ME 591: Mechanics of Forming Processes
Fall 2023
Computing Assignment 1

Consider the three sets of mapping parameters given in the files `ca1_a.txt`, `ca1_b.txt`, and `ca1_c.txt`. These three files give the locations of the vertices of a body in the current (deformed) configuration for three different motions. The reference configuration is a unit cube with vertices at the extrema, defined in the reference coordinate system:

$$0 \leq X_1 \leq 1$$
$$0 \leq X_2 \leq 1$$
$$0 \leq X_3 \leq 1$$

For each set of motions, consider two points in the body with reference coordinates:

$$\underline{X} = (0.25, 0.25, 0.25)$$
$$\underline{X} = (0.75, 0.75, 0.75)$$

For the assignment below, submit a brief report detailing your answers (where appropriate or requested) in numerical format, using plots, or with a short explanation. Submit an archived (zip or equivalent) package containing your code.

1. Output the following in the $\underline{e}$ basis, using 3x3 matrices to represent tensors:

    (a) The deformation gradient and its determinant.
    (b) The left and right stretches and the rotation (plus its axial vector, or rotation axis).

2. Plot the following:

    (a) Two plots each for `ca1_a.txt`, `ca1_b.txt`, and `ca1_c.txt`. Each plot should contain an outline of the body along with the deformed fiber jacks corresponding to a set of fibers in the initial frame aligned with the coordinate system.

        i. The first plot should give the outline of the body in the reference configuration, together with the fiber jacks corresponding to $\underline{\underline{U}}$.
        ii. The other plot should give the outline of the body in the current configuration, with the fiber jacks corresponding to $\underline{\underline{V}}$.

    (b) Plot with MATLAB viewpoint $(3, 1, 1)$ and equal axes to facilitate easy comparison (or equivalent, in Python).
    (c) Plot the jacks at the the location at which they are calculated (i.e., the two points above), in the correct position depending on configuration.
    (d) Set the lengths of the initial jacks to 0.2, such that the plots depict 0.2λ.

3. Discuss the following:

    (a) Discuss `ca1_a.txt` and `ca1_b.txt` in terms of generalized homogeneous deformation given in Table 2.1 of Bower and properties of the mapping employed in your code.
    (b) In what ways are the motions given by `ca1_a.txt` and `ca1_c.txt` alike, and in what ways do they differ?