AA222 - Intro to MDO
Spring Quarter 2012
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STANFORD AERONAUTICS & ASTRONAUTICS

PROBLEM SET 4 **Due Date: May 30th, 2012, 5pm**

1. Consider the unconstrained problem from Homework 2.

   (a) Compute the drag gradient at $(A, S) = (10, 20)$ using the complex-step method.

   (b) Compute this gradient using a finite-difference formula of your choice, and find the best step size.

   (c) Study the effect of decreasing the gradient precision on the number of optimization iterations and accuracy of the optimum.

2. You will now compute sensitivities for a simple finite-element structural analysis of an aircraft wing. The program is given as a set of Matlab functions (posted in the class website):

   - `test.m`: Sample call for `wing.m`. Add your code in `test.m` to compute the sensitivities.
   - `wing.m`: This is the main function that computes the wing displacements and tip twist angle. The element properties are set such that they correspond to tubes of diameter D and wall thickness t.
   - You should not need to read the other functions (`kgrid.m`, `merge.m`, `cubic`, and `plotwing.m`).

   We are interested in computing two different vectors of sensitivities:

   - The sensitivity of the twist angle at the tip with respect to all 6 diameters of the finite-elements, $\mathrm{d}\gamma_{\text{tip}}/\,\mathrm{d}D_i$, for $i = 1, 2, \ldots, 6$.
   - The sensitivity of all finite-element displacements with respect to the diameter of element 1, $\mathrm{d}u_j/\,\mathrm{d}D_1$, for $j = 1, 2, \ldots, 18$.

   Calculate these two sets of sensitivities using the following methods:

   (a) A finite-difference formula of your choice.

   (b) The complex-step derivative approximation.

   (c) The analytic adjoint method.

   Show that the results exhibit the expected accuracy and that the results are consistent. Discuss the relative merits of all three approaches.

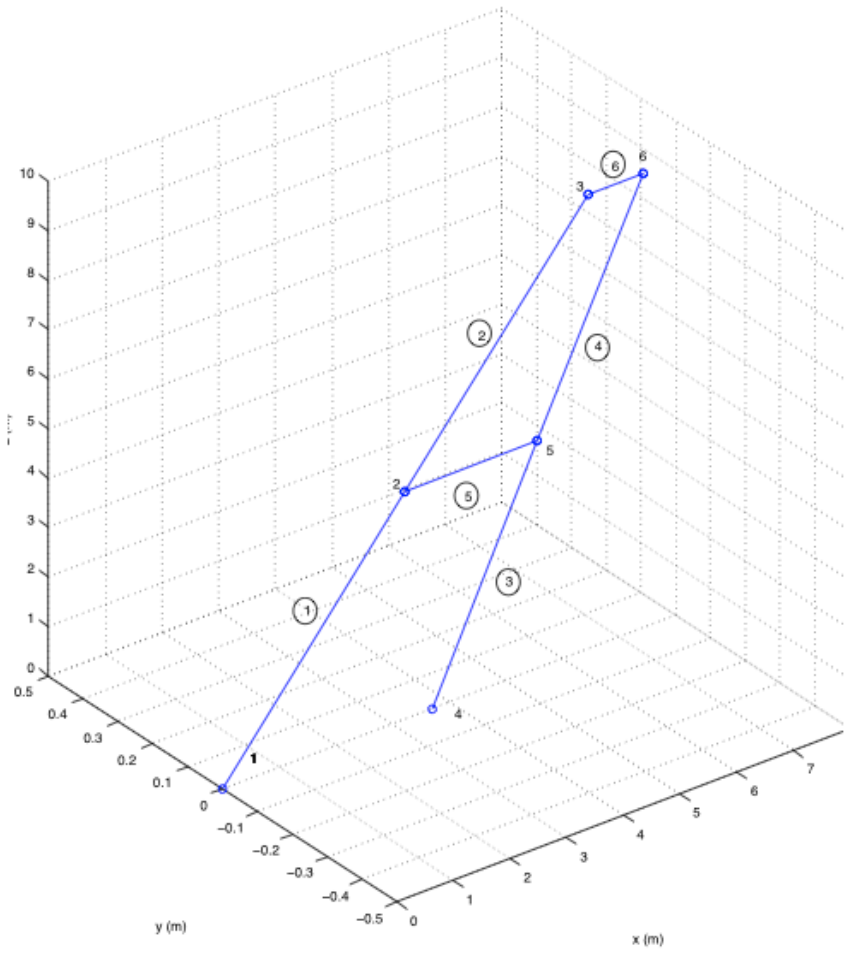

Figure 1: Finite-element structural model of a business jet wing. Node numbers are as shown, circled numbers are elements. Each node has 3 degrees of freedom: displacement in the y direction, rotation about x and rotation about z, in that order.