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ALGORITHM UPDATE FOR 3D BAR ELEMENTS

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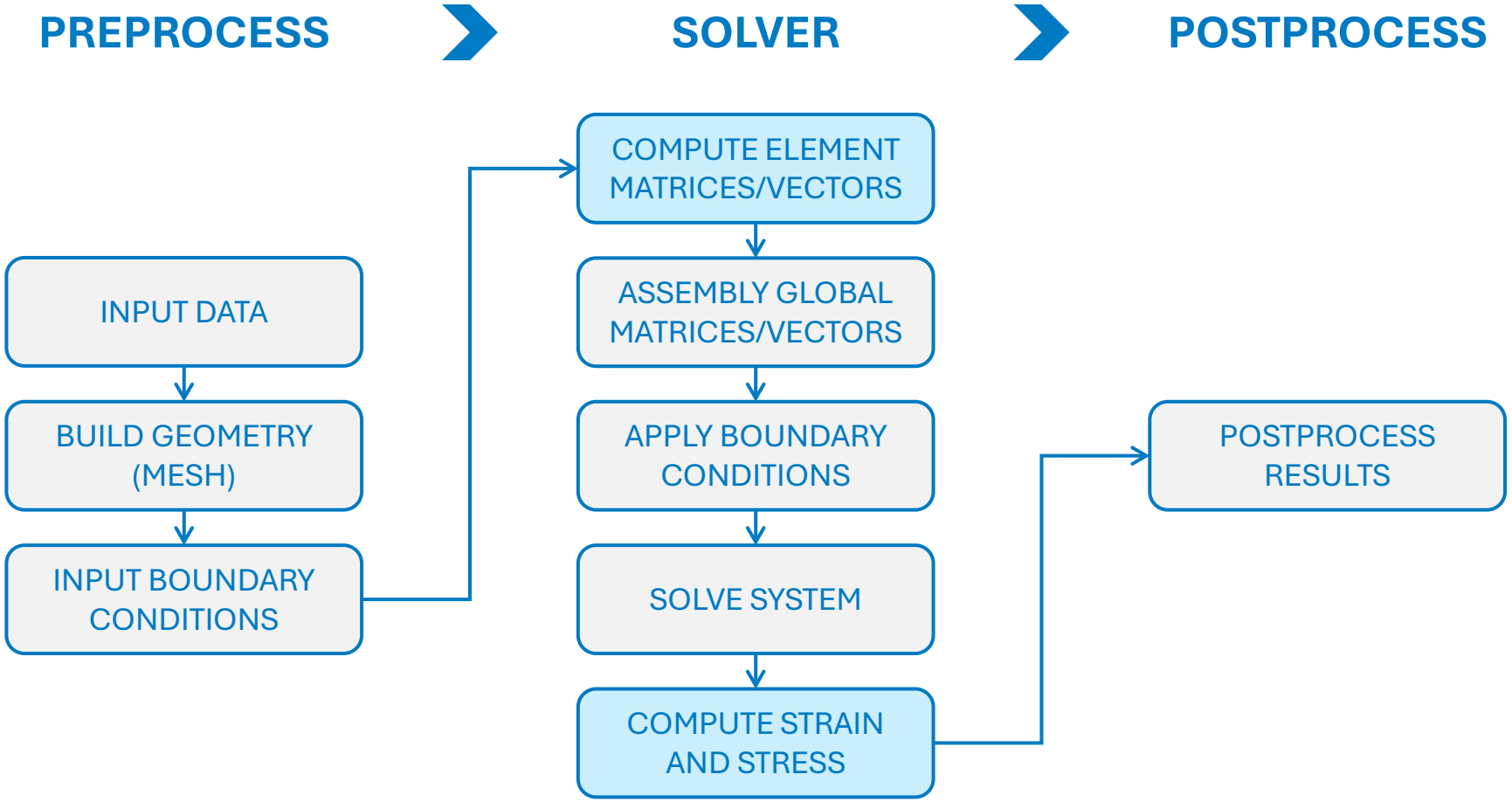
– ESTRUCTURES AEROESPACIALS –

