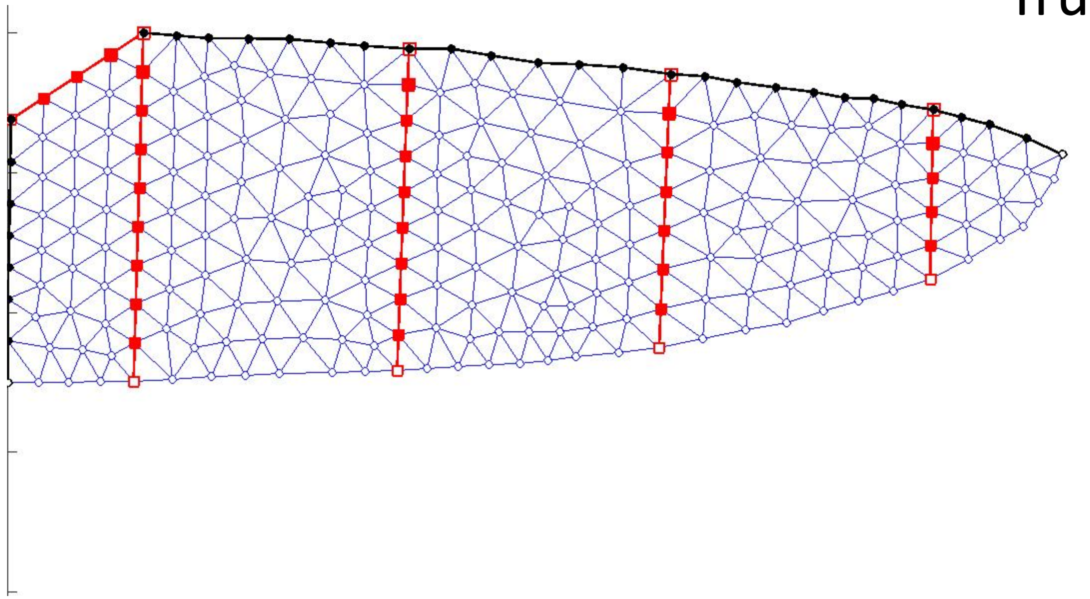
AIFIT meeting
Wing modeling using mass-spring system

Truong Dinh Hung



Paris, 06/12/18

Membrane model

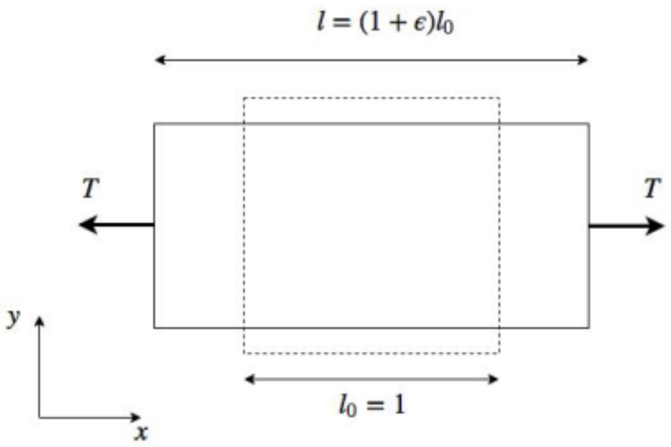


FIGURE 2.14: Deformation of a 2D sheet along the x axis under the uniaxial tension T.

