Data Visualization & Design

Week 10

1. Visualizing **Scalars**, **Vectors**, & **Tensors**
2. Studio: Building **Wind Vector Maps** in R

Scalars, vectors, and tensors refer to different types of **data objects in space**.

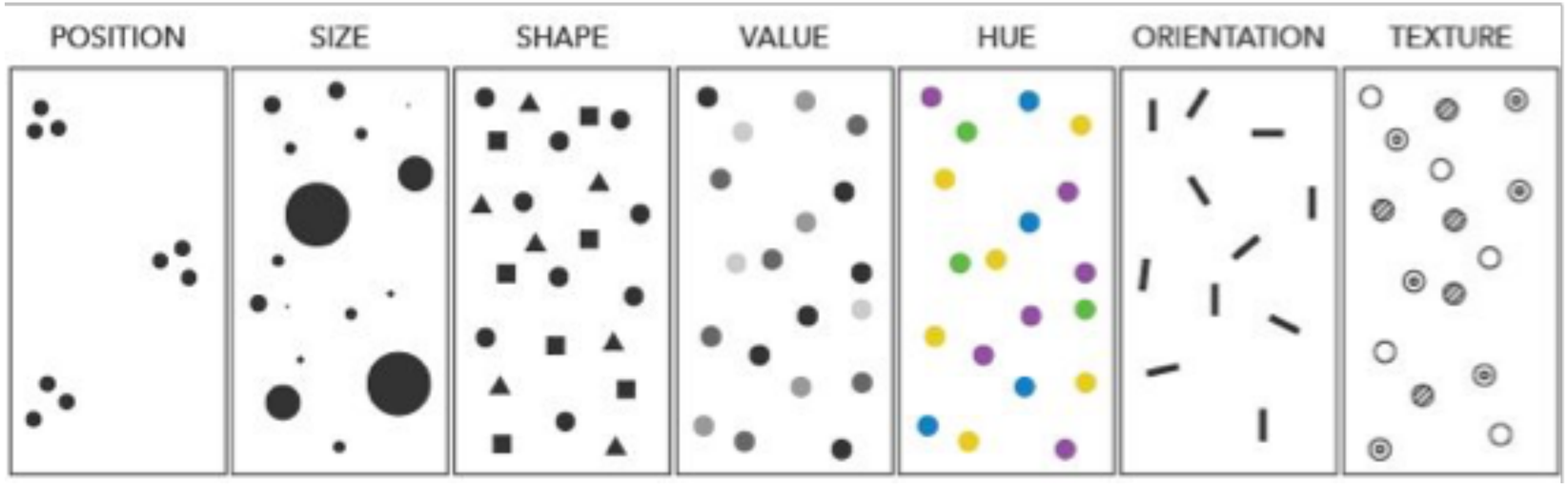
They contain data dimensions **in addition to position**.

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’d

- **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:



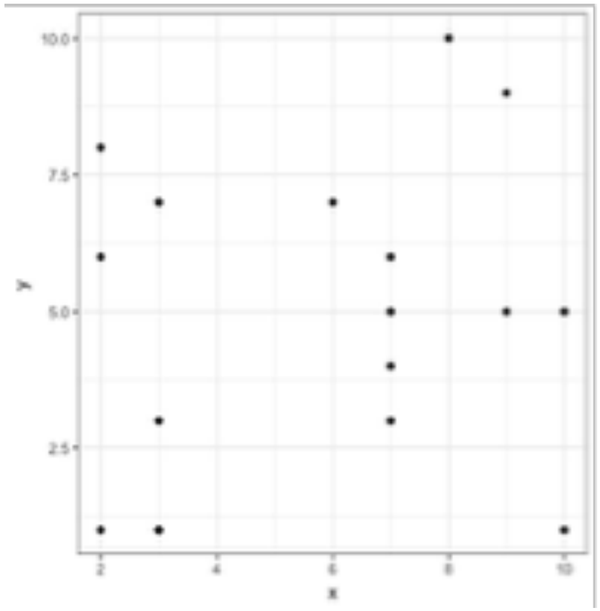
Data Objects can contain **n-dimensions** of information.

