

Visualizing Scalars, Vectors, and Tensors

Data Objects in Space

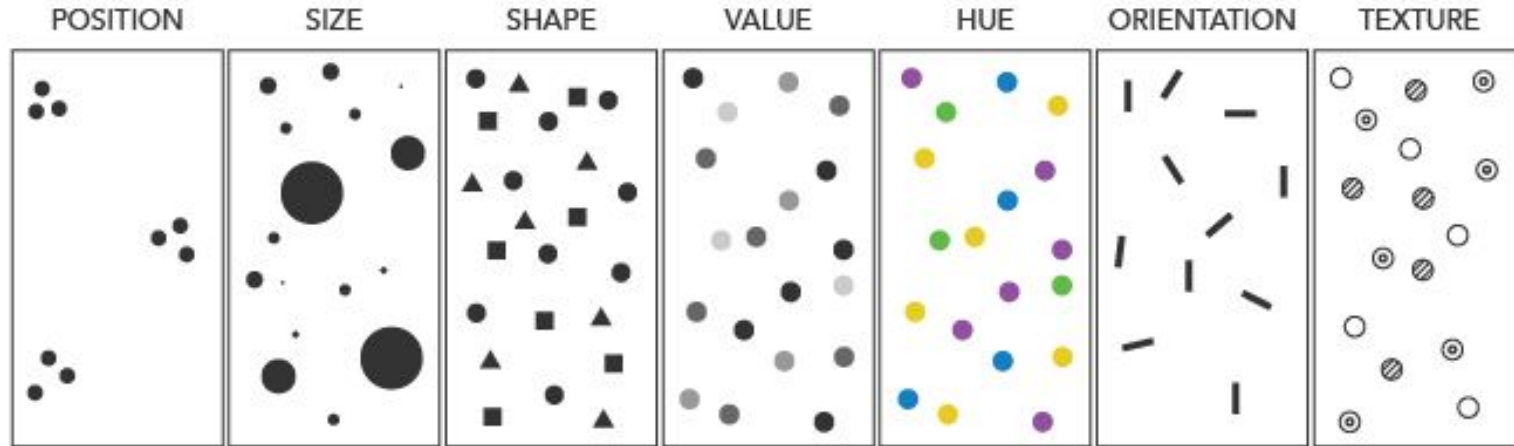
Terminology

Data Dimensions: The dimensions of information that the data represents. They are variables or features that a dataset contains -- think columns in a table.

n-D Space: The visual space that data is projected onto. For visualization, information must be projected onto 1-D, 2-D, or 3-D space.

Terminology, cont.

Visual Variables: A concept that was developed by Jacques Bertin, Visual Variables are the channels that information can be mapped into a visual appearance. Bertin defined seven main categories of visual variables:



Data Objects in 2-D & 3-D Space

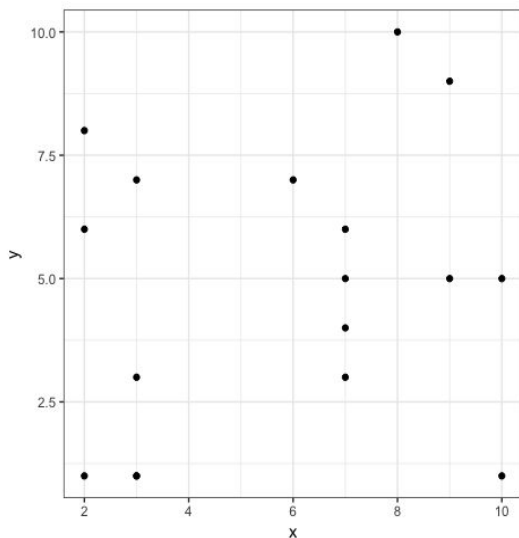
Data Objects can contain n-dimensions of information.

Each data entry is represented as a point in space. That position carries anywhere between 2 and 3 data dimensions, depending on the space it's projected onto (2-D or 3-D space).