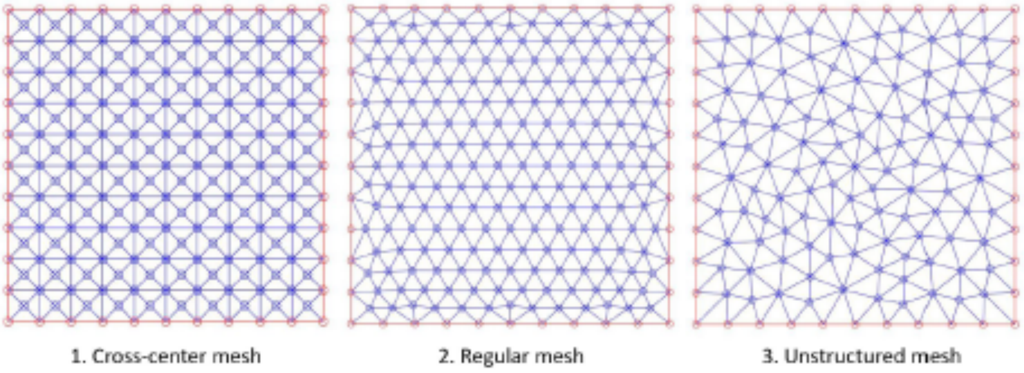


FIGURE 2.15: Three types of mesh used for the study of the effect of mesh topology on the relation between the spring stiffness k and the corresponding Young's modulus Es

Membrane model

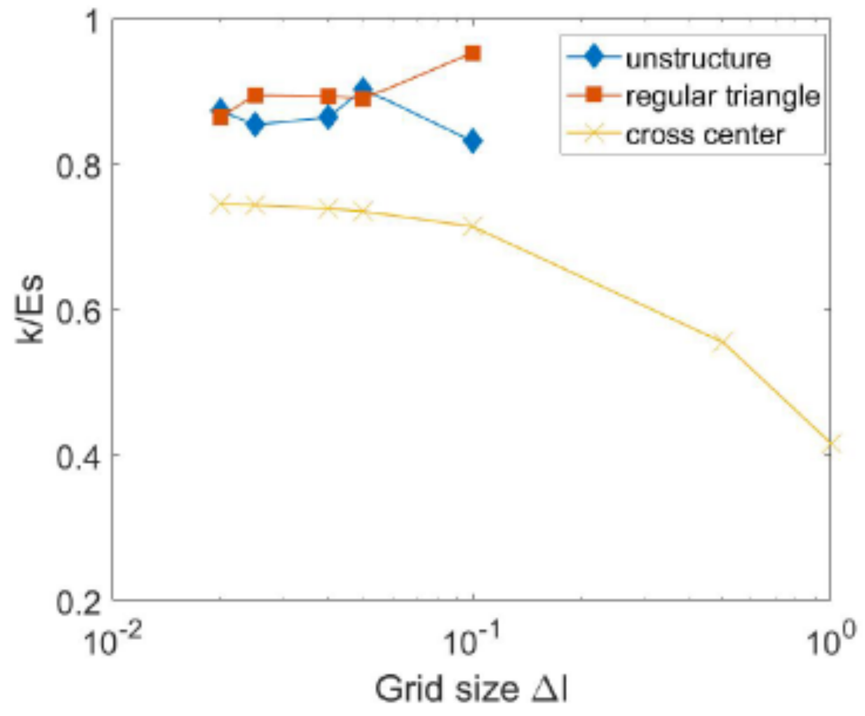
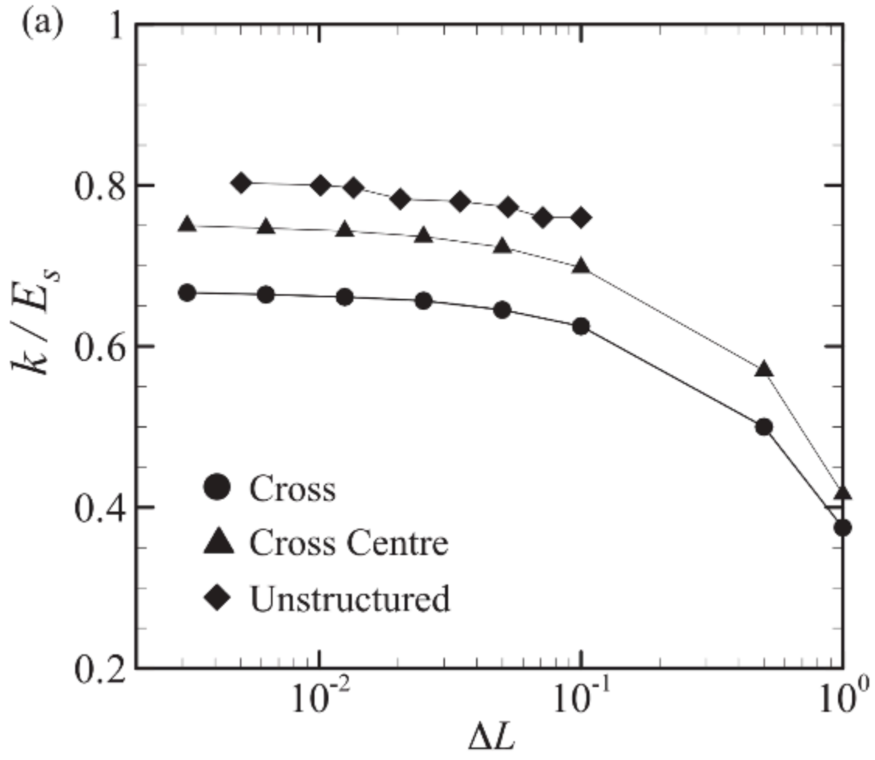


