Neural Network Model of the Eppler 231 Airfoil Based on Wind Tunnel Data

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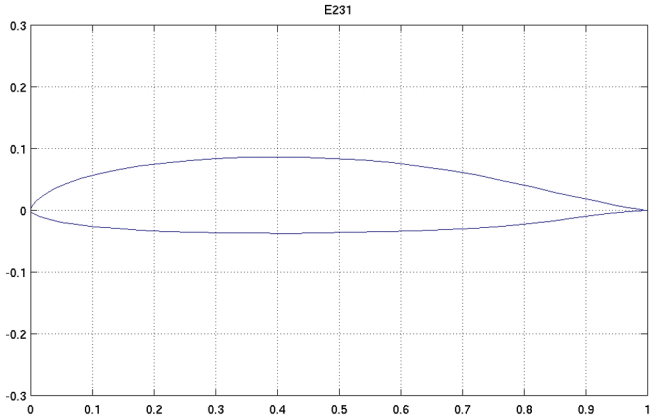

1 Data

There are 2 batches of data:

1. C_L and C_m only
    - 245 measurements
    - Re range: $[61100, 402800]$
    - Angle of attack range: $[-6.2, 19.32]$ degrees
2. C_L and C_D only
    - 81 measurements
    - Re range: $[60800, 400400]$
    - Angle of attack range: $[-4.57, 11.86]$ degrees

Below are plots of both batches of data. The second batch is the more interesting one, because it allows to build a polar curve.

