Computer Project

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Introduction

The wing planform I study is the wing from a bat. Bats are the only mammals that can fly, so I wanted to understand the aerodynamic properties of their wings. The program we wrote uses the assumption of thin airfoil theory, and the bat's wings are made of a thin film, so I think it is very suitable for analysis by our program.

Model settings

The original bat wing picture (**Figure 1**) is come from [Properties of the bat wing. (A) Muscle bundles (red) of the wing... | Download Scientific Diagram (researchgate.net)]

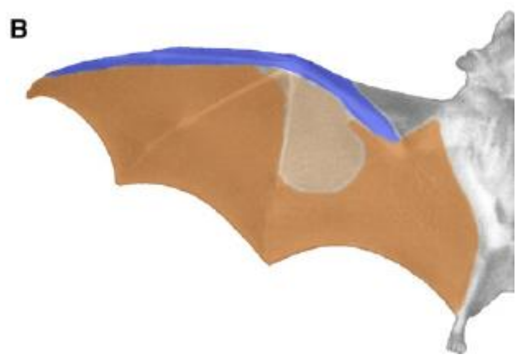

Figure 1

I used WebPlotDigitizer to convert the image to point data and output it as "bat_project.json", and the chord distribution file is "bat_planfrom.txt", both of which are attached in the zip file. **Table 1** below shows the parameters I used, and the part 2 of the json file "input2.json" is also attached to the zip file.

Parameters	value
Planform type	"file"
Aspect ratio	6.495228458657533 (compute from the file)
Taper ratio	-
filename	"bat_planform.txt"
Airfoil lift slope	6.283185307179590,
Node per semispan	100
Washout distribution	"optimum"
Washout amount[deg]	"optimum"
CL design	0.65
B3	0.0
Aileron begin[z/b]	0.15
Aileron end[z/b]	0.4
Aileron begin[cf/c]	0.18
Aileron end[cf/c]	0.18
Hinge efficiency	0.85
Alpha root[deg]	"CL"
CL	2
Aileron deflection	0.0
pbar	0.0

Result

The shape of the plot of the planform (**Figure 2**) is not the same as the original bat wing (with forward sweep) because the program will place the position of the quarter chord of the wing at the position of c/b = 0.

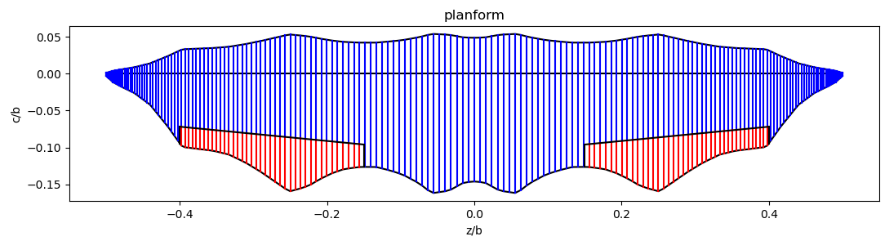

Figure 2

The design lift coefficient I chose is 0.65. Under this condition, the root angle of attack = 9.59817174 (deg), the optimum washout distribution is shown in **Figure 3**, the optimum washout magnitude = 5.95754168 (deg), and the lift distribution is shown in **Figure 4**.