FIGURE 2.16: Effect of mesh topology on the relation between the spring stiffness k and the corresponding Young's modulus Es



=> Compared to reference [1], the error is smaller than 1%

[1] T. Omori, T. Ishikawa, D. Barthes-Biesel, A.-V. Salsac, J. Walter, Y. Imai, and T. Yamaguchi, Comparison between spring network models and continuum constitutive laws: Application to thelarge deformation of a capsule in shear flow

Membrane model

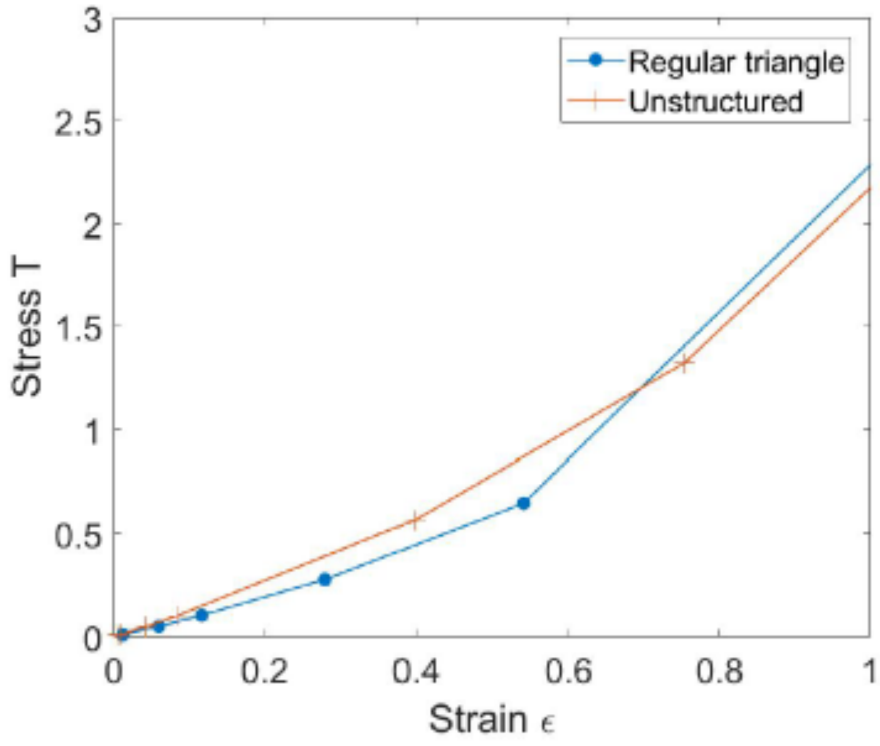
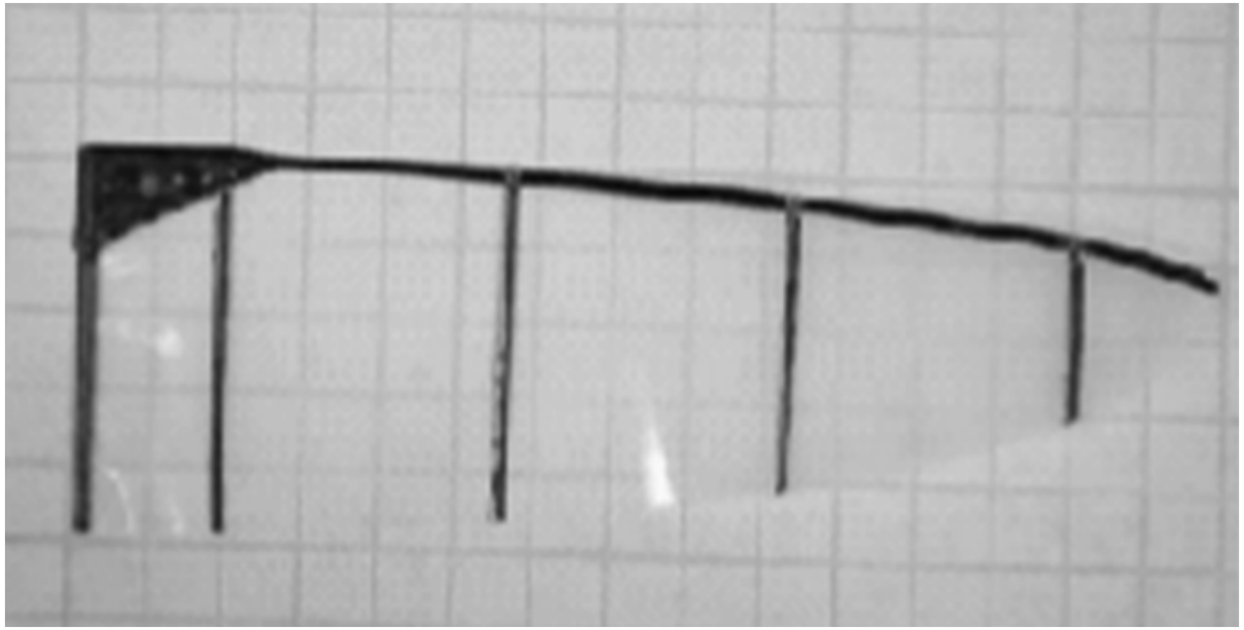
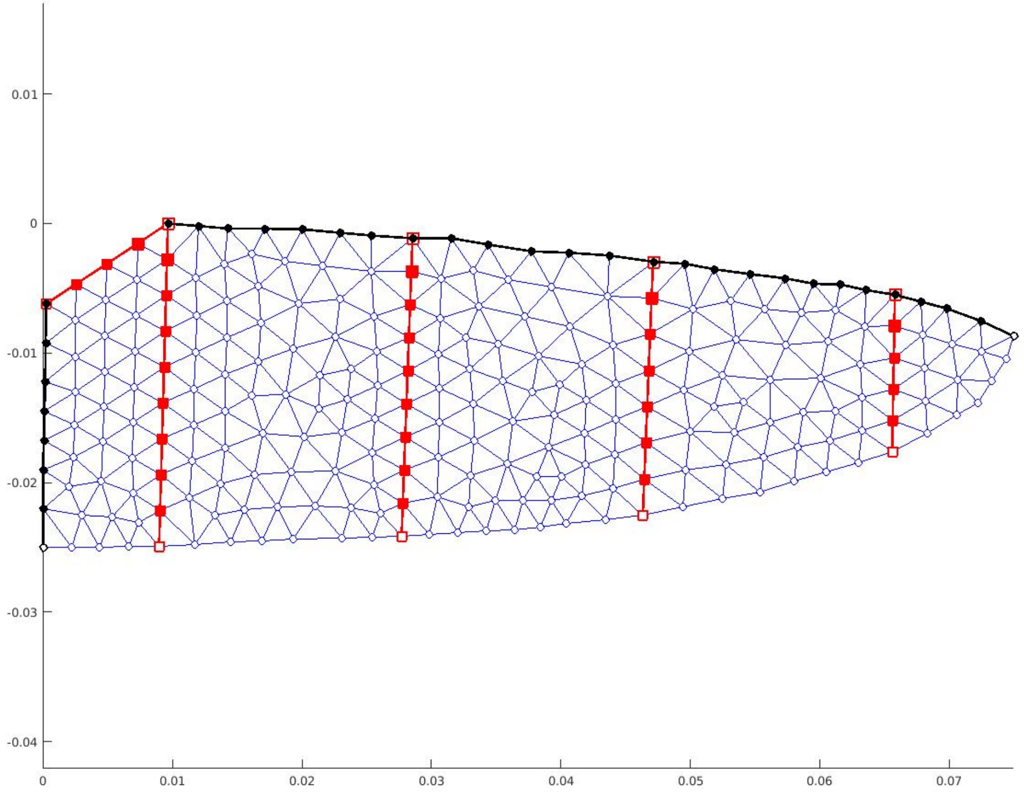