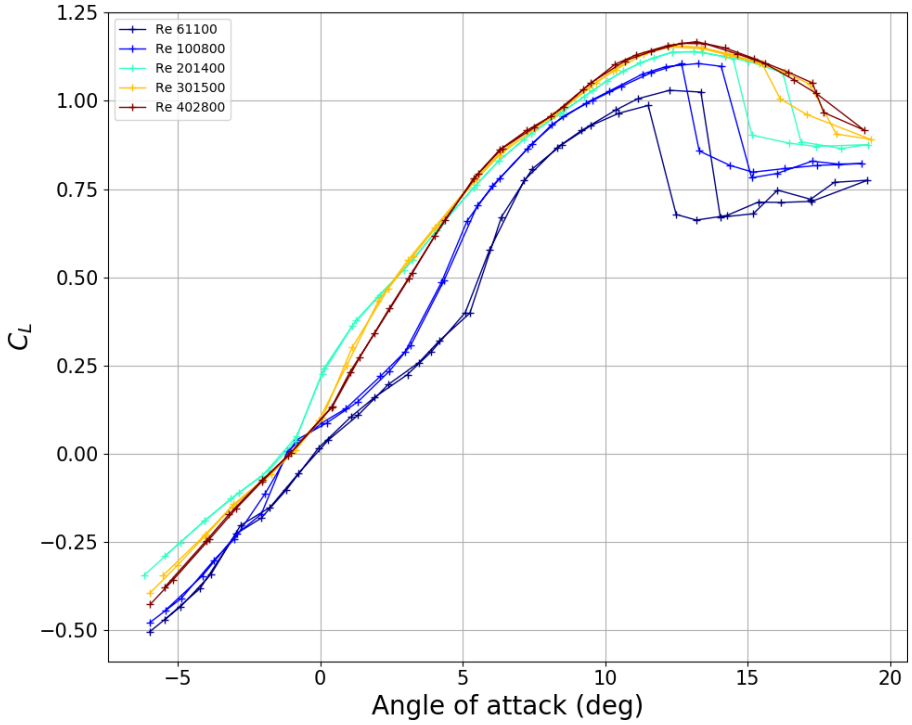

Figure 1: Batch 1: C_l versus angle of attack

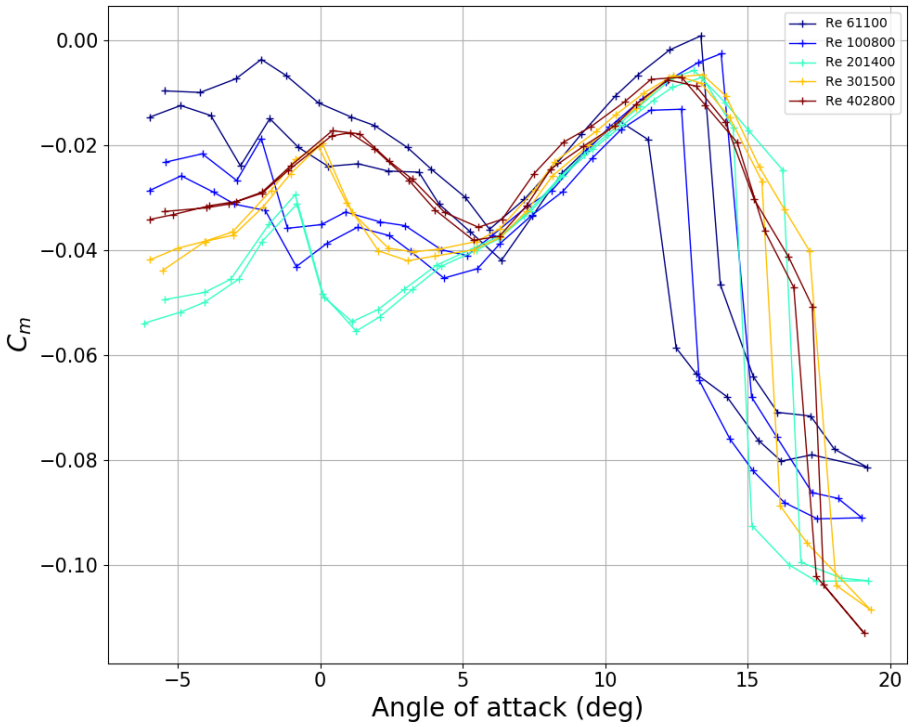

Figure 2: Batch 1: C_m versus angle of attack

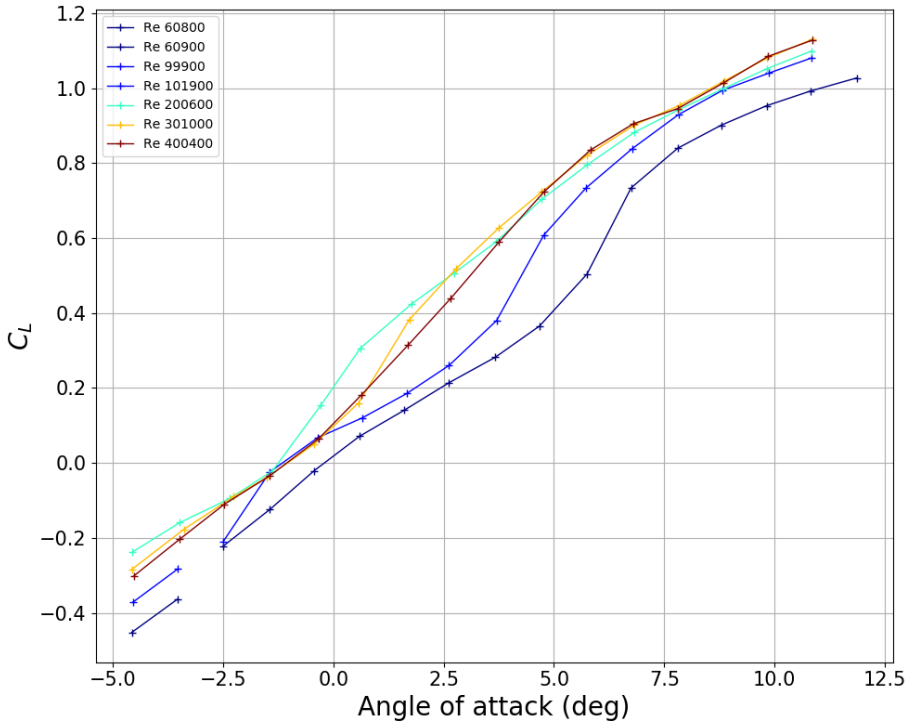

Figure 3: Batch 2: C_L versus angle of attack

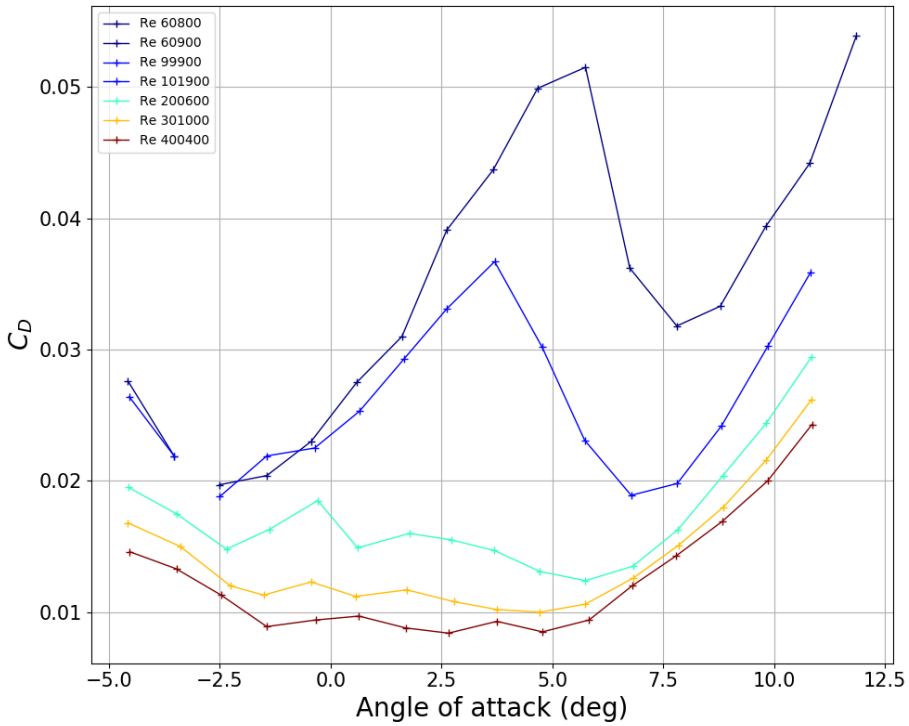

Figure 4: Batch 2: C_D versus angle of attack

2 Polar fit

To create an airfoil polar curve, only the second dataset can be used, which only leaves 81 data