Industrial Immersion 2020

# Multiobjective optimization of the airplane wing

Skoltech

In partnership with:

DATADVANCE

# Project Team

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# Background

- Optimation studies are a standart process of development. Wings shape design is important becasue they have the most economical effectiveness from the geometrical design point of view.
- There are many ways to desribe wings geometry (NACA, PARSEC, etc.), but most of them are not flexble enough to adress modern requirements or these methods are not suatable for optimization
- Approaches for parametric description of 3d is active field of modern research. Unite in one parametrization aeridynamic and technological factors and keep the robustness of the method.

# Objectives

- Explore and apply DR (Dimension Reduction) algorithm for wing shape parametrization
- Develop a workflow for wing optimization with DR using Xfoil solver. Validate results with Ansys solver.
- Propose the approach and develop workflow for 3D wing parametrization and perform test optimization study.

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# Process

Implement several approaches for 2D airfoil parametrization. Investigate the features of the DR approach.

Develop the methodology for effective oppredelenija feasable domain for DR parametrization based on the convex hull (Fig 1).

Create the automated workflow for the aerodynamic optimization of the airfoils based on DR using Xfoil solver.

Validate the 2D DR optimization results with the Ansys solver. Develop the routine for the automathic 3D simulation model assemly in Ansys solver.

Propose a technique used for the effective 3D wing parametrization and implement it in the form of the automated workflow in pSeven.

Perform 3D wing shape optimization study to validate and test the robustness of proposed method of parametrization.

