Evolving Hydrofoils

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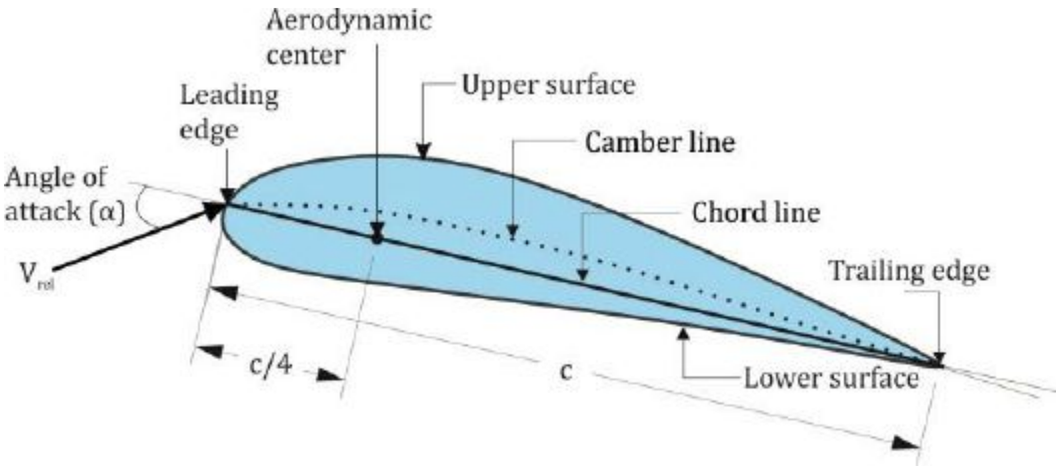
Survey Link:

http://tinyurl.com/y4ufyqmf

What is a foil?

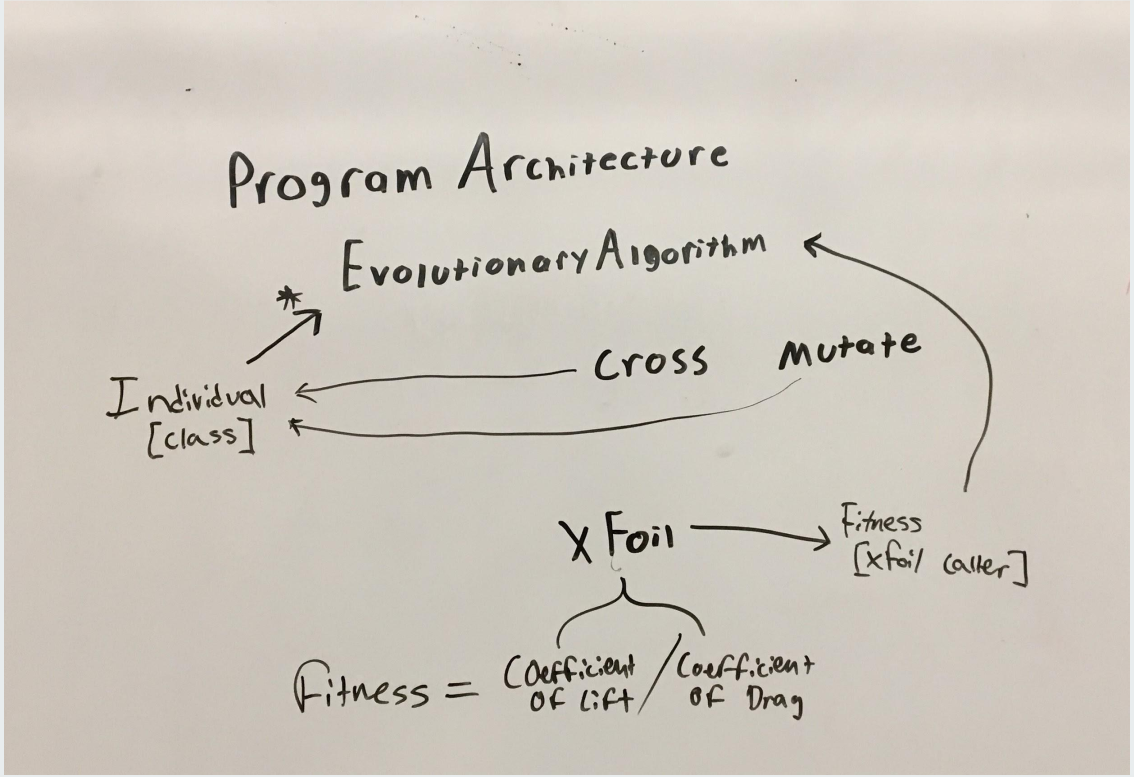
In the context of our project, we define a foil as a 2 dimensional shape defined by a set of points that has characteristics such as a coefficient of lift, coefficient of drag, leading and trailing edges, and a characteristic length.



