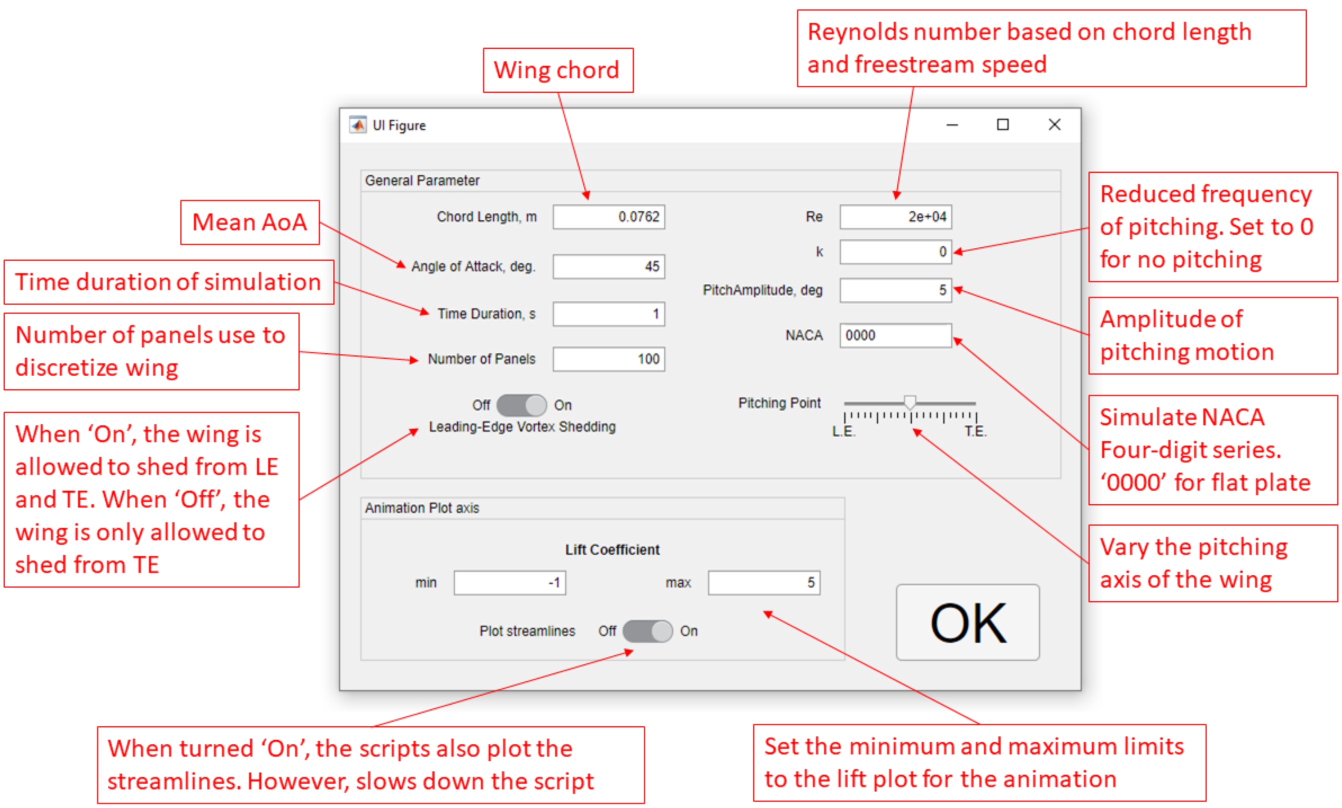
Unsteady aerodynamic model manual

Two unsteady aerodynamic models are provided in this package. Both models rely on potential flow modeling and confining vorticity to singular elements in the flow. These models are used to simulate unsteady flows under unsteady flow conditions and wing maneuvers. For more information regarding the development of these codes, See Low-Speed Aerodynamics by Katz and Plotkins. To run the models, set the folder containing the scripts to be your MATLAB directory, and type ‘GUI’ in the Command Window.

