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Multi-element Airfoil Lift Maximization Problems with Uncertainties using Evolutionary Optimization and Unstructured Meshes

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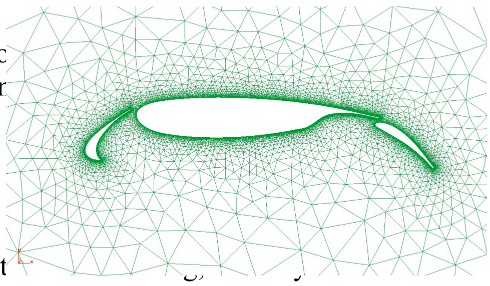
Keywords

Design with Uncertainties, Taguchi Robust Control Methods, Lift Maximization, Evolutionary Algorithms, Semi-Torsional Spring Analogy, Response Surface Modelling

Objectives

- Investigate aerodynamic shape design optimizations including uncertain operating conditions and apply in high lift devices optimization with uncertainties on angle of attack.
- Examine Taguchi robust design methods in aerodynamic optimization with uncertainties.
- Evaluate a recently developed optimization algorithm based on Genetic Algorithms (GAs) when coupled to Taguchi strategies.
- Utilize Response Surface Modelling (RSM) to estimate fitness value using the polynomial approximate model.
- Use Semi-Torsional spring analogy technique to adjust mesh according boundary movements.

Applications



The proposed approach is applied to the robust optimization c devices of a business aircraft, by maximizing the mean ar variance of the lift coefficients with uncertain free-stream landing and takeoff flight conditions respectively.

Results

1. Single-point lift maximization design at landing fly condit the maximum lift, because drag is useful for landing. The nominal operating condition are defined for landing condition by the free-stream incidence , Mach number and Reynolds number (Figure 1).
2. Single-point lift maximization design at takeoff fly Condition. For takeoff, we concern about not only maximum lift but also minimum drag. The nominal operating condition are defined for takeoff condition by the free-stream incidence , Mach number and Reynolds

number (Figure 2).

3. Lift maximization with uncertain angle of attack at landing fly condition. We suppose that the free-stream angle of attack is subject to random fluctuations. For simplicity, we assume that its PDF is Gaussian with a given mean and variance. The mean angle of attack corresponds to the nominal incidence and its standard deviation is . Free-stream Mach number is and Reynolds number (Figure 3).

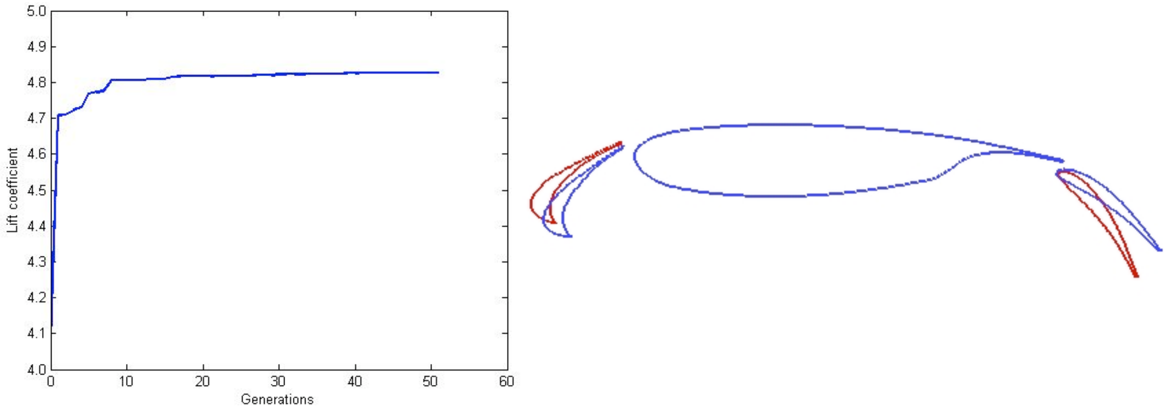


Figure 1. Convergence history of lift coefficient and optimized multi element airfoil configuration for landing

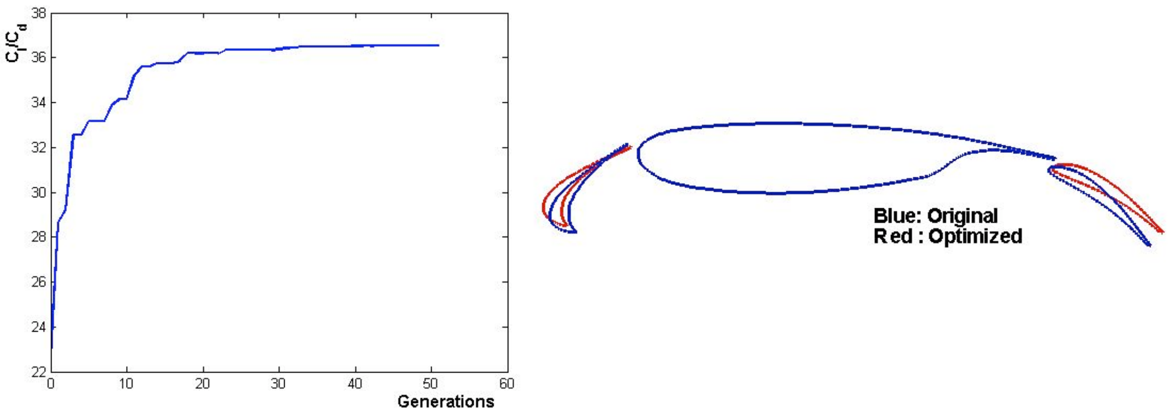


Figure 2. Convergence history of aspect ratio of lift to drag coefficient and optimized multi element airfoil configuration for takeoff

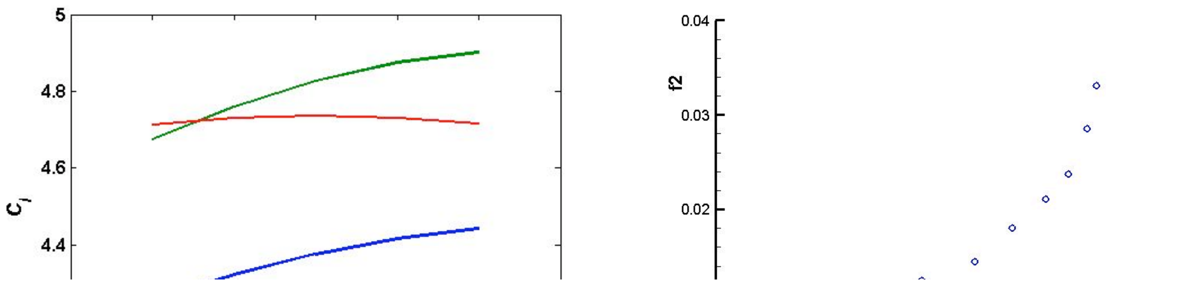


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Figure 3. (a) Lift coefficient comparison among robust optimized, traditional single-point optimized and baseline Airfoils, (b) Pareto front between mean lift and its variance.

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