Our Project

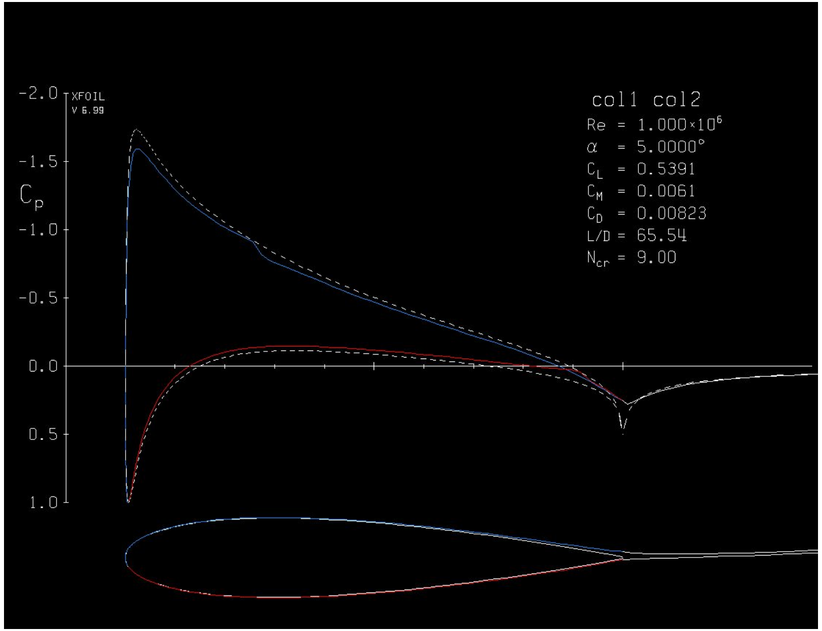
We are attempting to generate a hydrofoil using evolutionary algorithms.

Architectural Diagram



How do we evaluate foils?

Foils are evaluated using one of many computational fluid dynamics programs. For this project, we decided to use XFoil, a Fortran based command line tool for 2-D foils. It is able to perform both viscous and inviscid simulations on foils at any specified angle of attack and return quantitative representations of its performance.

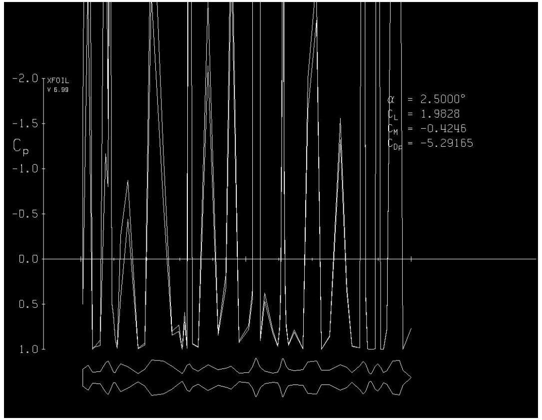


A viscous simulation of a common foil

Our current issue

How should we define the initial hydrofoil?

As a set of points?



Defining a curve using mathematical expressions?

Equation for a symmetrical 4-digit NACA airfoil [edit]

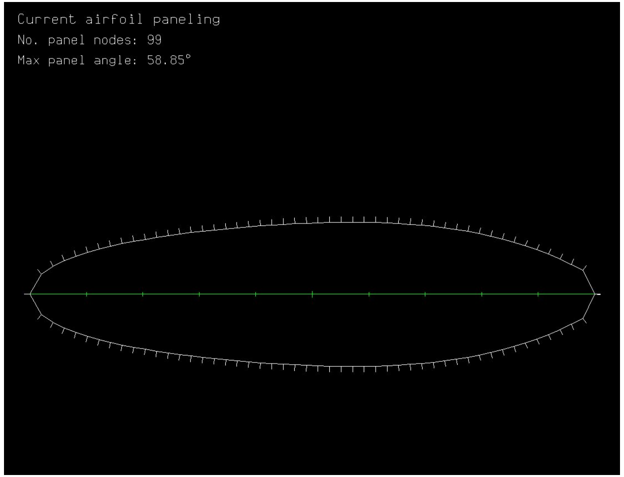
The formula for the shape of a NACA 00xx foil, with "x" being replaced by the percentage of thickness to chord, is:[3]

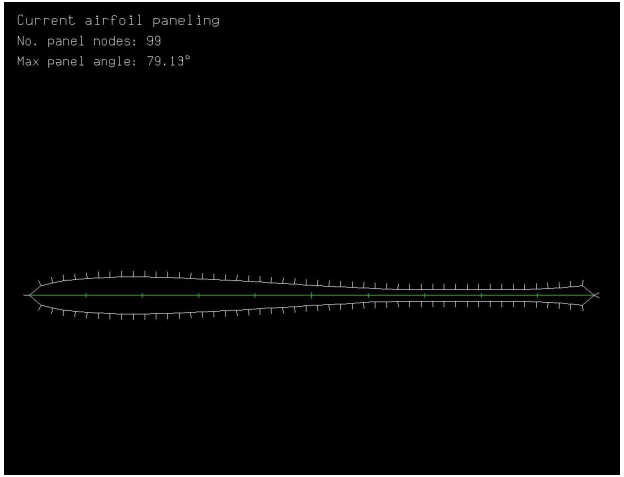
$$y_t = 5t\left[0.2969\sqrt{x} - 0.1260x - 0.3516x^2 + 0.2843x^3 - 0.1015x^4\right],$$ [4][5]

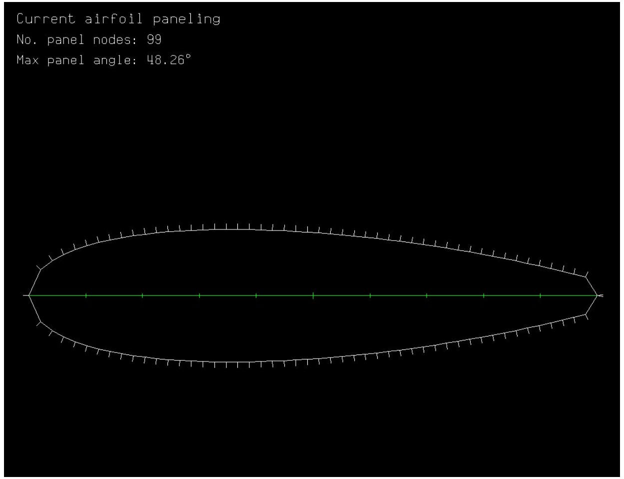
where:

- x is the position along the chord from 0 to 1.00, (0 to 100%)
- y_t is the half thickness at a given value of x (centerline to surface), and
- t is the maximum thickness as a fraction of the chord (so t gives the last two digits in the NACA 4-digit denomination divided by 100).

Some Current Examples







Considerations of a starting point

- A circle?
- An ellipse / other conic section?
- A preexisting hydrofoil?
- A triangle?
- A square?

Evolving Algorithms

There are many choices for potential algorithms to achieve the iterative process we need. We are currently using DEAP, which automates much of the iteration and selection process for us.

Is it better to define the iteration and selection steps ourselves? Is it worth the time?

Within DEAP there are options to define exactly how many individuals are created and move on per generation. Is it better to define these ourselves or let DEAP optimize these variables?

How should we scope learning about evolutionary algorithms whilst evolving airfoils?

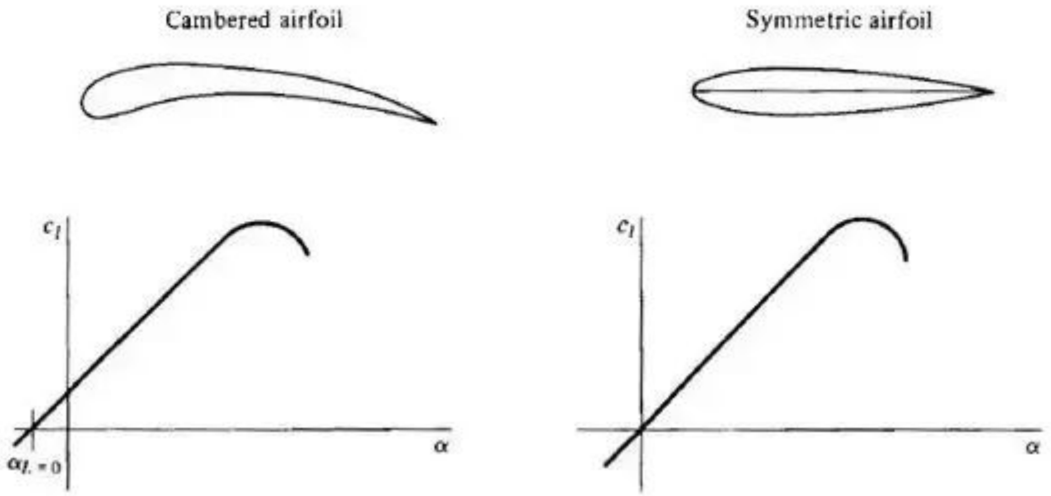
Algorithms in DEAP

eaSimple - Applies crossover and mutation

eaMuPlusLambda - Applies crossover, mutation, or reproduction; next generation is selected from both the offspring and the population

eaMuCommaLambda - Applies crossover, mutation, or reproduction; next generation is selected from only the offspring

Which foil would be more interesting to consider?



What should we consider a “good” hydrofoil?

For our MVP, we use the ratio between the drag coefficient(Cd) and the lift coefficient(Cl) of the evolved hydrofoil.

Data values we get from the CFD simulation:

Coefficient of Drag	Coefficient of Lift	Angular Moment	Angle of Attack

Thinking beyond the mvp, we hope to include the angular moment acting on the hydrofoil into our analysis and assign an appropriate weight to it account for its contribution.

We are also inclined towards sweeping various angles of attack and observe the evolution