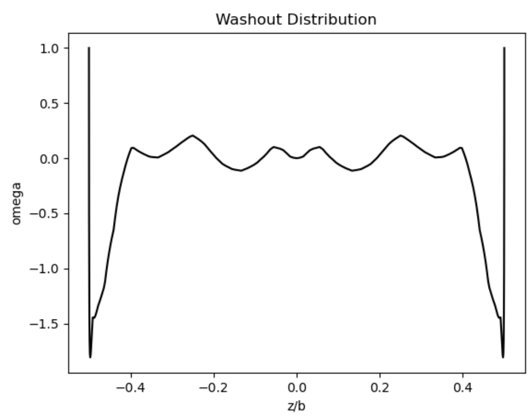

Figure 3

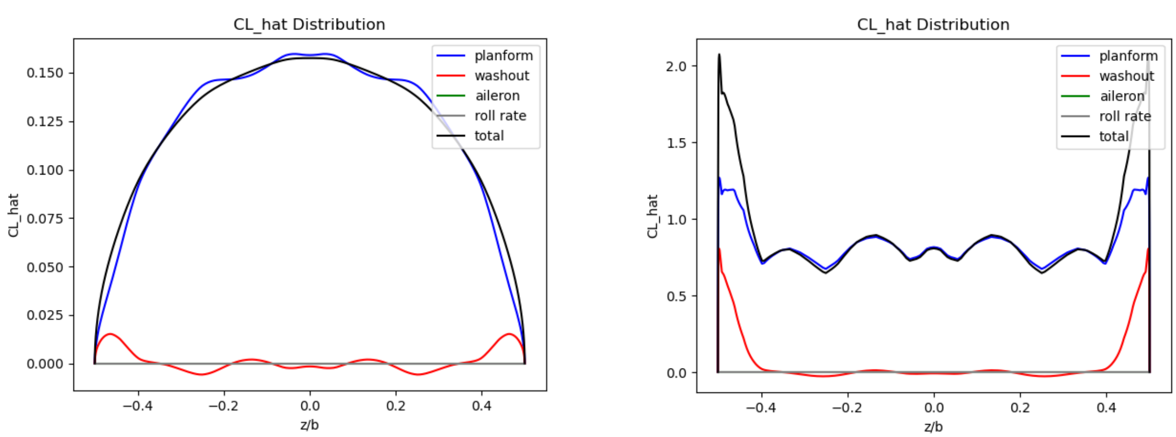

Figure 4

The induced resistance is calculated when design lift coefficient is fixed at 0.65 and when design lift coefficient = CL(operating lift coefficient). As shown in **Table 2** and **Figure 5**, the induced drag for design lift coefficient = CL is always smaller than design lift coefficient = 0.65 when B3 = 0, because when design lift coefficient = CL, is always calculated under the condition of minimizing the induced drag. At CL = 0.6 and 0.7, the two curves almost overlap, because at this point the CL is close to design lift coefficient.

	B3 = 0		
	CLd = 0.65	CLd = CL	
CL	Cdi	Cdi	difference
-1	0.05283906	0.04900673	0.003832
-0.9	0.04307733	0.03969545	0.003382
-0.8	0.03432389	0.03136431	0.00296
-0.7	0.02657874	0.0240133	0.002565
-0.6	0.01984188	0.01764242	0.002199
-0.5	0.0141133	0.01225168	0.001862
-0.4	0.00939301	0.00784108	0.001552
-0.3	0.00568101	0.00441061	0.00127
-0.2	0.0029773	0.00196027	0.001017
-0.1	0.00128187	0.00049007	0.000792
0	0.00059473	0	0.000595
0.1	0.00091588	0.00049007	0.000426
0.2	0.00224532	0.00196027	0.000285
0.3	0.00458304	0.00441061	0.000172
0.4	0.00792905	0.00784108	8.8E-05
0.5	0.01228335	0.01225168	3.17E-05
0.6	0.01764594	0.01764242	3.52E-06
0.7	0.02401682	0.0240133	3.52E-06
0.8	0.03139598	0.03136431	3.17E-05
0.9	0.03978343	0.03969545	8.8E-05
1	0.04917916	0.04900673	0.000172

Table 2

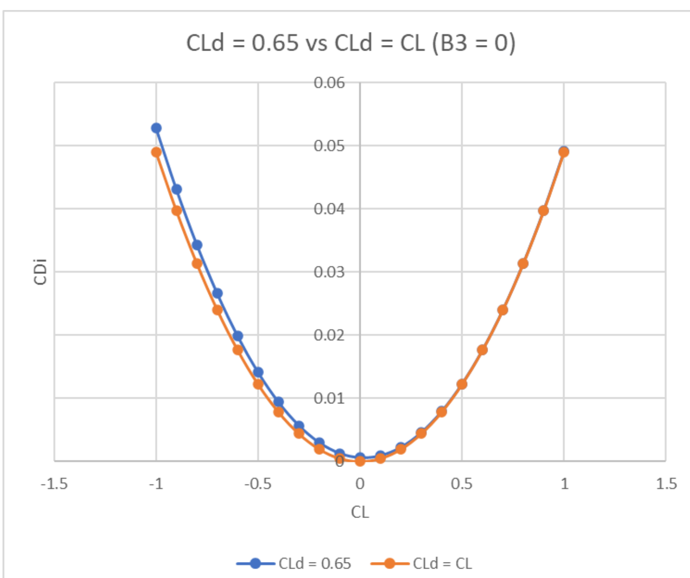

Figure 5

Part 3. Extra Credit

1. The advantage of using class structure is that new function can be easily added or removed, and parameters can be easily reused, which makes modifying code easy and neat looking.

2. When a code is clean, legible and well commented, it will be easy to modify and debug the code, especially if someone else is taking over your work.