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

1. Output the following in the e basis, using 3x3 matrices to represent tensors:

   (a) The deformation gradient and its determinant.

   For file `ca_1a.txt`, at point [0.25,0.25,0.25]

$$F = \begin{bmatrix} 1.1437 & -0.9508 & 0.7677 \\ 0.23031875 & 0.43504375 & -0.41338125 \\ -0.874 & 1.0157 & 0.8957 \end{bmatrix}$$

$$J = 1.249991080910437$$

   At point [0.75,0.75,0.75]

$$F = \begin{bmatrix} 1.1437 & -0.9508 & 0.7677 \\ 0.23031875 & 0.43509375 & -0.41338125 \\ -0.874 & 1.0157 & 0.8957 \end{bmatrix}$$

$$J = 1.2500758500049372$$

   For file `ca_1b.txt`, at point [0.25,0.25,0.25]

$$F = \begin{bmatrix} 1.1437 & -0.9508 & 0.7677 \\ 0.26150625 & 0.46623125 & -0.38219375 \\ -0.874 & 1.0157 & 0.8957 \end{bmatrix}$$

$$J = 1.3434322443823123$$

   At point [0.75,0.75,0.75]

$$F = \begin{bmatrix} 1.43309375 & -0.16538125 & 0.76771875 \\ 1.22831875 & 0.35829375 & -0.41338125 \\ -0.66140625 & 0.30709375 & 0.89569375 \end{bmatrix}$$

$$J = 1.2500945450701213$$

   For file `ca_1c.txt`, at point [0.25,0.25,0.25]

$$F = \begin{bmatrix} 1.43304375 & -0.16538125 & 0.76771875 \\ 1.22831875 & 0.35824375 & -0.41338125 \\ -0.66145625 & 0.30704375 & 0.89564375 \end{bmatrix}$$

$$J = 1.2498803219574341$$

   At point [0.75,0.75,0.75]

$$F = \begin{bmatrix} 1.43304375 & -0.16538125 & 0.76771875 \\ 1.22831875 & 0.35824375 & -0.41338125 \\ -0.66145625 & 0.30704375 & 0.89564375 \end{bmatrix}$$

$$J = 1.2498803219574341$$

   (b) The left and right stretches and the rotation (plus its axial vector, or rotation axis).
   For file `ca_1a.txt`, at point [0.25,0.25,0.25]

$$V = \begin{bmatrix} 1.60545011 & -0.23273154 & -0.41206747 \\ -0.23273154 & 0.58988489 & -0.10519361 \\ -0.41206747 & -0.10519361 & 1.5546497 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.71653701 & -0.33072645 & 0.61416181 \\ 0.61417304 & 0.71654377 & -0.33069094 \\ -0.33070558 & 0.61415393 & 0.7165534 \end{bmatrix}$$

$$U = \begin{bmatrix} 1.24999562e+00 & -7.49988903e-01 & -1.51394873e-05 \\ -7.49988903e-01 & 1.24997874e+00 & -6.78148052e-06 \\ -1.51394873e-05 & -6.78148052e-06 & 1.25001033e+00 \end{bmatrix}$$

At point [0.75,0.75,0.75]

$$V = \begin{bmatrix} 1.60544845 & -0.23274521 & -0.4120662 \\ -0.23274521 & 0.58992048 & -0.10517058 \\ -0.4120662 & -0.10517058 & 1.55465159 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.71653974 & -0.33072211 & 0.61416096 \\ 0.61416496 & 0.71655372 & -0.33068439 \\ -0.33071468 & 0.61414466 & 0.71655714 \end{bmatrix}$$

$$U = \begin{bmatrix} 1.25000484e+00 & -7.49973548e-01 & -1.78647644e-05 \\ -7.49973548e-01 & 1.25000535e+00 & -1.58664376e-05 \\ -1.78647644e-05 & -1.58664376e-05 & 1.25001033e+00 \end{bmatrix}$$

For file `ca_1b.txt`, at point [0.25,0.25,0.25]

$$V = \begin{bmatrix} 1.60898954 & -0.21227061 & -0.40930119 \\ -0.21227061 & 0.61610188 & -0.08478693 \\ -0.40930119 & -0.08478693 & 1.55662606 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.70564657 & -0.34268565 & 0.62018502 \\ 0.62049174 & 0.72147942 & -0.30733929 \\ -0.34212997 & 0.6016926 & 0.7217431 \end{bmatrix}$$

$$U = \begin{bmatrix} 1.26833205 & -0.72913753 & -0.001869 \\ -7.29137530e-01 & 1.27334094e+00 & 1.11363523e-04 \\ -1.86900369e-03 & 1.11363523e-04 & 1.24004449e+00 \end{bmatrix}$$

