Tensor Visualization:

2nd order tensor field in 3D
- 9 values at each location.

Simple tensor visualization:
- display each one on a 3x3 grid;
- use cutting planes.

- user needs to integrate 9 components.

Usually work with symmetric tensors.

I.e. Tensor $T$ can be decomposed into:
- symmetric & anti-symmetric parts

$$T = S + A = \frac{1}{2}(T + T^T) + \frac{1}{2}(T - T^T)$$

$S$
- rotational part.
Example
Stress & Strain tensors:
- each has normal & shear components:

\[
\begin{bmatrix}
T_x & T_y & T_z \\
J_{xy} & J_{yz} & J_{xz} \\
J_{zx} & J_{zy} & J_{yz}
\end{bmatrix}
\]

\(T\) \(\rightarrow\) direction of normal stress
\(J\) \(\rightarrow\) shear stress components

Stress tensor.

\[
\begin{bmatrix}
\frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} + \frac{\partial v}{\partial z} & \frac{\partial u}{\partial z} + \frac{\partial w}{\partial x} \\
\frac{\partial v}{\partial y} + \frac{\partial u}{\partial z} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \\
\frac{\partial w}{\partial z} + \frac{\partial u}{\partial x} & \frac{\partial w}{\partial y} + \frac{\partial u}{\partial z} & \frac{\partial w}{\partial z}
\end{bmatrix}
\]

Strain tensor

treat each triple as vector components
convert into 3 eigenvector & 3 eigenvalues
- eigenvectors are orthogonal.

Tensor Ellipsoids:
- eigenvectors form local coordinate frame
eigenvalues mapped to major, medium, minor axes.
Hyper Streamlines:

Idea: Integrate along the major eigenvector tensor field.

Use geometry (e.g., ellipse or cross defined by medium & minor axes) to sweep along hyperstreamline.

Deformation-Based:

- e.g. Spring
- Ink
- Rays.