Scientific Visualization
Part 4: Multidimensional Data

John Keyser

Multidimensional Data

- Scientific data often has many dimensions
  - Can be both scalar and vector
  - Or Tensor data (higher order than vector)
- Presents an additional level of challenge on top of existing issues like interpolation, occlusion
- Because of the geometric component, other methods for multidimensional data are not applicable
  - Radar charts, parallel coordinates, scatter plot matrices, etc.

Fundamental Limitations

- We will have a limitation on how many dimensions can be reasonably shown

- Limitations on how our visual system in terms of low-level signaling

- Each additional dimension will add to cognitive load

- We can present more data, but will not be intuitive to really understand patterns and relationships

Principles

- Combining multiple approaches together
- We can combine various visual channels
  - Color: Hue, Saturation, Intensity
  - Texture/Pattern: Type, orientation, frequency
  - Glyphs/Streamlines
  - Time
  - Height (if data is 2D to start)
- We can potentially convey more information in glyphs
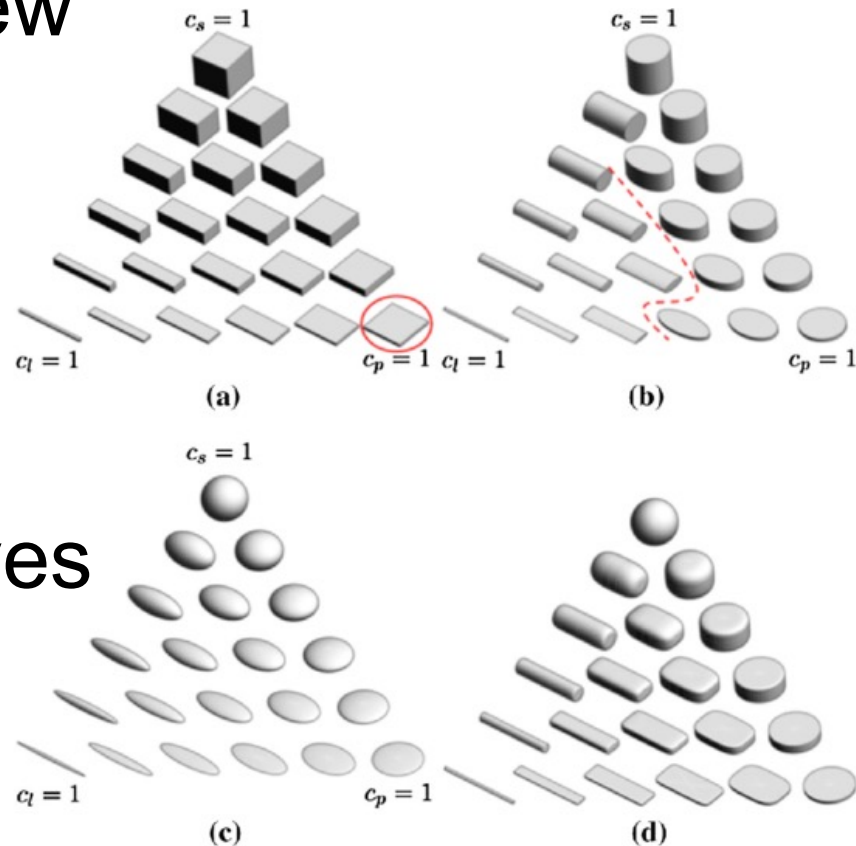 - Especially common for tensor data visualization