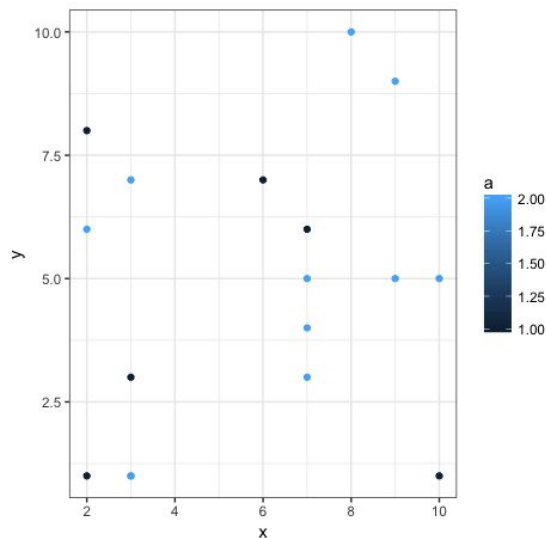
Each point may contain extra dimensions of information, in addition to its position.

Data Objects in 2-D Space

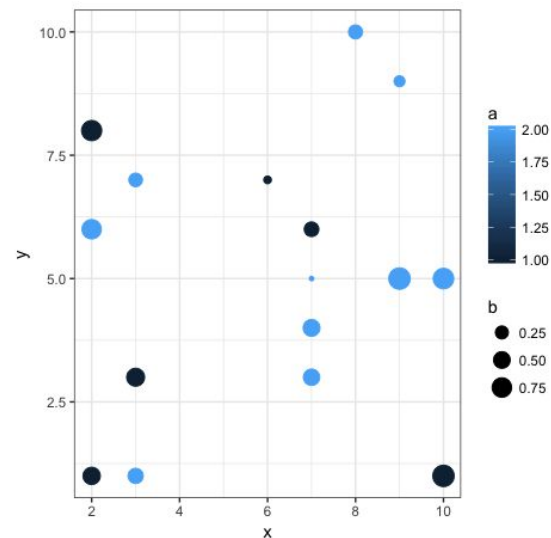
2 total data dimensions:
2-D position



3 total data dimensions:
2-D position +
'a' data dimension



4 total data dimensions:
2-D position +
'a' + 'b' data dimensions



Scalars

Scalars

Scalars are data types that contains information about only magnitude.

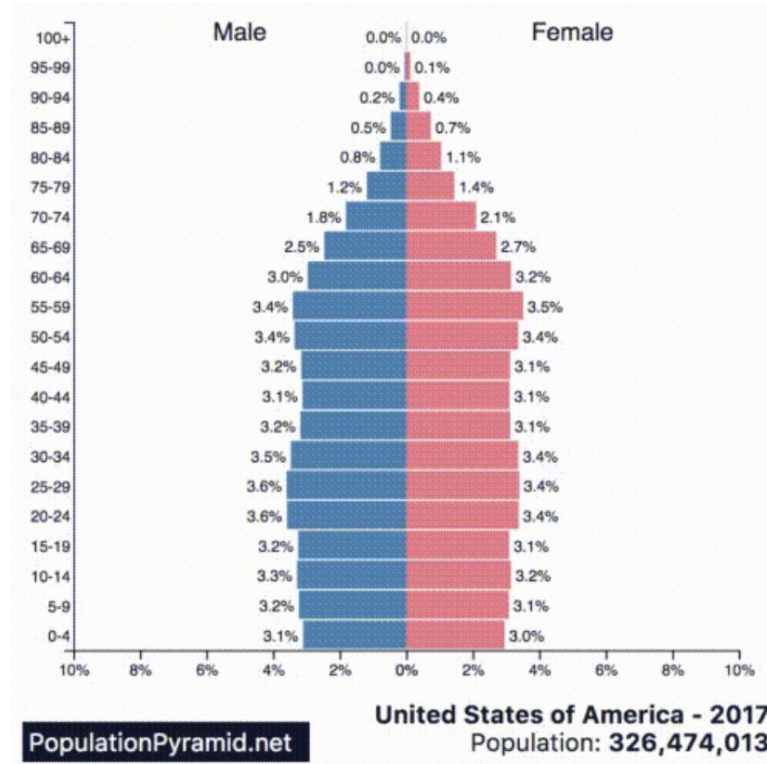
They are typically continuous variables.