points. The data was fitted using a 1 hidden layer neural network of 8 units, with gradient descent and a learning rate of 0.002 for 10000 steps. Importantly, the very limited amount of data made testing challenging, and a future work includes a proper cross-validation test loss.

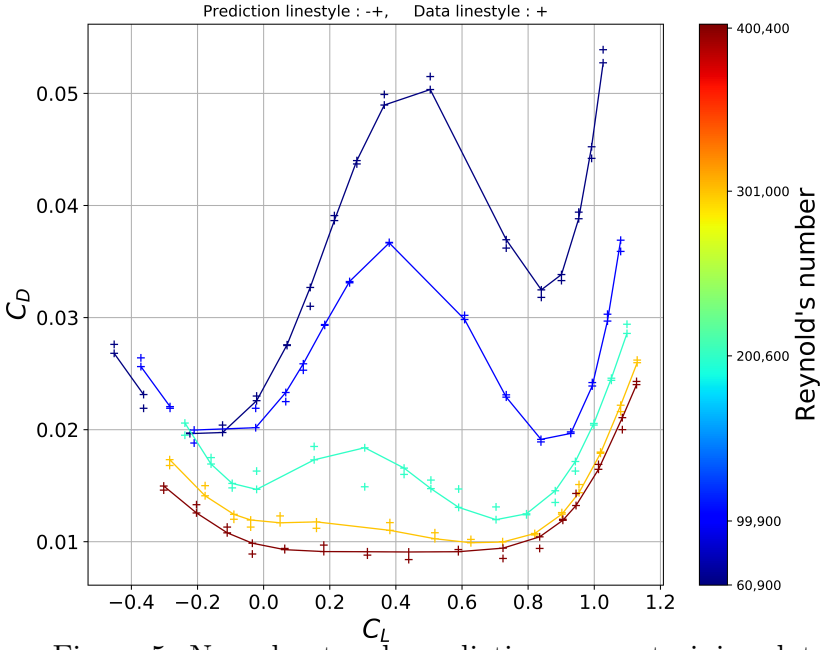

Figure 5: Neural network prediction versus training data

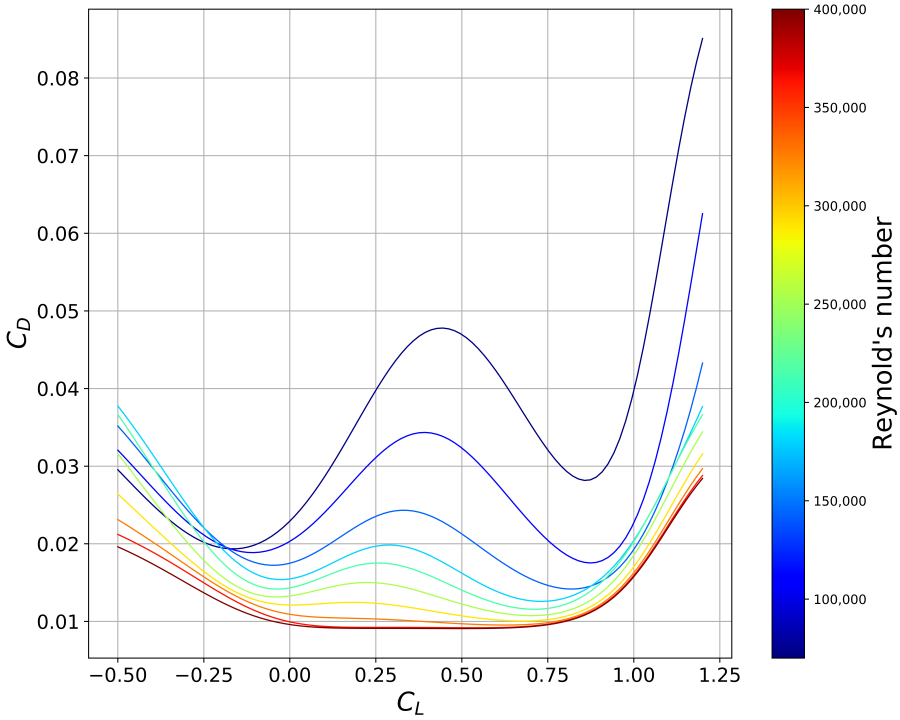

Figure 6: Contour plot of the neural network fit