Haber Glyph for Tensors

- For visualizing stress tensor
- Cylinder and elliptical disk
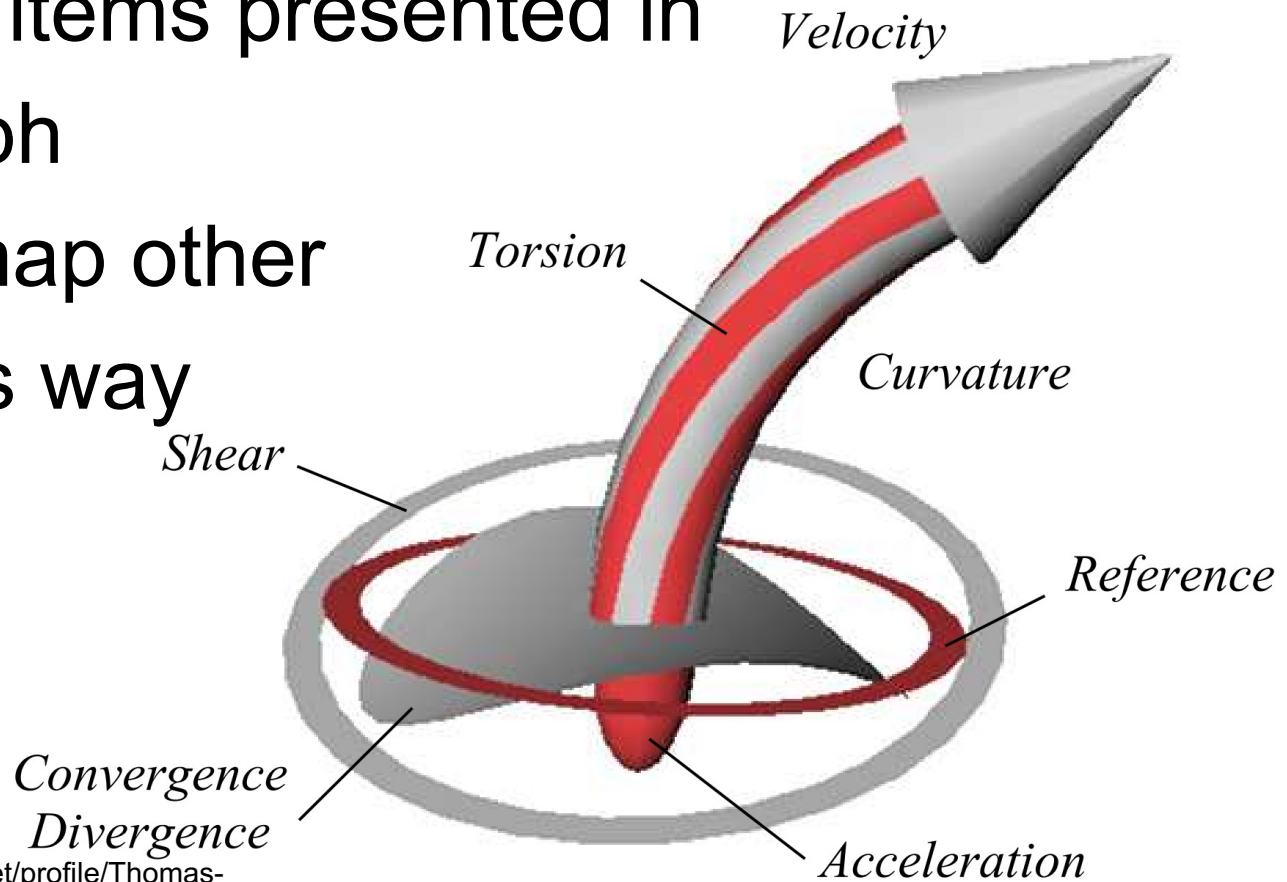- Orientation of major axis
- Amount of major, middle minor axes
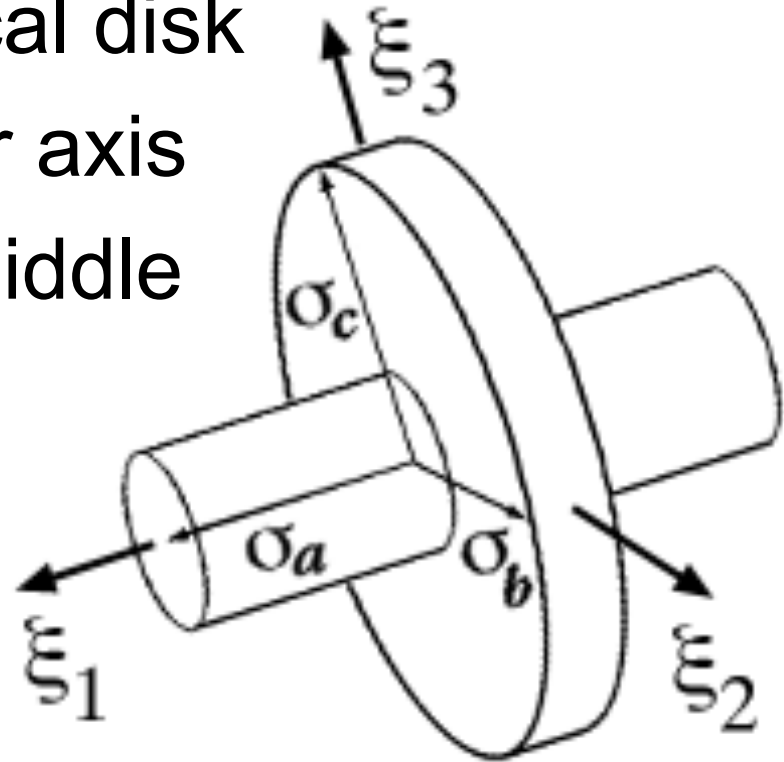
KindImann Superquadric Tensor Glyph

- Some glyphs can appear ambiguous depending on view
  - Appear same if different
  - Appear different when same
- Superquadric gives less ambiguity

de Lueew and van Wijk Glyphs

- Several items presented in one glyph
- Could map other data this way

Velocity

Torsion

Curvature

Shear

Reference

Convergence Divergence

Acceleration

From: https://www.researchgate.net/profile/Thomas-Steinke/publication/2724879_Visualization_of_Vector_Fields_in_Quantum_Chemistry/links/0c96051a4767952a28000000/Visualization-of-Vector-Fields-in-Quantum-Chemistry.pdf?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6Il9kaXJlY3QiLCJwYWdlIjoicHViGljYXRpb24iLCJwcmV2aW91c1BhZ2UiOiJfZGlyZWN0In19

Glyphs for Multivariate Data

- A wide variety of different approaches to glyphs have been used to convey more information
    - Continues to be a topic of active research
- The way the glyphs are laid out is also important.
    - Easy to have occlusion of glyphs
    - Slicing into 3D data, projecting onto 2D are common
    - Using a glyph as a "probe" to find values at a point (esp. if interactive view/movement of probe)

A Last Comment

- Though we have discussed grids, scientific data is sometimes projected/displayed on other 3D geometry
  - Blood vessels
  - Surface of a vehicle
  - Topographical Map
- All the methods discussed still apply, but the mapping usually requires a 3D visualization