A scalar quantity has a one-dimensional visual representation at each point in space.

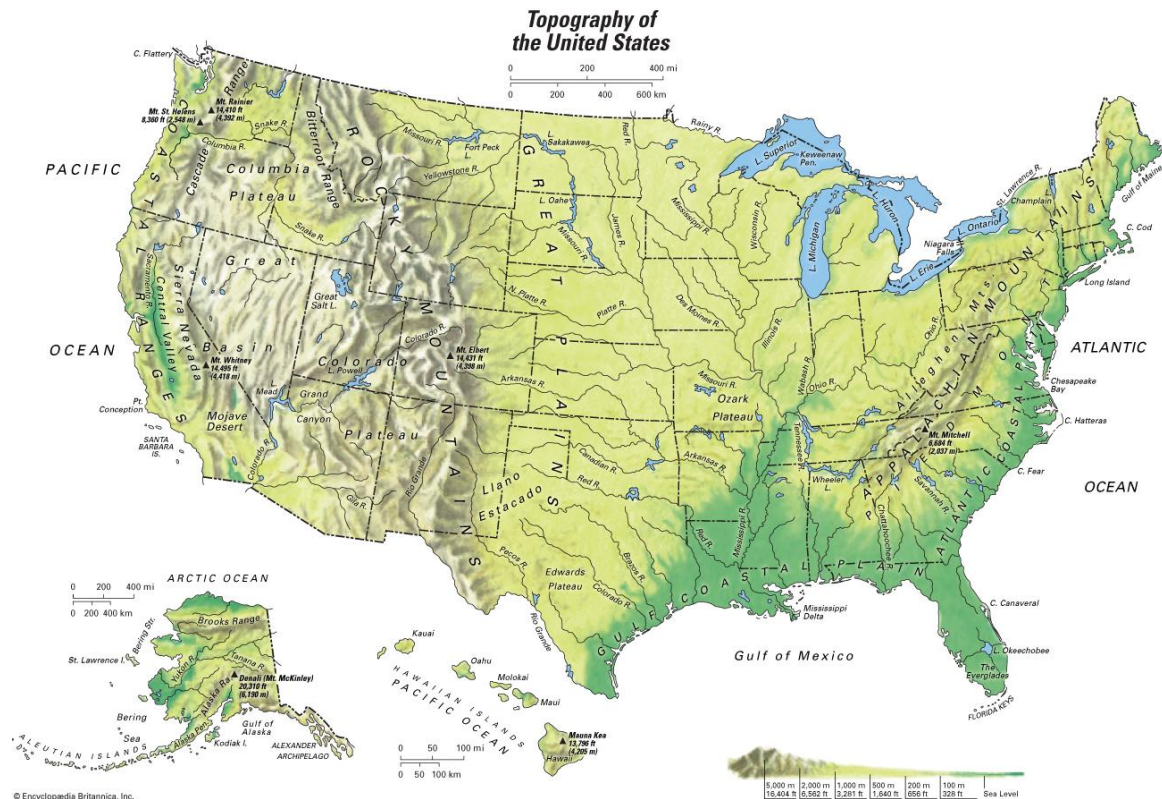
Examples of scalar data variables:

- Temperature
- Area
- Speed
- Density

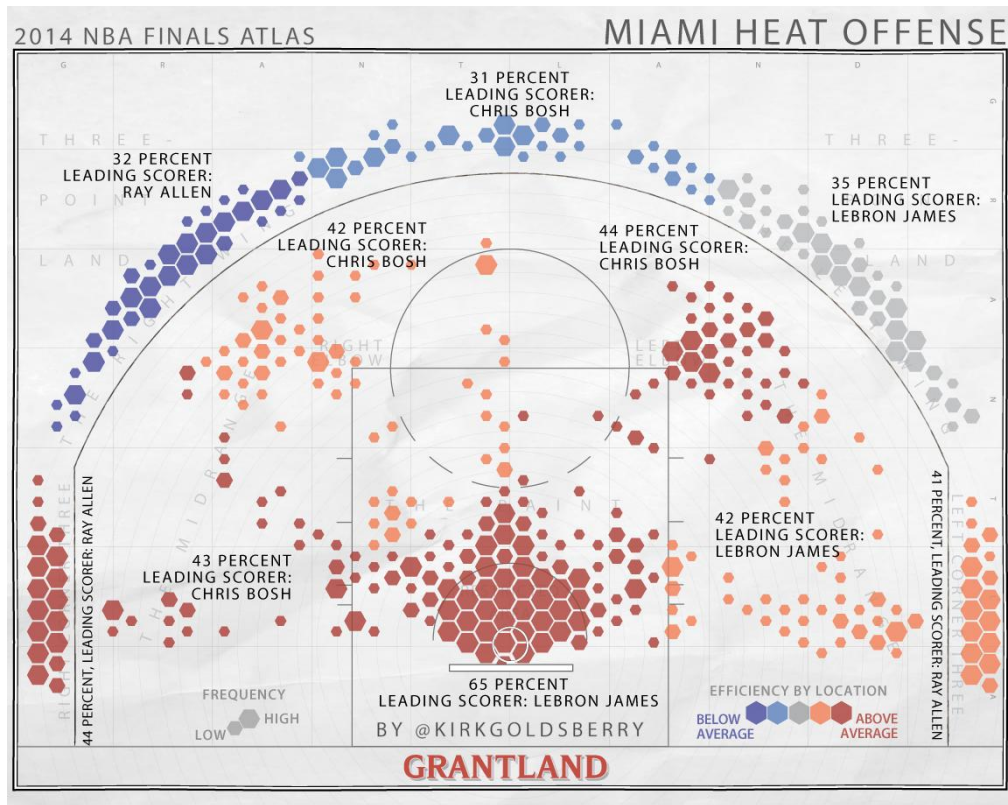
Scalars: Visual Examples



Scalars: Visual Examples



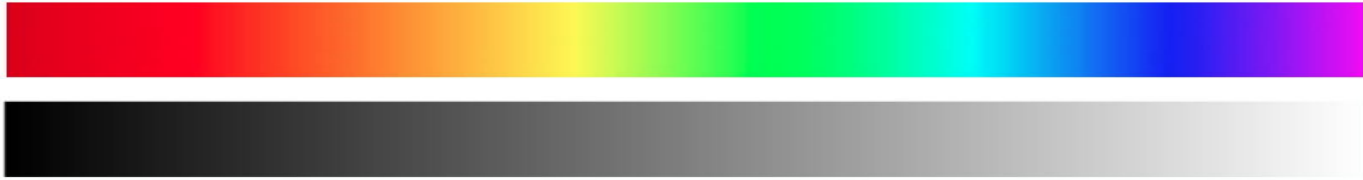
Scalars: Visual Examples



Scalars: Visual Variables Used

1. Color

- a. Hue
- b. Luminance



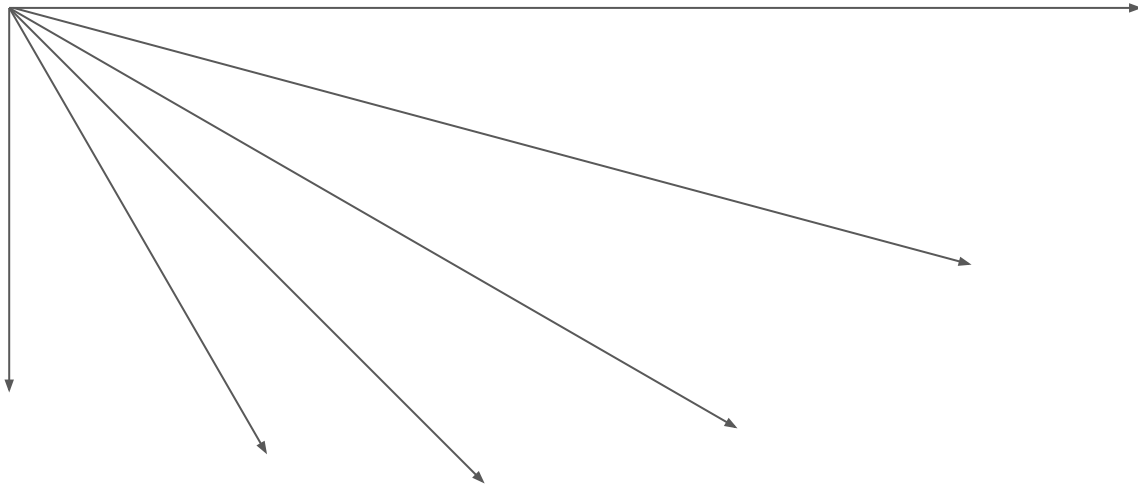
2. Size

- a. Area
- b. Length



Vectors

Vectors



Vectors

Vectors are data types that contains information about magnitude and direction.

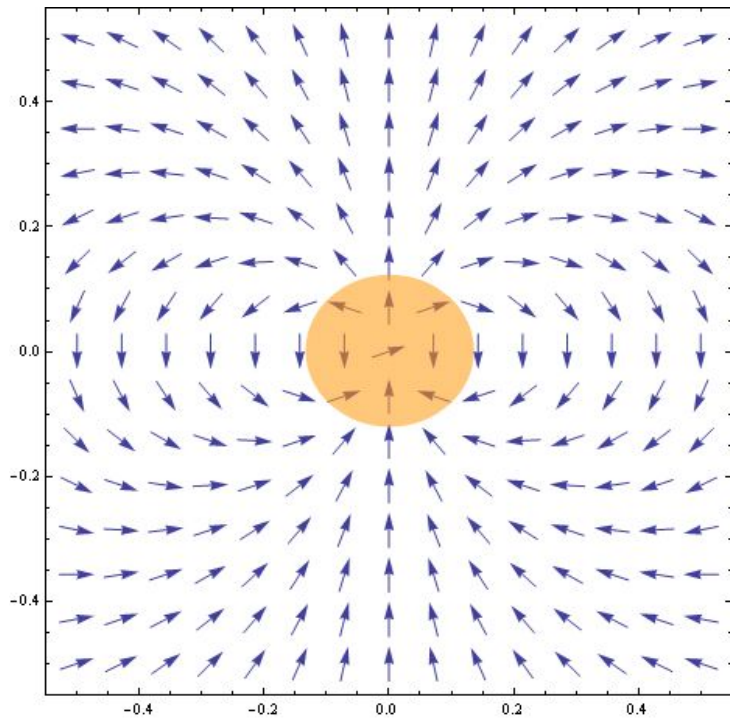
They are quantitative data types that are typically continuous variables.

A vector quantity has a two-dimensional visual representation at each point in space.

Examples of vector data variables:

- Velocity (Speed + Direction)
- Force

Vectors: Visual Examples

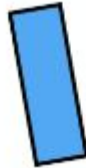


Vectors: Visual Examples

Wind Vector Map: <http://hint.fm/wind/>

Vectors: Visual Variables Used

1. Color
 - a. Hue
 - b. Luminance
2. Size
 - a. Area
 - b. Length
3. Orientation



Tensors

Tensors

Tensors are the generalized data object that scalars and vectors fit into.

Scalars: Rank 0 Tensors

Vectors: Rank 1 Tensors

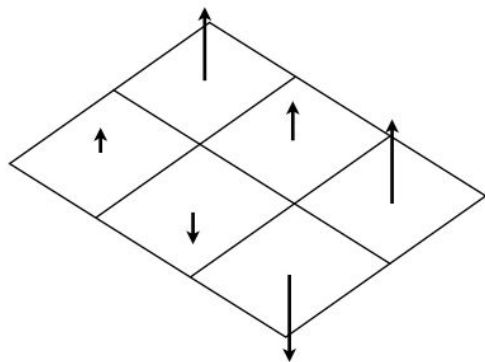
Matrices: Rank 2 Tensors

Higher-Dimensional Objects

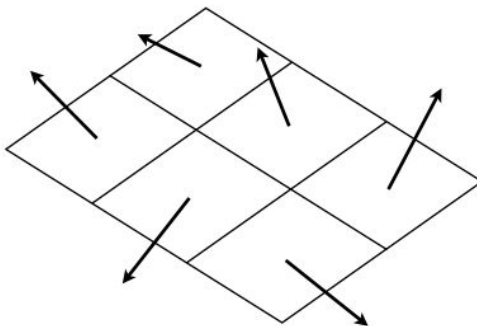
Typically in tensor visualization (non scalar/vector), a tensor quantity represents at least three dimensions at every point in space.

Tensors

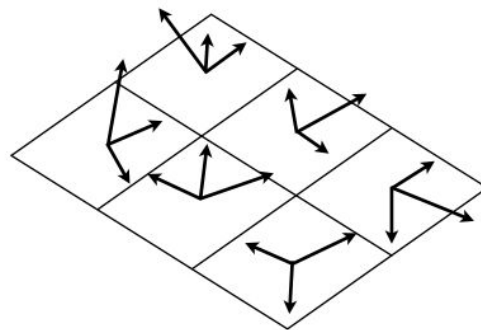
Scalar field



Vector field

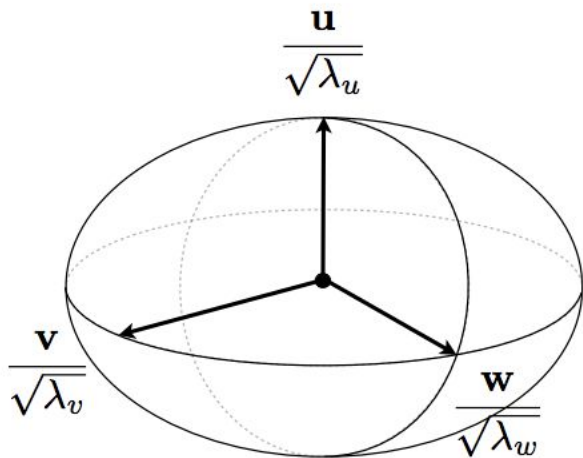


Tensor field (Rank 2)