PanelMethod:

The model in the ‘PanelMethod’ directory can be used to simulate the unsteady aerodynamics of a NACA 4-digit series wing under sinusoidal pitching motions. Below is a guide to the contents of the graphical user interface.

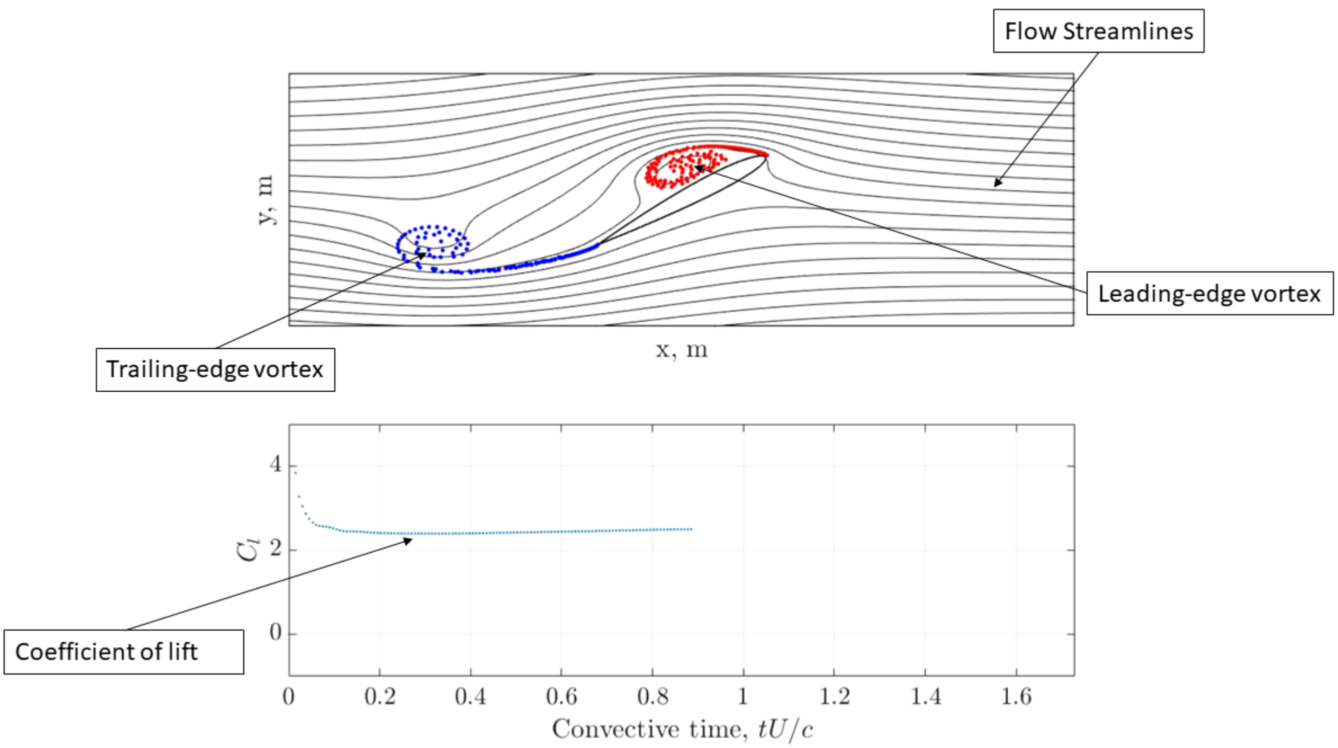
User interface:



Output files:

- Parameters.txt: text file containing the parameters that are input to the GUI
- Data.mat: file containing the results of the simulation.
    - Cl: lift coefficient
    - Cd: drag coefficient
    - Cm: pitching moment coefficient
    - dcirc_dt_lev: change rate of circulation of leading-edge vortex
    - circ_lev: circulation of leading-edge vortex
    - dcirc_dt_tev: change rate of circulation of trailing-edge vortex
    - circ_tev: circulation of trailing-edge vortex
    - Time: time in seconds
    - AoA: angle of attack in degrees
- Animation.avi: A video that contains the lift coefficient and the flowfield evolution in time

