LUDVM | LESP-modulated Unsteady Discrete Vortex Method

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Brief description

Code to solve 2D unsteady airfoil flow problems: using unsteady thin-airfoil theory augmented with intermittent LEV model. Proposed by Kiran Ramesh and Ashok Gopalarathnam.

LESP stands for Leading-edge Suction Parameter: $\mathrm{LESP}(t) = A_0(t)$, defined as:

$$A_0(t) = -\frac{1}{\pi}\int_0^{\pi} \frac{W(x,t)}{U} \mathrm{d}\theta, \tag{1}$$

with $W(x,t)$ being the induced velocity normal to the aerofoil surface, computed from components of motion kinematics, U being horizontal velocity of the airfoil, and θ being a variable of transformation related to the chordwise coordinate x. When reaching a critical value of the $\mathrm{LESP}(t)$ such that $|\mathrm{LESP}(t)| \geq \mathrm{LESP}_{crit}$, which is an input of the code, the $\mathrm{LESP}(t)$ is limited to such value and a Leading Edge Vortex (LEV) is shed at that time step.

The code is distributed in a python class called LUDVM, and its methods:

- airfoil
- motion_plunge | motion_sinusoidal
- induced_velocity
- airfoil_downwash
- time_loop
- compute_coefficients
- flowfield
- animation

Example of calling:

```
self = LUDVM(t0=0, tf=20, dt=5e-2, chord=1, rho=1.225, Uinf=1, \
             Npoints = 81, Ncoeffs=30, LESPcrit=0.2, Naca = '0012')
```

Details:

> Publication providing details on the LDVM theory is:
> Kiran Ramesh, Ashok Gopalarathnam, Kenneth Granlund, Michael V. Ol and Jack R. Edwards, "Discrete-vortex method with novel shedding criterion for unsteady aerofoil flows with intermittent leading-edge vortex shedding," Journal of Fluid Mechanics, Volume 751, July 2014, pp 500-538. DOI: http://dx.doi.org/10.1017/jfm.2014.297
> Available from:
> http://www.mae.ncsu.edu/apa/publications.html#j023

> Publication on the large-angle unsteady thin airfoil theory is:
> Ramesh, K., Gopalarathnam, A., Edwards, J. R., Ol, M. V., and Granlund, K., "An unsteady airfoil theory applied to pitching motions validated against experiment and computation,"
> Theor. Comput. Fluid Dyn., January 2013, DOI 10.1007/s00162-012-0292-8. Available from:

http://www.mae.ncsu.edu/apa/publications.html#j021

Publication containing the details of the modified model:
A modified discrete-vortex method algorithm with shedding criterion
for aerodynamic coefficients prediction at high angle of attack
Thierry M. Faure, Laurent Dumas, Vincent Drouet, Olivier Montagnier.
Applied Mathematical Modelling, December 2018.

More details in Katz J. & Plotkin A. Low Speed Aerodynamics
Chapter 13, Section 13.8 -> Unsteady Motion of a Two-Dimensional
Thin Airfoil. The paper is based on this section, adding the
effect of the LESP for the Leading edge shedding, the Vatista's
vortex model and the placement methodology for the shed vortices
of Ansari et al. (2006) and Ansari, Zbikowski & Knowles (2006).

More detailed info on PhD thesis:
Kiran Ramesh. Theory and Low-Order Modeling of Unsteady Airfoil Flows

External dependencies

Needs the package *airfoils* installed: https://pypi.org/project/airfoils/
Installation:

1. First choice (if you are not in conda):

```
pip install airfoils
```

2. Second choice: if you are using anaconda, you need to install the *pip* package inside conda before. Thus do:

```
conda install pip
```

   Now you need to use *pip* to install airfoils. Introduce the following:

```
~/tools/anaconda3/bin/pip install airfoils
```

   Where *~/tools/anaconda3/bin/pip* is the path to the *pip* package in your anaconda distribution.