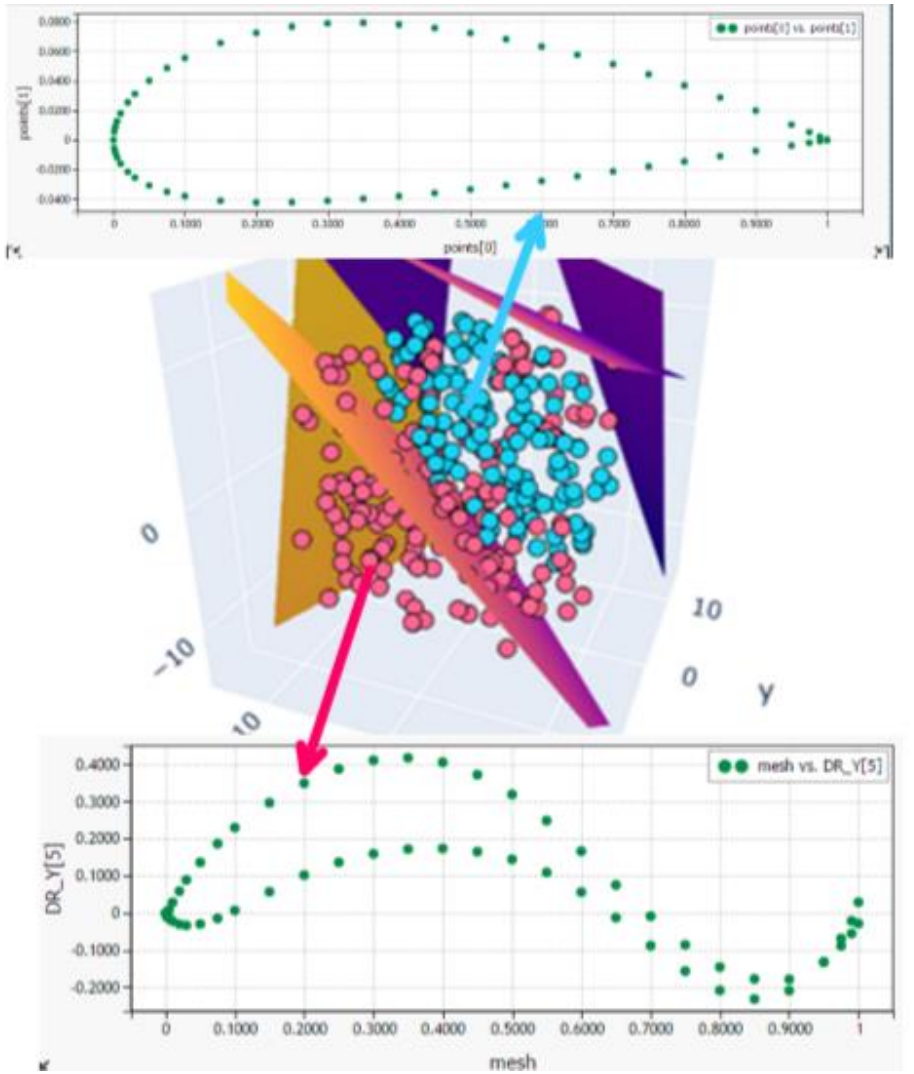


Figure 1 – graphical representation of the linear constrains in the 3-dimentional space (DR is performed in 6D).

# Results



Python code for the NACA, PARSEC and DR airfoil parametrization implemented

Generic purpose fully automated routine for linear constraint cut off of the feaseable design space was developed

The optimization study results were obtained for single objective problem statement for the cruise flight mode.

Xfoil limitation were revealed with the validation check. Ansys 3D CFD models were developed.

Workflow for the 3D wing shape optimization with custom parametrization was develped. Results are shown in Fig 2.

Based on the obtained results a further action plan was proposed

- Red point -> Fy = 2449 N (CL = 0.551) and Fx = 316.4 N (CD = 0.0714)
- Blue point -> Fy = 2811 N (CL = 0.551) and Fx = 345.5 N (CD = 0.0714)
- Yellow point -> Fy = 4940 N (CL = 0.551) and Fx = 706.6 N (CD = 0.0714)

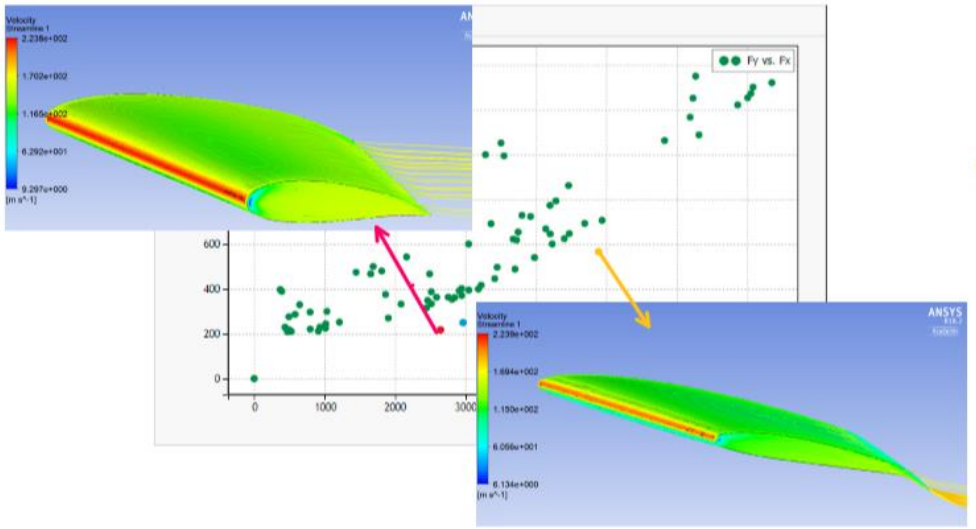


Figure 2 – 3D wing optimization results with the pressure distribution and airflow velocity streamlines display for 2 best design points

# Conclusions

- During the industrial immersion project at Datadvance I have learned and practiced valuable skills such as python coding, simulation modelling in CFD, optimization automation routines working in pSeven and developing workflows (Fig 3) for various problems. Also, I have gained an experience in the field of aerodynamics and wing design.

- For each stage of the internship I received the problem statement and key ideas of implementation from the curator with further biweekly meeting to check the progress and discuss the revealed technical problems. I've got an insight about the wing optimization aspects and what real world problem are currently being solved and how.

- As a result, I developed automated workflows for 2D and 3D wing shape optimization with effective parametrization of the wing geometry based on modern mathematical algorithms.