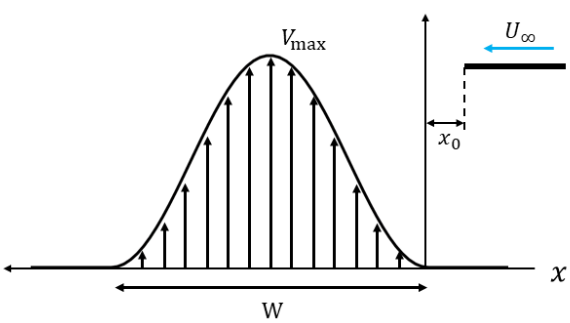
Output animation:



DVM:

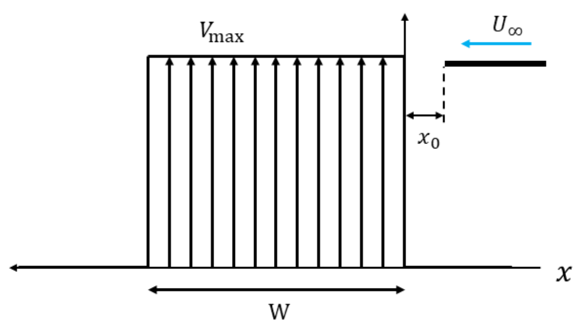
The model in the 'DVM' directory can be used to simulate the unsteady aerodynamics of an infinitely thin wing under various wing motion profiles as well as transverse gust encounters. However, unlike the previous codes, it does not model finitely thick wing. Below is a guide to the contents of the graphical user interface along with gust schematics that can be modeled using these scripts.