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)

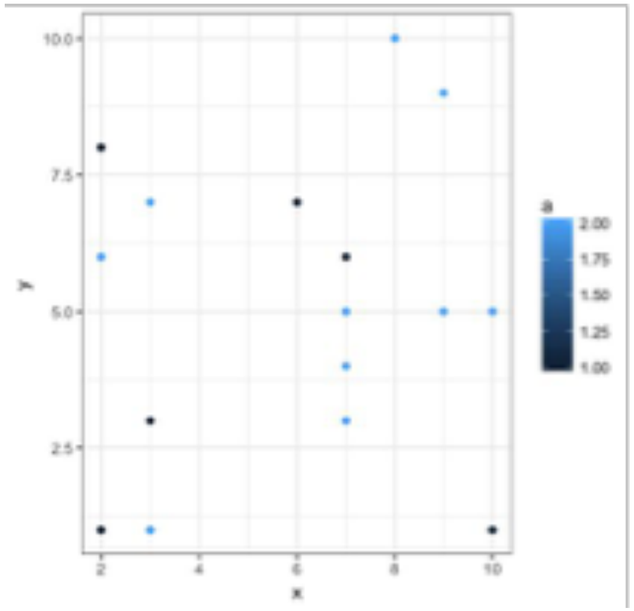
Each point may contain **extra dimensions of information**, in addition to its position.

Data Objects in 2-D Space

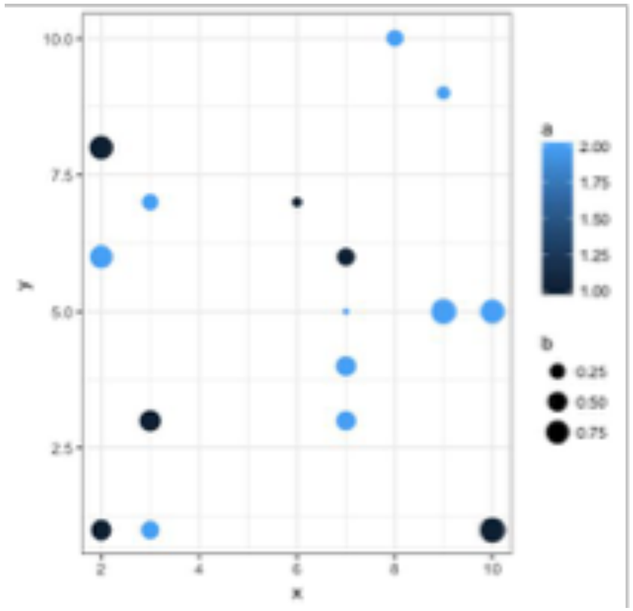
- **2** total data dimensions
- **2-D** position