FIGURE 2.17: Stress-strain diagram of a mass-spring system

=> Membrane model shows strain-hardening behavior

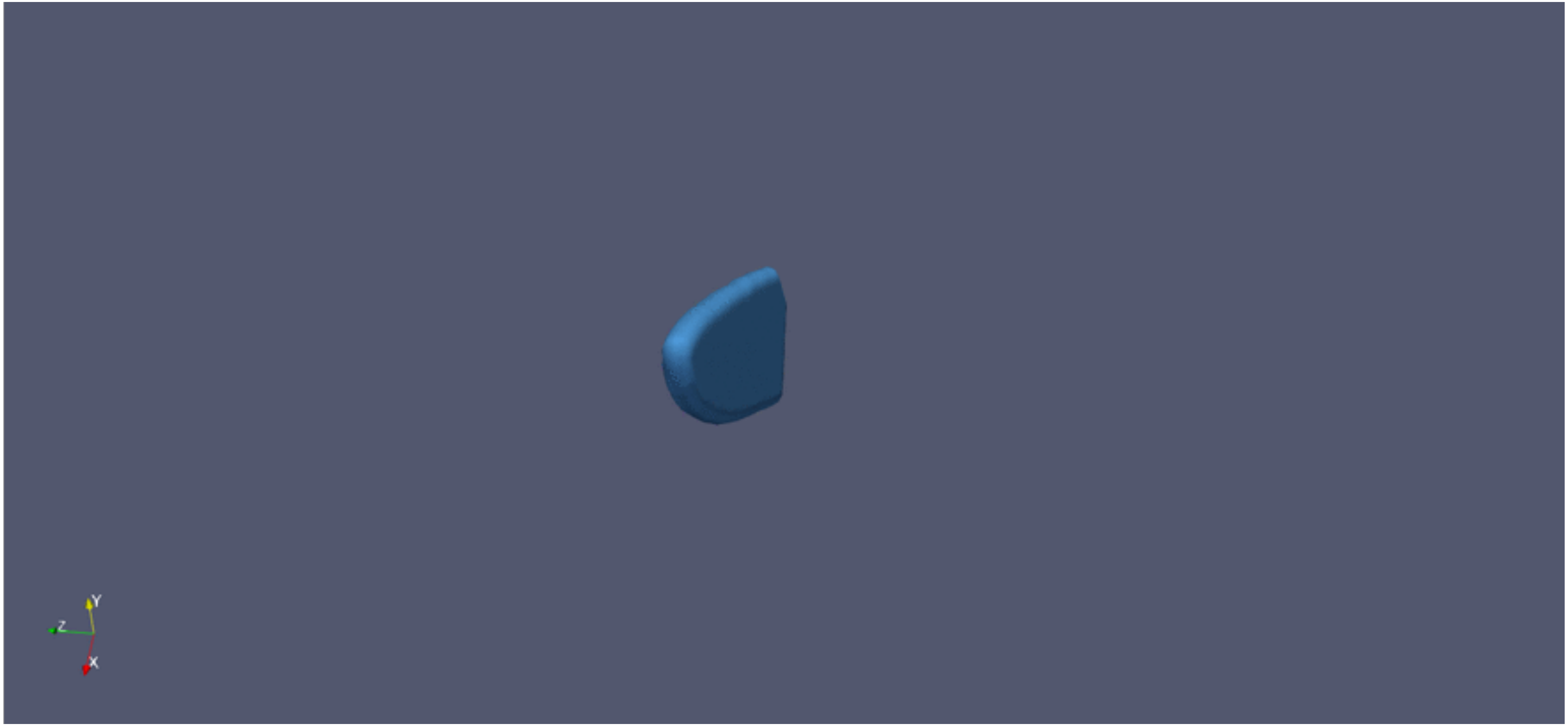
Fully coupling FSI – Zimmerman wing





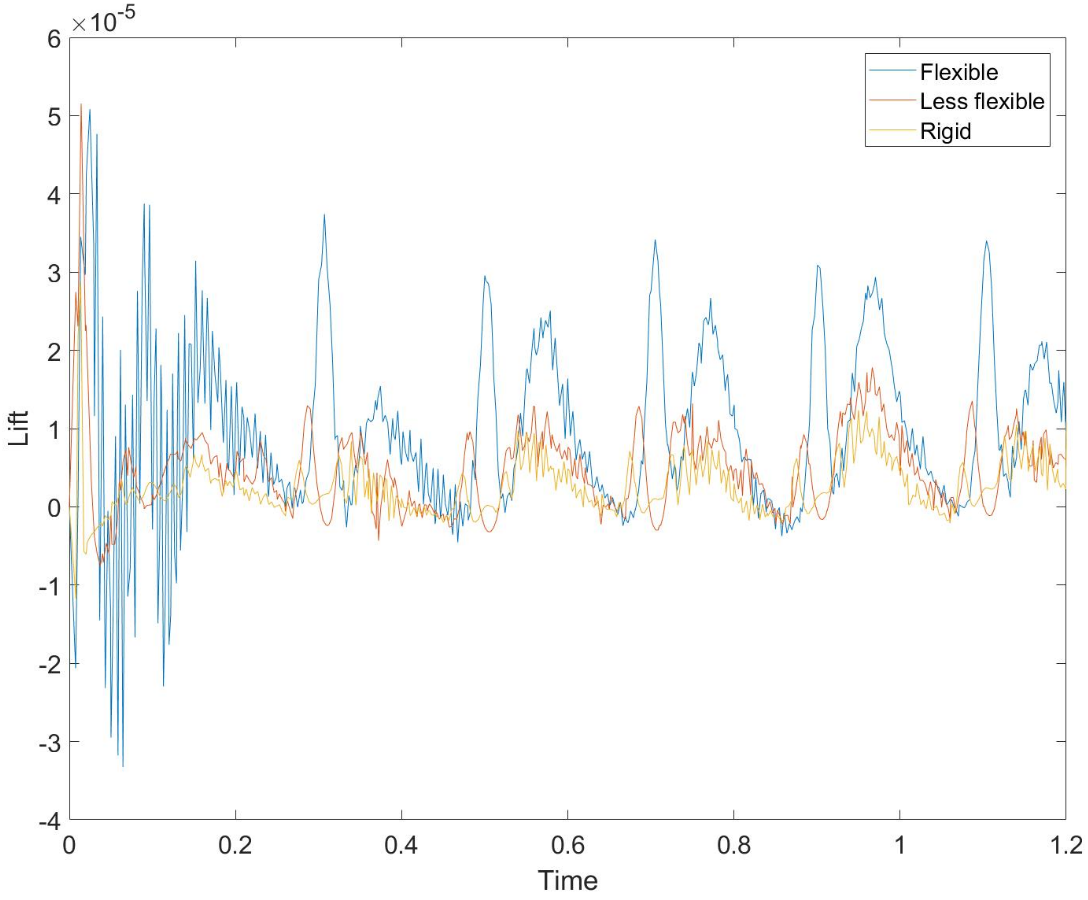
Meshed Zimmerman wing in Matlab

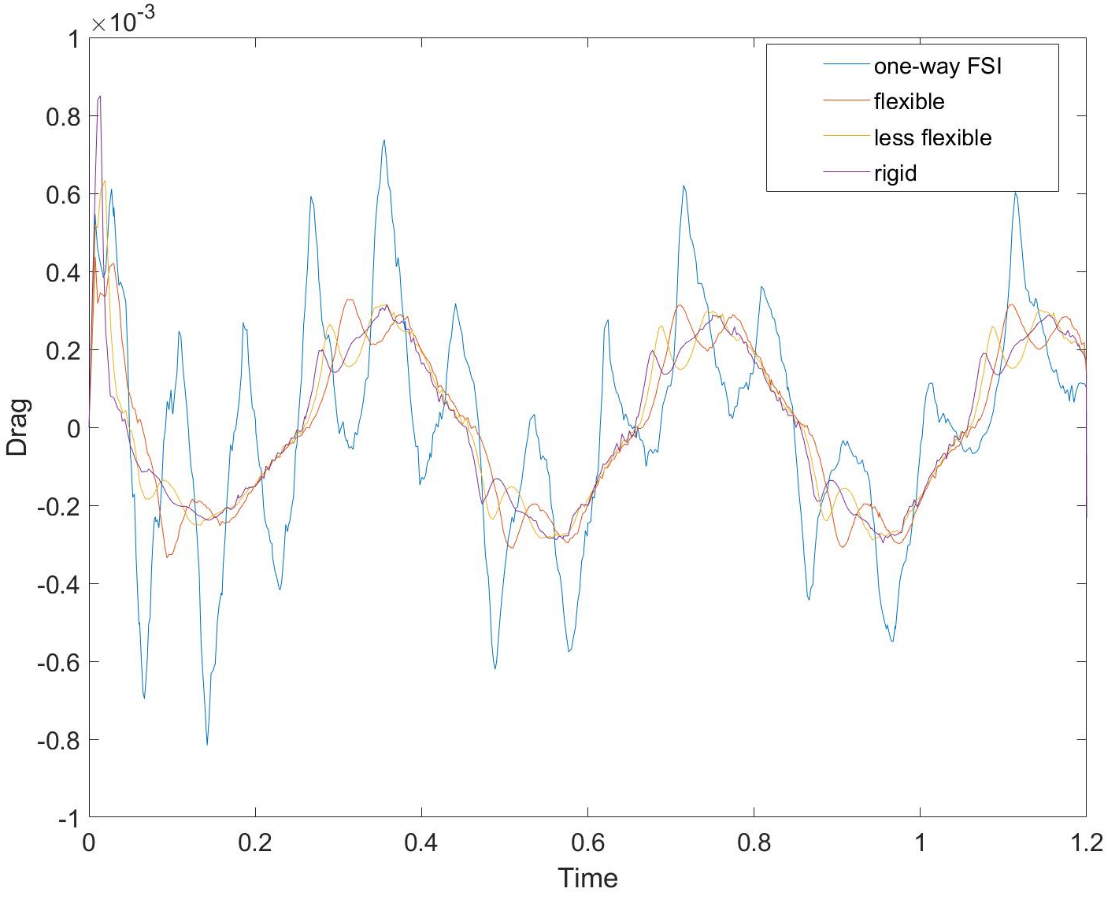
Fully coupling FSI - Zimmermanwing



Oscillating wing $z_{BC} = \mathrm{A}\sin(5\pi t)$

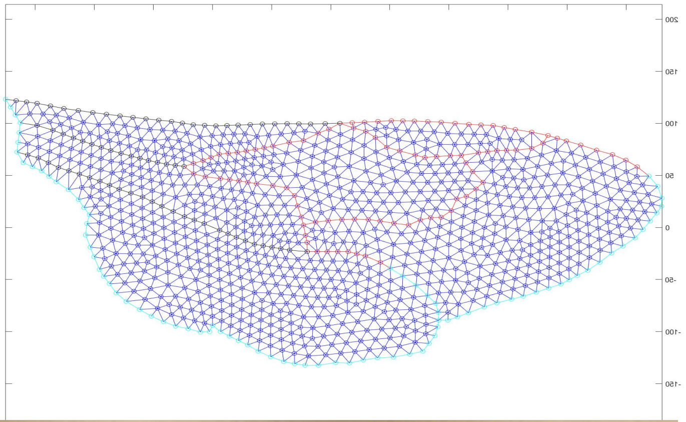
Fully coupling FSI - Zimmermanwing

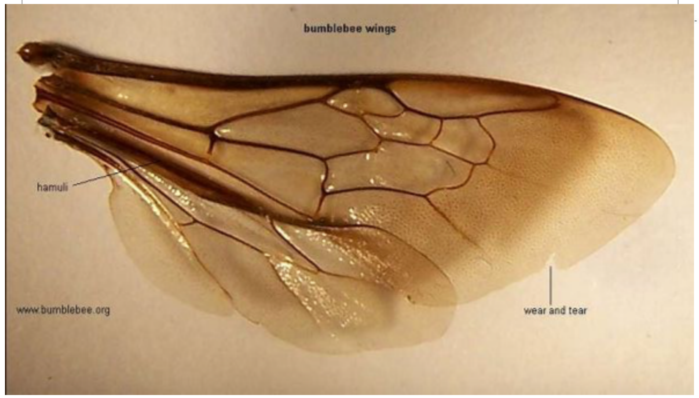


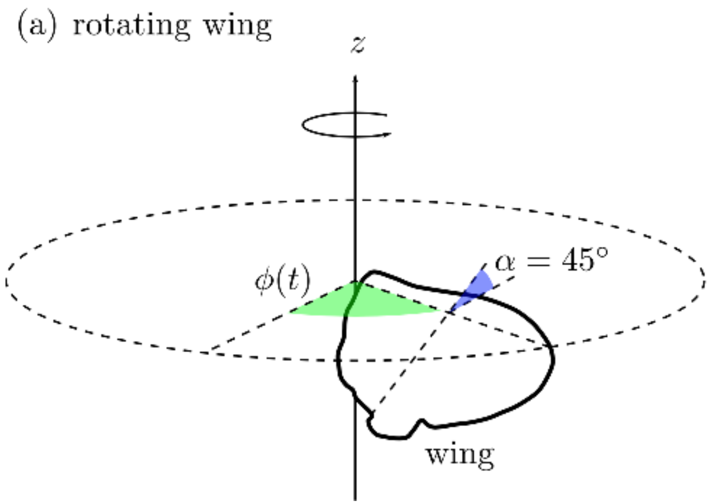