At point [0.75,0.75,0.75]

$$V = \begin{bmatrix} 1.55307016 & 0.5077688 & -0.0253901 \\ 0.5077688 & 1.14783002 & -0.48237176 \\ -0.0253901 & -0.48237176 & 1.04914485 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.716544 & -0.33071757 & 0.61415844 \\ 0.61416539 & 0.71654621 & -0.33069985 \\ -0.33070465 & 0.61415585 & 0.71655217 \end{bmatrix}$$

$$U = \begin{bmatrix} 1.99999572e+00 & -8.65194634e-06 & 9.71002030e-06 \\ -8.65194634e-06 & 5.00031939e-01 & -9.28667692e-06 \\ 9.71002030e-06 & -9.28667692e-06 & 1.25001737e+00 \end{bmatrix}$$

For file `ca_1c.txt`, at point [0.25,0.25,0.25]

$$V = \begin{bmatrix} 1.55302689 & 0.50775903 & -0.02541015 \\ 0.50775903 & 1.14779924 & -0.48241814 \\ -0.02541015 & -0.48241814 & 1.04909724 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.7165283 & -0.33071356 & 0.61417891 \\ 0.61417385 & 0.71654406 & -0.33068883 \\ -0.33072297 & 0.61416053 & 0.71653971 \end{bmatrix}$$

$$U = \begin{bmatrix} 1.99997643e+00 & -2.28241818e-05 & -5.70492479e-06 \\ -2.28241818e-05 & 4.99965404e-01 & -3.18410620e-05 \\ -5.70492479e-06 & -3.18410620e-05 & 1.24998154e+00 \end{bmatrix}$$

At point [0.75,0.75,0.75]

$$V = \begin{bmatrix} 1.55302689 & 0.50775903 & -0.02541015 \\ 0.50775903 & 1.14779924 & -0.48241814 \\ -0.02541015 & -0.48241814 & 1.04909724 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.7165283 & -0.33071356 & 0.61417891 \\ 0.61417385 & 0.71654406 & -0.33068883 \\ -0.33072297 & 0.61416053 & 0.71653971 \end{bmatrix}$$

$$U = \begin{bmatrix} 1.99997643e+00 & -2.28241818e-05 & -5.70492479e-06 \\ -2.28241818e-05 & 4.99965404e-01 & -3.18410620e-05 \\ -5.70492479e-06 & -3.18410620e-05 & 1.24998154e+00 \end{bmatrix}$$

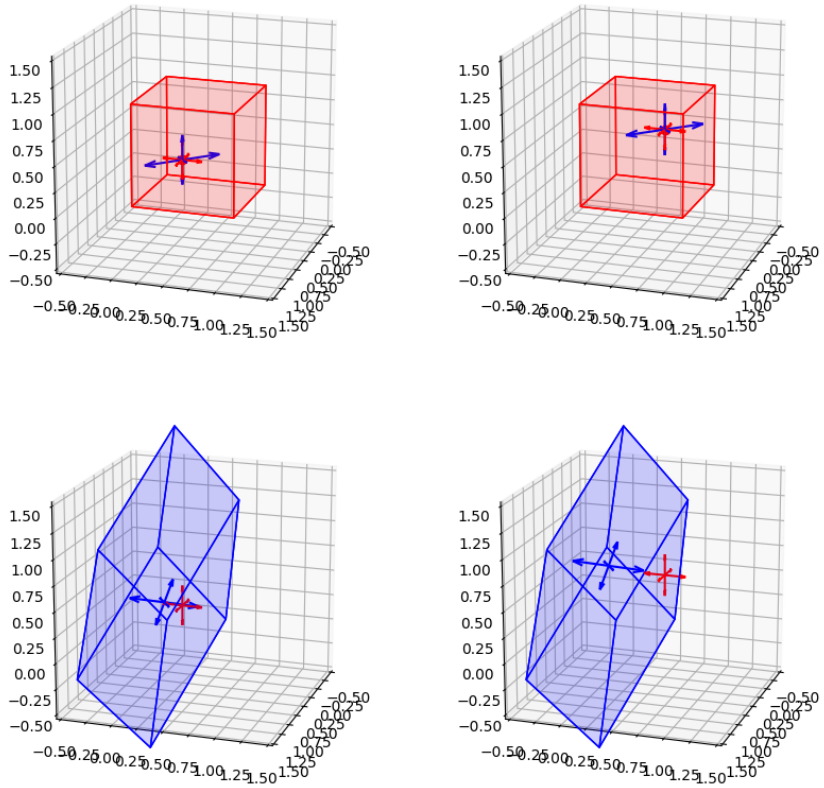

Figure 1: ca_1a.txt

2. Figure 1 shows `ca_1a.txt` , figure 2 `ca_1b.txt`, and figure1 `ca_1c.txt` with the columns showing the two points of interest and row 1 the undeformed body with the stress jacks for U and row 2 the deformed body with the stress jacks for V.

3. (a) The shape in `ca1_a.txt` is deformed in a manner that is more homogeneous throughout the shape in that visually the faces are all distorted in a similar way while in `ca1_b.txt` the distortion is not uniform and specifically the [1,1,1] node is deformed father out than the others.

   (b) The motions in `ca1_a.txt` and `ca1_c.txt` preserve the shape as a parallelepiped while having varied rotations.

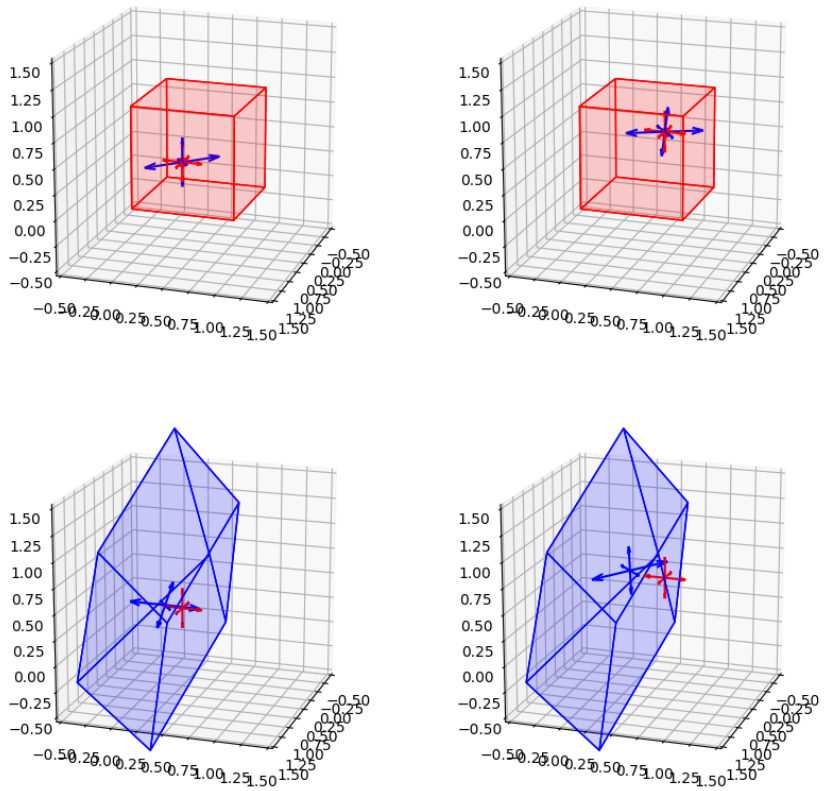

Figure 2: ca_1b.txt

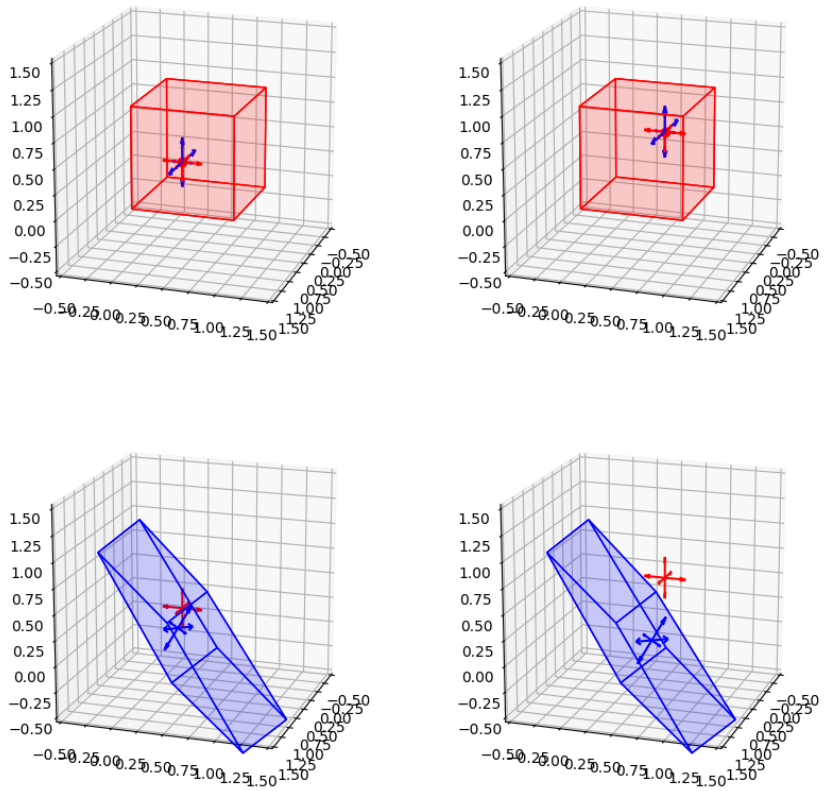

Figure 3: ca_1c.txt