CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

J0108

Project Title

Airfoil Optimization by Applying Evolutionary Algorithms to Computational Fluid Dynamics

Abstract

Objectives/Goals

The goal of my project was to apply a genetic computational strategy to optimize airplane wing shapes.

Methods/Materials

Materials: Python 2.7 programming language interpreter, Gmsh 2.16 3D finite element grid generator, SU2 4.0 Computational Fluid Dynamics (CFD) software, SigmaPlot 10.0 scientific graphing software, Easel 3D carving software, Desktop 3D carving machine (CNC Mill, Carvey; Inventables) at San Diego Central Library and poplar wood for milling, home-made wind tunnel, Force meters (Phidget Bridge with 100 g Micro Load Cells; Phidgets)

Methods: - Write genetic algorithm with non-sexual reproduction in Python to evolve wing shapes with control vertex points to define splines; - Apply Gmsh to generate wing meshes for CFD (wing width, 40 units; computational domain, 100x100 units) ; - Use SU2 for steady-state CFD analysis of lift and drag of wings; - Extract wing shapes by converting JPEG image into SVG format, and importing SVG into Easel software; - Use CNC mill to cut wing shapes in wood; - Construct wind tunnel with drainage pipe, straws, and leaf blower; - Determine lift and drag of milled wings in wind tunnel using Phidgets force meters; - Compare CFD-predicted and wind tunnel-measured value.

Results

1) My results demonstrate that efficient wing shapes can be generated with genetic algorithms.
2) Very efficient (many times more than in commercial aircraft) wings were obtained, but were so thin they could not be easily built or flown on a plane without breaking, much less be able to hold fuel like modern wings.
3) By placing a constraint on the wing thickness, less efficient (but still similar to commercial wings), more structurally sound wings were produced.
4) Wind tunnel measurements showed a strong positive correlation with predicted wing performances, although the results were generally lower than the CFD calculations.

Conclusions/Discussion

My project shows that using natural principles and applying them to optimization problems in aerodynamics and perhaps other engineering challenges can produce strong results that may compete with or even exceed designs generated by other methods.

Summary Statement

An evolutionary algorithm was implemented to optimize the aerodynamic performance of airplane wing shapes, and some representative shapes were machined and tested in a wind tunnel.

Help Received

My dad and mom helped me in discussing experiments and proof reading my project write-up.