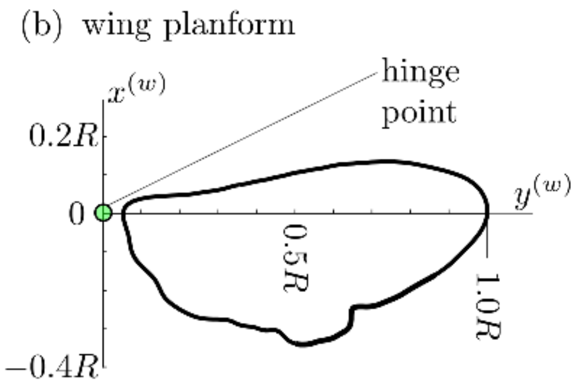
Fully coupling FSI – Zimmerman wing

Idea for first validation – revolving bumblebee wing









source [1]

[1] T. Engels, D. Kolomenskiy, K. Schneider, M. Farge, F.-O. Lehmann, J. Sesterhenn, Helical vortices generated by flapping wings of bumblebees, 2018

Parameter identification

The quality criterion is usually defined as the euclidean distance between the nodes of the learning and the reference model:

$$G(\theta) = \sum_i \left\| \mathbf{p}_i^{ref} - \mathbf{p}_i(\theta, \mathbf{f}^{ref}) \right\|^2,$$

Optimization methods used for spring stiffness identification in literature:

- Simulated Annealing [1]
- Evolutionary Genetic [2],[3],[4]

[1] Oliver Deussen and Leif Kobbelt and Peter T¨ucke, Using Simulated Annealing to Obtain Good Nodal Approximations of Deformable Bodies, 1995
[2] Jean Louchet, Xavier Provot, David Crochemore, Evolutionary identification of cloth animation models, 1995
[3] G´erald Bianchi, Barbara Solenthaler, G´abor Sz´ekely, and Matthias Harders, Simultaneous Topology and Stiffness Identification for Mass-Spring Models Based on FEM Reference Deformations, 2004
[4] R. Nogami, H. Noborio, F. Ujibe, and H. Fujii, Precise Deformation of Rheologic Object under MSD Models with Many Voxels and Calibrating Parameters, 2004

Parameter identification

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$\Rightarrow$ transform solution of solid solver from lagrangian into euclidean?

$\Rightarrow$ choosing parameter for optimizing : bending stiffnesses of veins, extension stiffnesses of membranes

$\Rightarrow$ design a specific algorithm for the task based on Genetic Algorithm