Sine-square gust

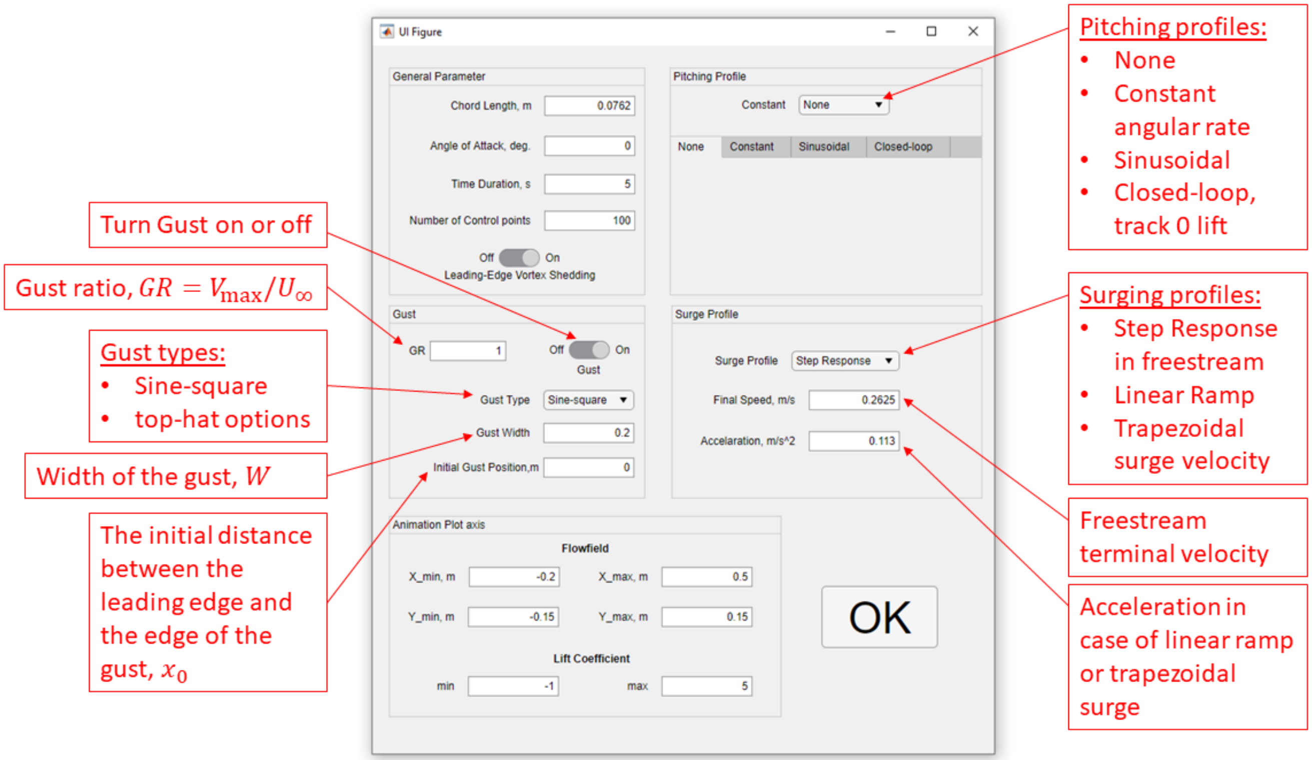


$$v(x) = V_{\max}\sin^2\left(\frac{x}{\mathrm{W}}\pi\right)$$

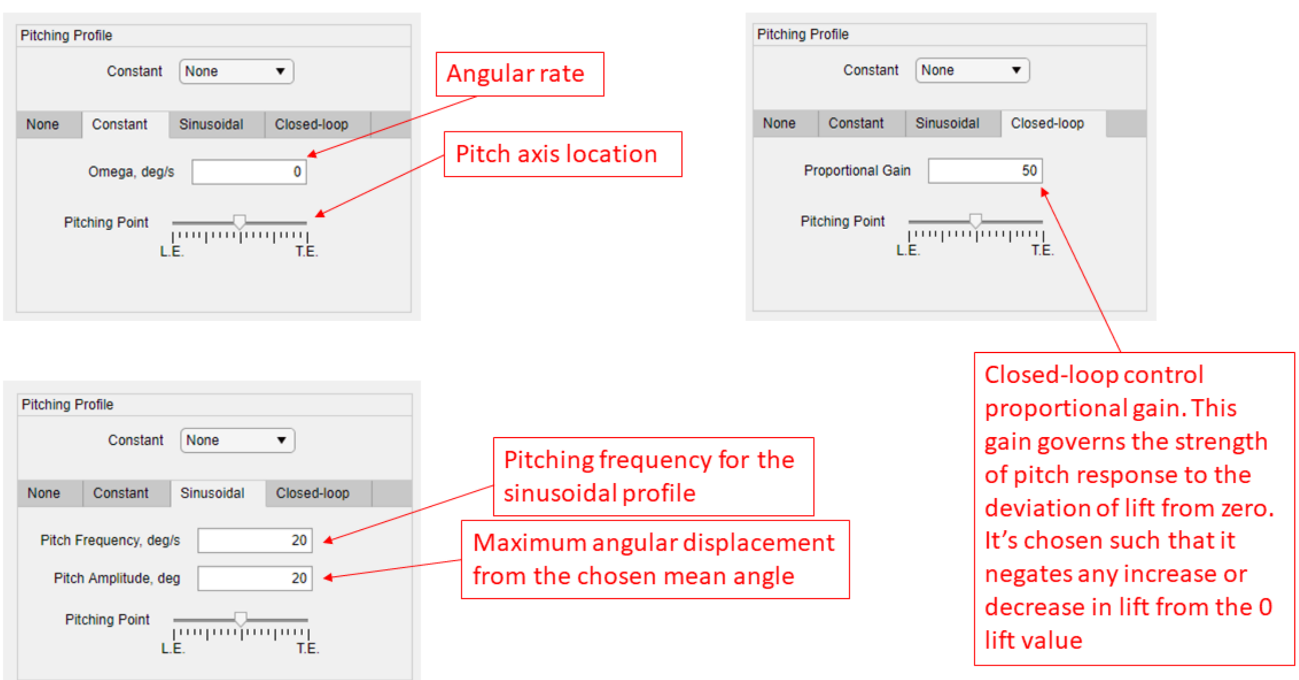
Top-hat gust



$$v(x) = \begin{cases} V_{\max} & 0 < x < W \\ 0 & \text{otherwise} \end{cases}$$



