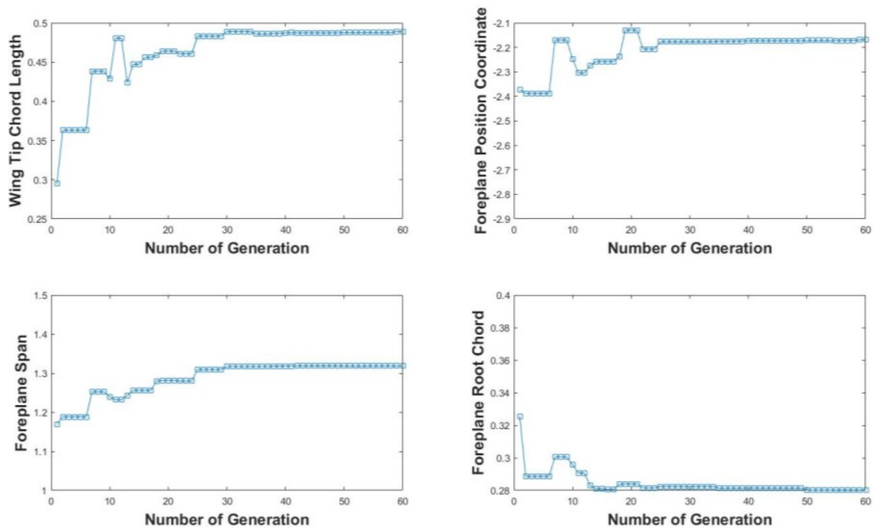
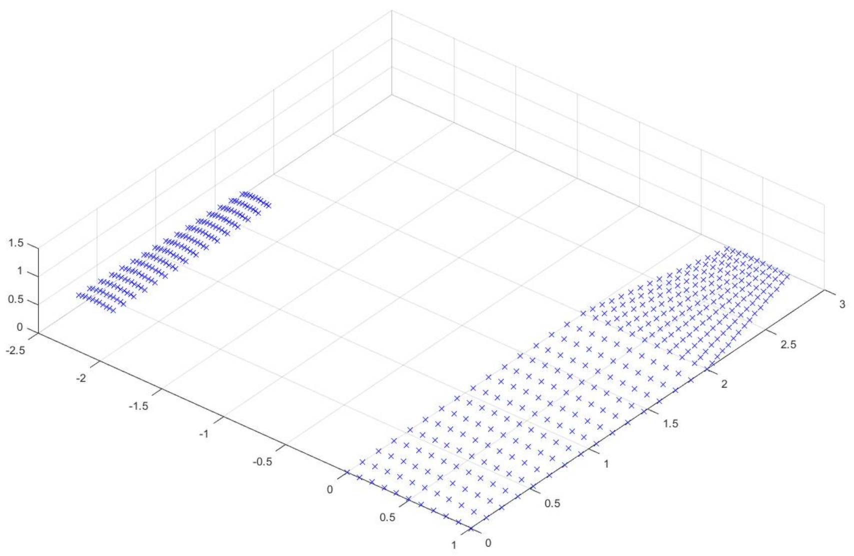
SwanVLM Opti *beta*

User Guide





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Introduction

SwanVLM *Opti* is a MATLAB software based on Vortex Lattice Method flow solver [1] and Modified Cuckoo Search (MCS) optimisation algorithm [2], which allows optimisation of aircraft aerodynamic configuration.

The flow solver offers the modelling of multiple wings defined by aerofoil profile, span, root and tip chord length, sweep, dihedral, taper and twist, over a range of Angles of Attack, providing properties such as Coefficients of Lift and Drag, Pitching Moment, Aerodynamic Centre location. It was written as part of the undergraduate research project, "The 3D Aerodynamics of Lifting Surfaces Using Vortex Lattice Methods", by Chris Walton and supervised by Professor K. Morgan, at the School of Engineering, Swansea University.

Modified Cuckoo Search program was developed by Dr. Sean Walton (sean.walton84@gmail.com). MCS is a gradient-free population-based algorithm, which ensures efficient combination of local search and global exploration of the design space with the aim of finding a global optimum.

Installation

Copy the SwanVLM *Opti* folder to a location on your computer. Ensure that the file structure remains intact and that all files are copied. In MATLAB, press the 'Browse for Folder' button to the right of the current directory bar at the top of the workspace window. Navigate to the SwanVLM *Opti* folder and then press OK.

File Input Example

1. In the SwanVLM *Opti* root folder open the 'example.xls' file;

2. Open the Geometry tab in example.xls.

Through this tab, the geometry of your lifting surfaces are inputted. Wings are defined by sections, with each section's properties inputted in the relevant cells. Take note that after the first section of a wing, certain properties can be omitted. This is annotated on the spreadsheet.

For the Root and Tip Profile columns, you may either enter the file name of a coordinate definition file from the Airfoils folder (i.e. 'e334.dat' would be entered as 'e334'), or you may enter 'n' followed by a 4 digit NACA profile number. A NACA 2408 profile would be entered as 'n2408'.

3. Open the Environment tab.

Through this tab you may enter the non-dimensionalising factors such as density, freestream velocity and flight altitude. Based on these values, temperature, kinematic viscosity, Mach number and Reynold numbers are defined It is also through this tab that you define the range of Alpha to solve for. Beta allows you to set a sideslip angle for the range.

The Centre of Gravity position is used for calculation of the static margin.

4. The Meshing tab allows you to set the number of chord and spanwise panels used for each section.

5. Save the Excel file and ensure that you close it.

Definition of Design Space

In *main.m* file define design space as follows:

```
vardef(1,1) = 0.4;  % Foreplane root chord
vardef(2,1) = 0.28;
vardef(1,2) = 0.25; % Foreplane tip chord
vardef(2,2) = 0.19;
vardef(1,3) = 1.5;  % Foreplane span
vardef(2,3) = 1.0;
vardef(1,4) = -2.1; % Foreplane position
vardef(2,4) = -2.9;
vardef(1,5) = 0.5;  % Wing tip chord
vardef(2,5) = 0.25;
```

Define the write path for each parameter in *solveAll.m* file:

```
    xlswrite('example.xls', piNest(i,1), 'Geometry','G5') %write
foreplane root chord
    xlswrite('example.xls', piNest(i,2), 'Geometry','I5') %write
foreplane tip chord
    xlswrite('example.xls', piNest(i,3), 'Geometry','J5') %write
span
    xlswrite('example.xls', piNest(i,4), 'Geometry','C5') %write
canard position
    xlswrite('example.xls', piNest(i,5), 'Geometry','I4') %write
wing tip chord
```

Definition of optimiser parameters

In *main.m* file specify number of nests, e.g:

NoNests = 15; % Number of Nests
NoGen = 20; % Number of Generations

In ACuckoo3.m define minimal number of nests throughout the oprimisation routine:

MinNests = 4; % Minimal number of nests

This number can be equal to number of initial nests or be reduced in order to save computational power.

Objective function definition

In SwanVLM.m file the following lines stand for the objective function calculation:

```
if abs(-Desired_SM+result.StaticMargin)<5
     FiNest=-max(result.LtD_ratio);
 else
     FiNest=-max(result.LtD_ratio)+1000;
```

By default, it defines Lift-to-drag ratio as an objective function and static margin as a constraint. In this case deviation from desired static margin by more than 5 percent leads to penalisation of the objective function.

The objective function may be modified by user. An example of another objective function, which requires lower computation effort is an optimisation of static margin value.

Postprocessing

As a result of the optimisation process the following data arrays are saved in the workspace:

- *pg* contains design parameters of optimal design;
- p contains design space parameters for all the evaluated nests and generations;
- F contains objective function values for all the evaluated nests and generations;

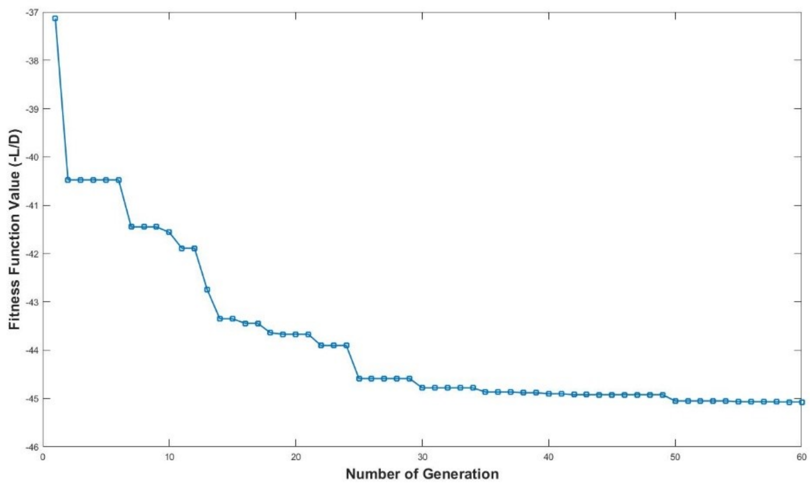
The obtained data is automatically saved in finalResults.mat file using *save* Matlab function. Afterwards, it may be loaded in Matlab at any time.