Global algorithm



Compute element matrices/vectors

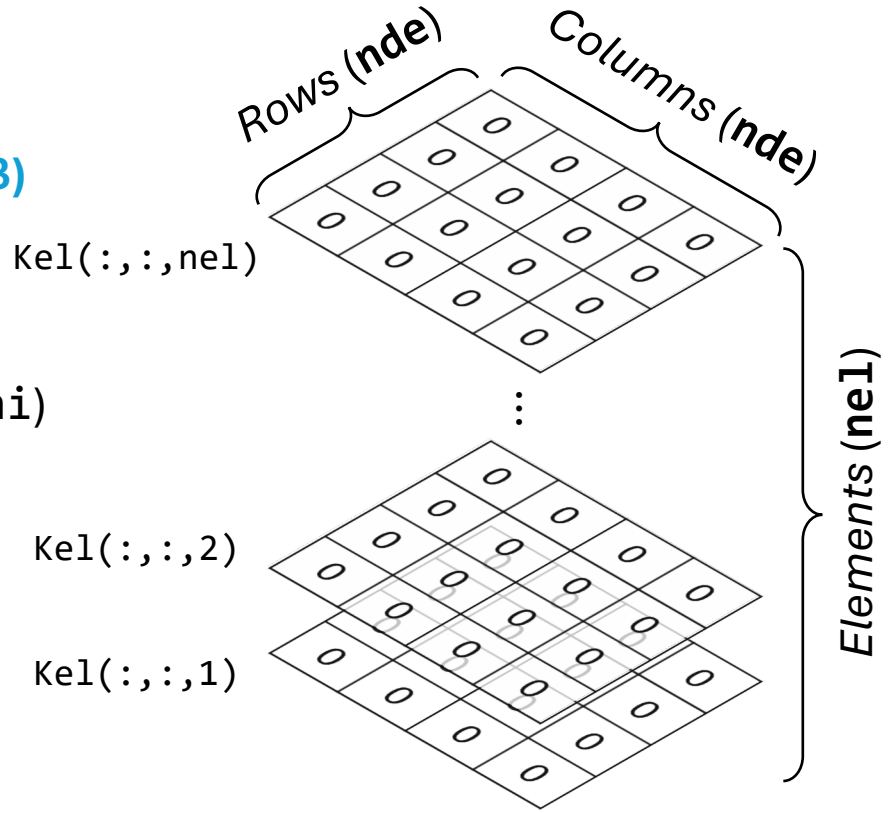
PREPROCESS

↓

`xnod`, `Tnod`, `mat`, `Tmat`, `fixnod`, `fdata` ... (other data)

Dimensions:

- **`nnod`** = Number of nodes
- **`ni`** = Number of DOFs per node **(for this case `ni=3`)**
- **`nel`** = Number of elements
- **`nne`** = Number of nodes per element
- **`ndof`** = Total number of DOFs (`ndof` = `nnod` × `ni`)
- **`nde`** = Number of DOFs per element (`nde` = `nne` × `ni`)



1. Initialize **element matrices** and **vectors**:

$$\texttt{Kel} = [\mathbf{0}]_{\texttt{nde} \times \texttt{nde} \times \texttt{nel}}$$

$$\texttt{fel} = [\mathbf{0}]_{\texttt{nde} \times \texttt{nel}}$$

Compute element matrices/vectors

2. Loop over each **element** (from e = 1 to `nel`)

2.1 From **xnod** and **Tnod**, get element nodal coordinates: $x_1, y_1, z_1, x_2, y_2, z_2$

2.2 From **mat** and **Tmat**, get element material properties: E, A, σ_0

2.3 Compute element length:

$$l = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

2.4 Compute rotation matrix

$$c_x = (x_2 - x_1)/l$$

$$c_y = (y_2 - y_1)/l$$

$$c_z = (z_2 - z_1)/l$$

$$[\mathbf{R}] = \begin{bmatrix} c_x & c_y & c_z & 0 & 0 & 0 \\ 0 & 0 & 0 & c_x & c_y & c_z \end{bmatrix}$$

Compute element matrices/vectors

2.5 Compute element force vector

$$\texttt{fel(:,e)} = -\sigma_0 A[\mathbf{R}]^{\mathrm{T}} \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

2.6 Compute element stiffness matrix

$$\texttt{Kel(:,:,e)} = EA/l[\mathbf{R}]^{\mathrm{T}} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} [\mathbf{R}]$$

Compute strain and stress

1. Loop over each **element** (from e = 1 to `nel`)

   1.1 From **xnod** and **Tnod**, get element nodal coordinates: $x_1, y_1, z_1, x_2, y_2, z_2$

   1.2 From **mat** and **Tmat**, get element material properties: E, σ_0

   1.3 From **Tnod** and **ni**, get element global DOFs: `I` (alternatively, get them from **Tdof**)

   1.4 Compute element length and rotation matrix: $l, [\mathbf{R}]$

   1.5 Get axial displacements of element: u'_1, u'_2

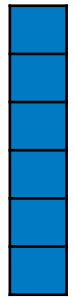
   1.6 Compute element strain

   $$\varepsilon = (u'_2 - u'_1)/l$$

   1.6 Compute element stress

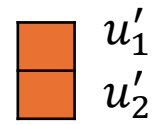
   $$\texttt{sig(e,1)} = \sigma_0 + E\varepsilon$$

Element nodal displ. in *global* coordinates



$\{\boldsymbol{u}_{\mathrm{el}}\} = \texttt{u(I)}$

Element nodal displ. in *local* coordinates



$\{\boldsymbol{u}'_{\mathrm{el}}\} = [\mathbf{R}]\{\boldsymbol{u}_{\mathrm{el}}\}$