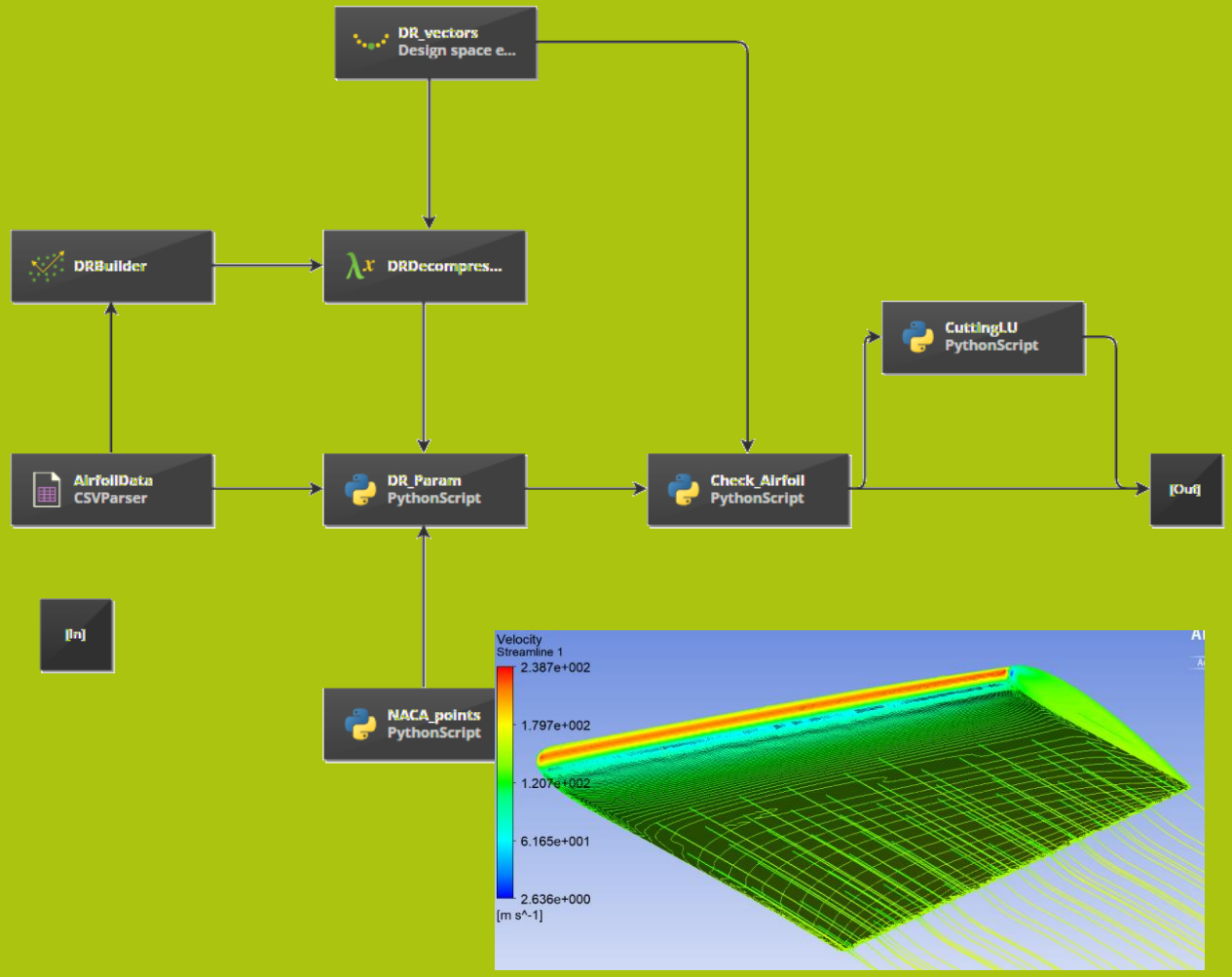


Figure 2 – Workflows examples in the pSeven software. Picture on the top is a linear constraint workflow. Picture on the bottom is a DR 2D optimization workflow with the Xfoil solver.

# thx.

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