is designed as a multiple input/multiple output system. Here, the inputs are defined by the flow parameters and the control surface deflections, whereas the outputs are represented by the aerodynamic coefficients (C_M, C_L, C_N, …).

As a first step, the ANN is trained and validated by applying an experimental database from multiple wind tunnel test. In the second step, a hybrid training dataset combining both experimental data (wind tunnel and flight test) and numerical data, is used. Since the experimental data is characterized by a high noise content, the addition of numerical data is assumed to improve the training and prediction performance of the ANN. Further, the additional data processing requirements when using different data sources are investigated and the capability of the resulting model to reflect the individual information content is assessed.

In order to investigate the overall performance of the trained ANN, the model is applied in the first step for the prediction of only one aerodynamic coefficient at a time. In the second step, the prediction is extended to several parameters. During the training, a k-fold cross validation algorithm is applied in order to find the best set of hyperparameters. In Figure 1, a comparison of pitching moment characteristics due to different control surface deflections as measured during wind tunnel tests (black dotted line) and the corresponding ANN prediction (colored line) is visualized. As shown, a precise prediction performance is achieved.

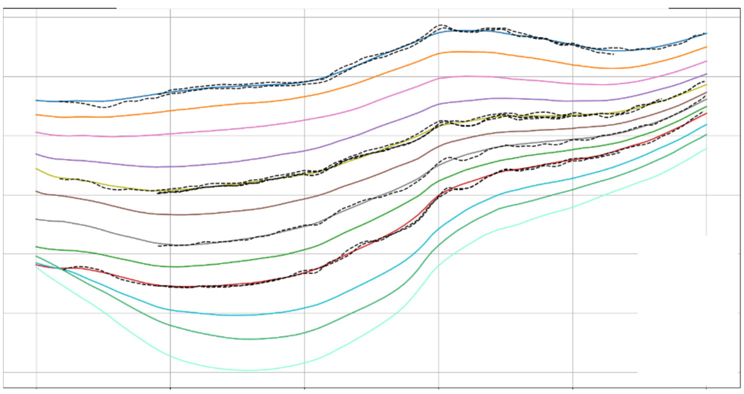

Fig. 1: *Comparison of wind tunnel and ANN predicted pitching moment coefficient trends.*