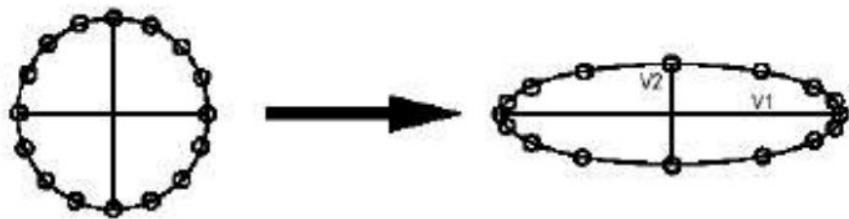


Tensors: 'Common' Visualization Methods

Ellipsoid Glyphs

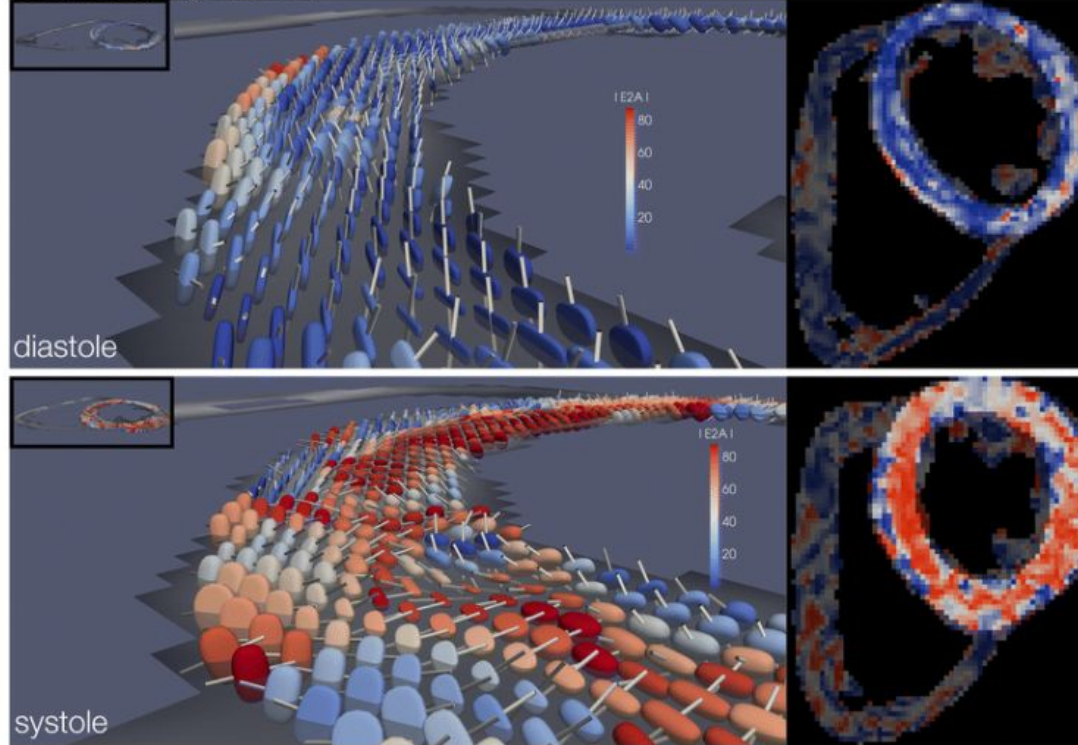


Hyperstreamlines

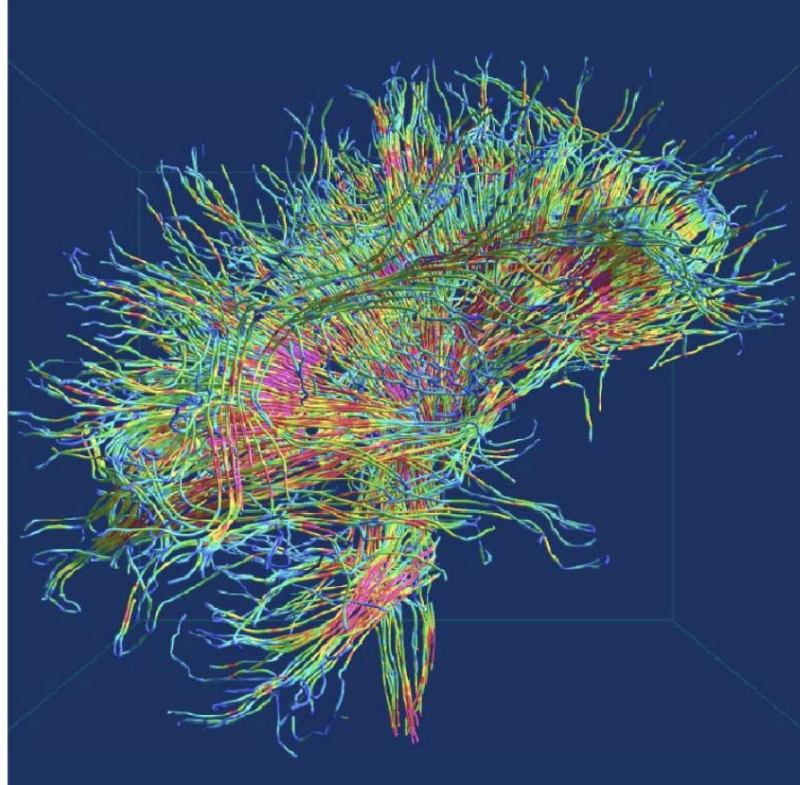


Tensors: Visual Examples (Ellipsoid Glyphs)

Secondary eigenvector



Tensors: Visual Examples (Hyperstreamlines)



Tensors: Visual Examples

<https://youtu.be/wvsE8jm1GzE?t=18s>

t-SNE in Python