UI Figure
General Parameter
Chord Length, m 0.0762
Angle of Attack, deg. 0
Time Duration, s 5
Number of Control points 100
Off On
Leading-Edge Vortex Shedding
Pitching Profile
Constant None
None Constant Sinusoidal Closed-loop
Gust
GR 1
Off On
Gust
Gust Type Sine-square
Gust Width 0.2
Initial Gust Position,m 0
Surge Profile
Surge Profile Step Response
Final Speed, m/s 0.2625
Accelaration, m/s^2 0.113
Animation Plot axis
Flowfield
X_min, m -0.2
X_max, m 0.5
Y_min, m -0.15
Y_max, m 0.15
Lift Coefficient
min -1
max 5
OK
Pitching profiles:
None
Constant angular rate
Sinusoidal
Closed-loop, track 0 lift
Surging profiles:
Step Response in freestream
Linear Ramp
Trapezoidal surge velocity
Freestream terminal velocity
Acceleration in case of linear ramp or trapezoidal surge
Turn Gust on or off
Gust ratio, $GR = V_{max}/U_{\infty}$
Gust types:
Sine-square
top-hat options
Width of the gust, W
The initial distance between the leading edge and the edge of the gust, x_0



Pitching Profile
Constant None
None Constant Sinusoidal Closed-loop
Omega, deg/s 0
Pitching Point
L.E.
T.E.
Angular rate
Pitch axis location
Proportional Gain 50
Pitch Frequency, deg/s 20
Pitch Amplitude, deg 20
Pitching frequency for the sinusoidal profile
Maximum angular displacement from the chosen mean angle
Closed-loop control proportional gain. This gain governs the strength of pitch response to the deviation of lift from zero. It's chosen such that it negates any increase or decrease in lift from the 0 lift value

Output files:

- Parameters.txt: text file containing the parameters that are input to the GUI
- Animation.avi: A video that contains the lift coefficient and the flowfield evolution in time
- Data.mat: file containing the results of the simulation. Data inside 'panel'
    - alpha: Evolution of angle of attack as a function of time
    - C: chord length, m
    - c: a structure that contains the coordinates of wing control points
    - C_l: Coefficient of lift over time
    - Time: Time array, s
    - U: Horizontal velocity vector in time, m/s
    - V: Vertical velocity vector in time, m/s
    - vb: a structure that contains the coordinates as well as vortex strength of vortices bound to the wing
    - vs: a structure that contains the coordinates as well as vortex strength of vortices shed from the wing

Structure content description:

Each parameter in the structure is a cell array. Each cell is a different point in time that corresponds to the corresponding Time array index. Each cell is composed of the parameter value for all instances of that parameter in the flowfield at a snapshot in time. For instance, if you'd like to access the 2nd (arbitrary distinction) shed vortex in the 5th snapshot in time, then the vortex strength is vs.G{5}(2), the x coordinate of that vortex is vs.X{5}(2), and the y coordinate of that vortex is vs.Y{5}(2). That snapshot in time corresponds to t=Time(5).

Only relevant quantities are listed

- vb.X_b, c.X_b: X coordinates in the body frame, m
- vb.Y_b, c.Y_b: Y coordinates in the body frame, m
- vb.G, vs.G: vortex strength
- vb.X, vs.X, c.X: X coordinates, m
- vb.Y, vs.Y, c.Y: Y coordinates, m

Output animation: