ASEN 5331 - HW3

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Using the code that is posted on the web page, associate the following concepts to both your notes and to the code. By associate, I mean a one-to-one correspondence between the variables in the notes and the variables in the code (complete with the range of their indices when they are arrays). Also, identify the routines where each of these variables get updated and thereby carry out the algorithms we have described in the notes (again mapping the algorithms from the notes to routines that carry them out)

1 Gradient of shape function in the parent domain

$$N_{a,\xi_l}(\boldsymbol{\xi}^k) \tag{1}$$

Where `nsd` is number of spacial dimensions (ie. 3 for 3D, 2 for 2D)

`npro` is the number of elements processed in a single call of e3.

`nflow` is the number of flow variables (usually 5)

Represented by `shgl (nsd,nen,nQpt)` (mentioned `common/shpt10t.f`). It appears that the `shgl` is defined in either `common/shp10t.f,shp4t.f`. Note this never gets called, but all other references use shgl as an input

Represented by `shgl (npro,nsd,nshape)` (mentioned `common/e3qvar.f`)

Represented by `shgl (nsd,nshl,ngauss)` (mentioned `common/e3.f`) nsd = l, nshl = a, ngauss=k

2 Gradient of shape function in real domain

$$N_{a,i} = \frac{\partial N_a}{\partial x_i} \tag{2}$$

Possibly `shg(npro,nshl,nsd)` is computed in `compressible/e3metric.f#64`

Note that `compressible/e3qvar.f` defines `shg(npro,nshape,nsd)` but `compressible/e3ivar.f` defines `shg(npro,nshl,nsd)` but

3 Metric tensor that maps §1 to §2

$$\boldsymbol{\xi_{j,i}} \tag{3}$$

for

$$N_{a,i} = N_{a,\xi_j} \boldsymbol{\xi_{j,i}} \tag{4}$$

Written as dxidx(npro,nsd,nsd) in common/e3metric.f. The index would then be a, j, i.

4 Global Residual

$$\boldsymbol{G}_A = \mathbb{A} \boldsymbol{G}_a^e \tag{5}$$

Stored as res(nshg,nflow) which is assembled by the subroutine common/local.f which is called from compressible/asigmr.f#84.

The local subroutine just performs the $\mathbb{A}$ operator.

nflow is the number of flow variables

5 Element Level Residual

$$\boldsymbol{G}_a^e \tag{6}$$

Defined as rl(npro,nshl,nflow) in common/e3.f

It is a collection of 5x1 vectors, one for each a and e, where e=npro and a=nshl

6 Element Level tangent matrix

$$\frac{\mathrm{d}\boldsymbol{G}_a^e}{\mathrm{d}\boldsymbol{Y}_b} \tag{7}$$

Appears to be stored as EGmass(npro,nedof,nedof) in compressible/e3conv.f#314 where e = npro and {a,b} = nedof.

This is built by inputting the jacobian of the advective flux ($\boldsymbol{A}_i = \boldsymbol{F}_{i,\boldsymbol{Y}}$ written in code as Ai) which is calculated in compressible/e3mtrx.f, multiplying this by the real space gradient of the shape function in lines compressible/e3conv.f#201-306 to make the AiNbi tensor. AiNbi is then multiplied by shape

7 The gradient of the solution vector

$$\boldsymbol{Y}_{,i} \tag{8}$$

Appears to be named as g[1..3]yi(npro,nflow) and is calculated in compressible/e3ivar.f#243.

It is calculated by the sum of the products of the real space gradient shape function shg and the element primitive variables yl.

8 Jacobian of the map from real domain to parent domain

$$\frac{\partial x}{\partial \xi} \tag{9}$$

Appears to be `dxdxi(npro,nsd,nsd)` in `common/e3metric.f#20`

It is calculated by the multiplying the nodal coordinates `xl` by the gradient of the local shape function `shgl`.

9 The advective/convective flux

$$\boldsymbol{F}_i^{\mathrm{adv}} \tag{10}$$

Defined as `ri` in `compressible/e3conv.f#74`. It is calculated directly using the definition of the advective flux

$$\boldsymbol{F}_i^{adv} = u_i \boldsymbol{U} + \begin{Bmatrix} 0 \\ p\delta_{ij} \\ u_i p \end{Bmatrix} \tag{11}$$

`ri` is formatted such that the $\boldsymbol{F}_1^{\mathrm{adv}}$ is `r1(:,1:5)`

10 The Jacobian of the Advective/Convective Flux

$$\boldsymbol{A}_i = \boldsymbol{F}_{i,\boldsymbol{Y}} \tag{12}$$

Defined in `compressible/e3mtrx.f#132` as `A[1..3]`, it is calculated in a similar direct way as $\boldsymbol{F}_i^{\mathrm{adv}}$, while additionally using `rYli` which is calculated in `compressible/e3conv.f#100`. Note that `rYli` is mascaraded as `e2p, e3p, e4p, drdp,` and `drdT`.