The optimal configuration corresponding to pg design space parameters or any other produced configuration may be visualised by copying example.xls file to *Input* directory and calling MeshTest.m function.

All the computation data involving lift and drag coefficients, lift curve slope, aerodynamic centre and static margin can be found in the *example*.xls files located in the corresponding nest folder.

The function postprocess.m allows visualising evolution of fitness function and design space. If called, it output the following plots:

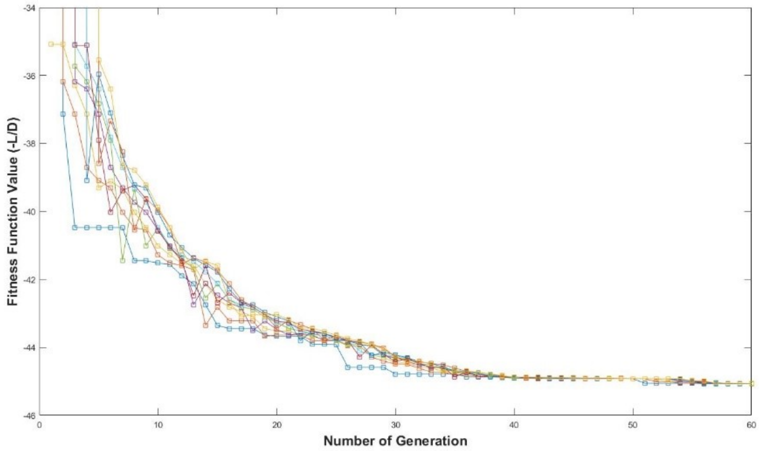
- Evolution of the best fitness function value



- Evolution of several best fitness values

The default number of best fitness values to output is 2. It may be changed by redefining the number in the following line of postprocess.m file:

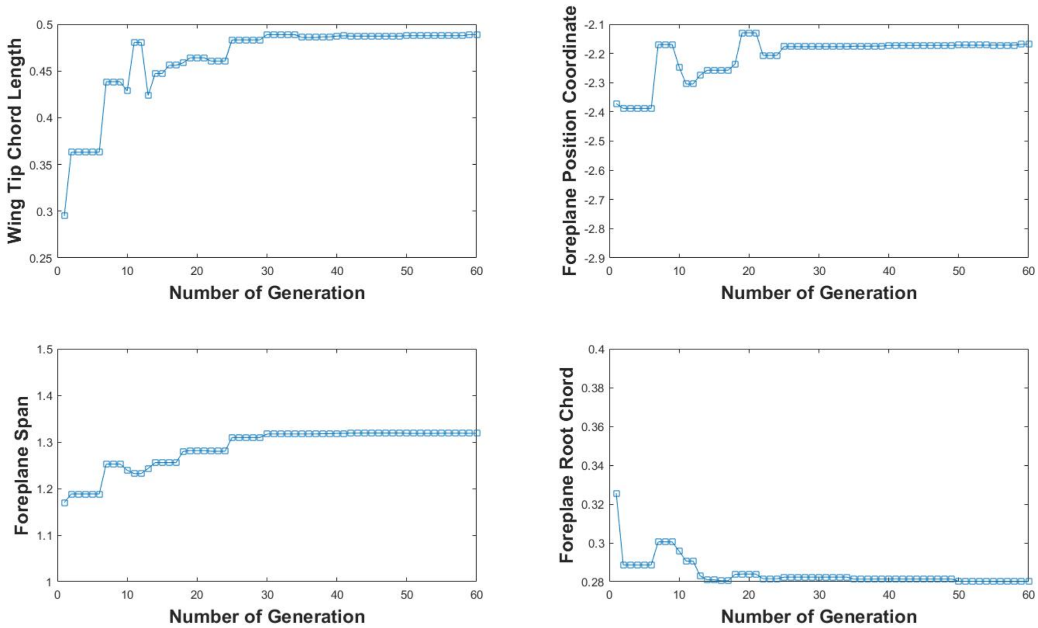
```
plot(F2(1:2,:)','-s')
```



- Evolution of the design space for the best nest

Layout of the figures may be defined by changing the numbers in the following line of the code:

```
subplot(3,3,i)
```



References

[1] C. Walton The 3D Aerodynamics of Lifting Surfaces Using Vortex Lattice Methods, Dissertation, Swansea University, 2009.

[2] S. Walton, O. Hassan, K. Morgan and M.R. Brown Modified cuckoo search: A new gradient free optimisation algorithm, Chaos, Solitons & Fractals, 44(9):710-718, September 2011.