- **3** total data dimensions
- **2-D** position
- ‘a’ data dimension



- **4** total data dimensions
- **2-D** position
- ‘a’ + ‘b’ data dimensions



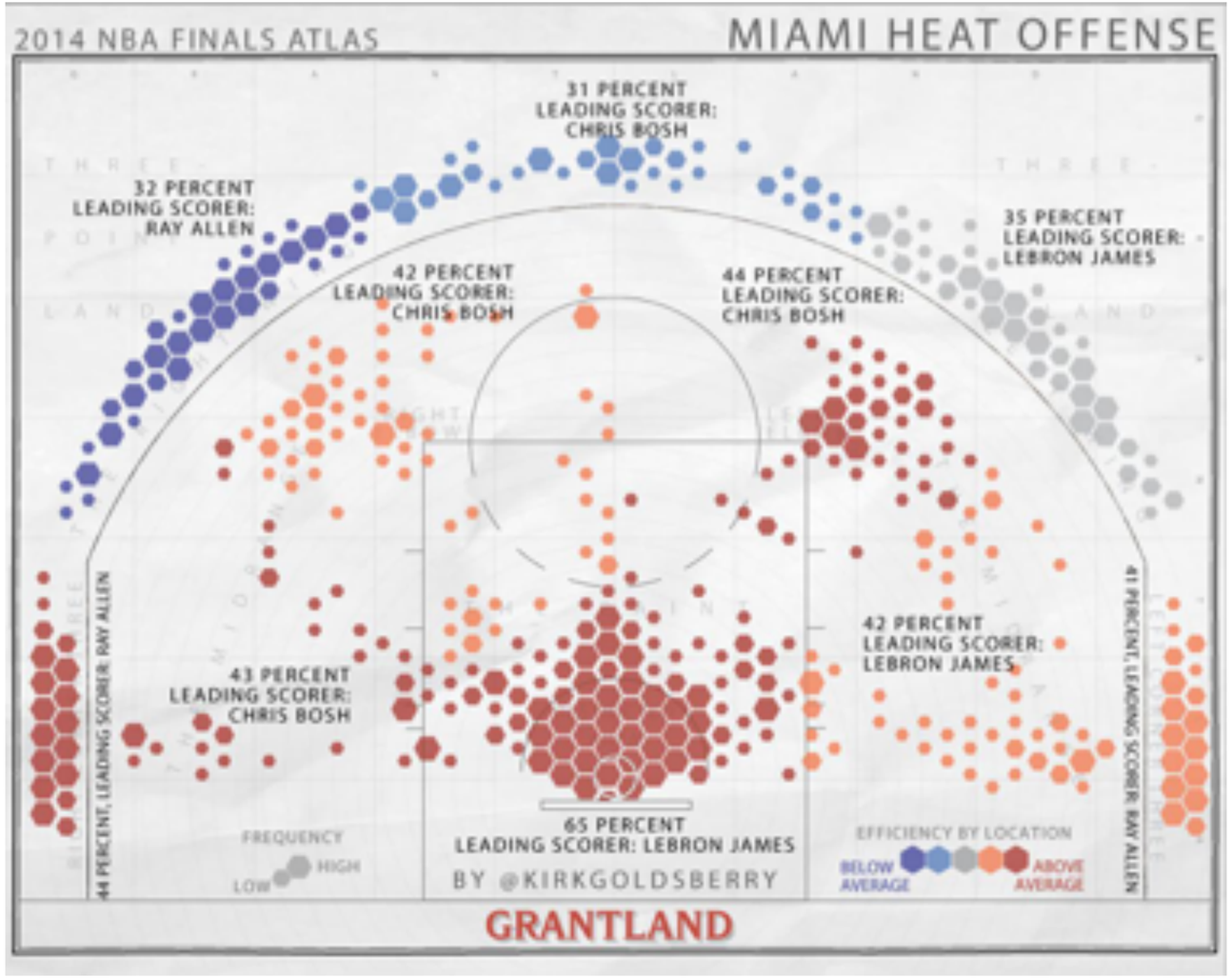
A closer look: **Scalars**

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**

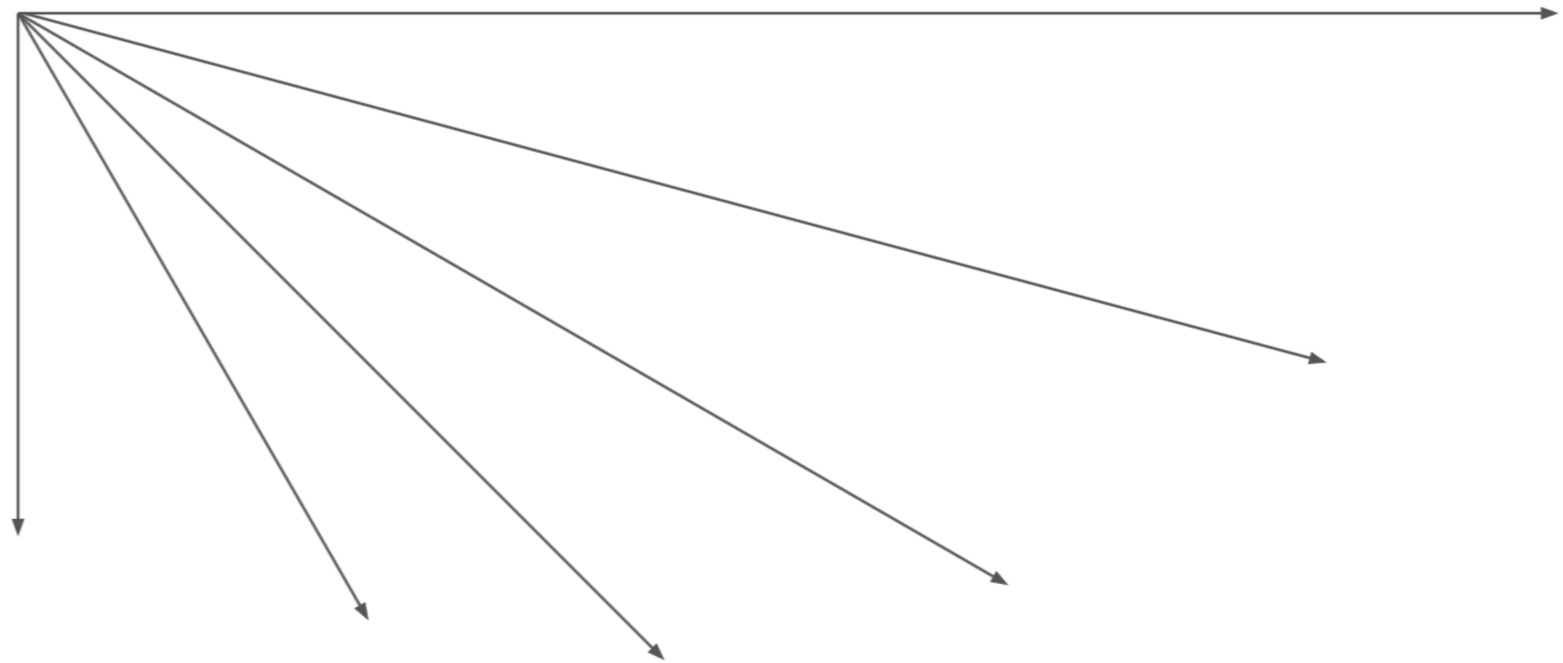


Scalars: **Visual Variables**

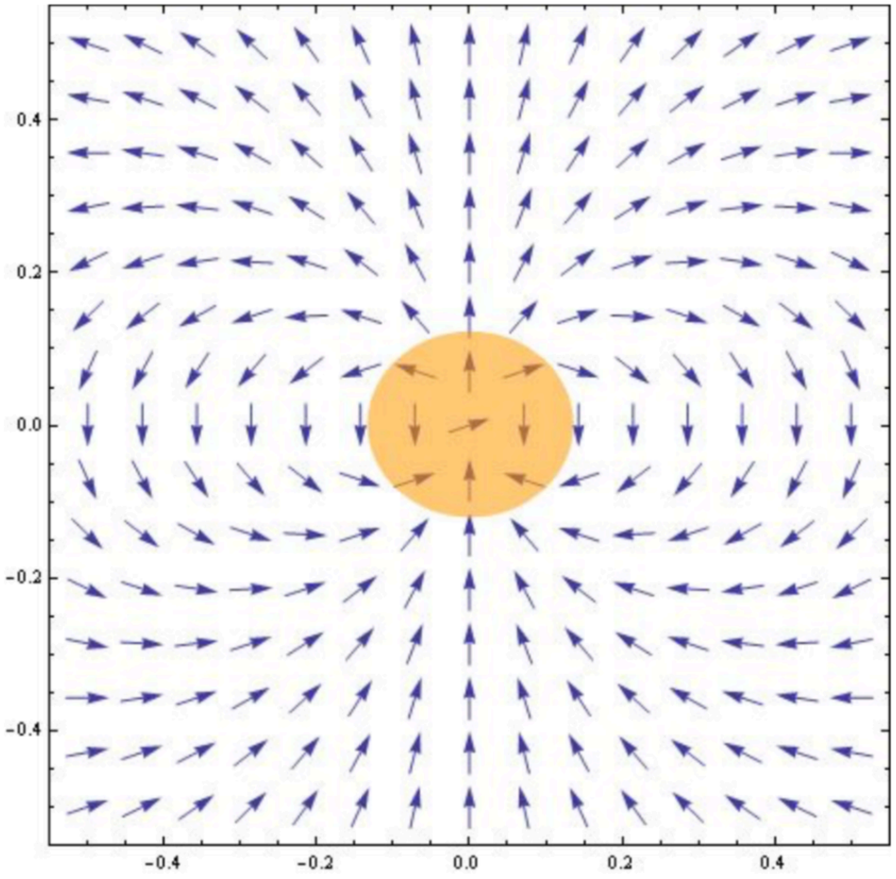
- Color
- Size
- Area
- Length

A closer look: **Vectors**

Vectors



Vectors: **Visual Examples**



Vectors: **Visual Examples**

http://hint.fm/wind/

Vectors: **Visual Variables**

- Color
- Size
- Orientation

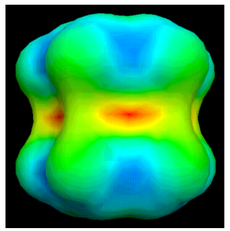
A closer look: **Tensors**

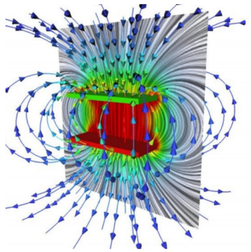
Scalars and vectors are both considered **tensors**.

What is a tensor?

- A tensor is a data of rank *k* defined in n-dimensional space
  - **Rank 0:** Scalar
  - **Rank 1:** Vector
  - **Rank 2:** Matrix
  - **Rank 3:** 3-D Array
- A tensor of rank *k* requires 3^k numbers

Visual variables per data type

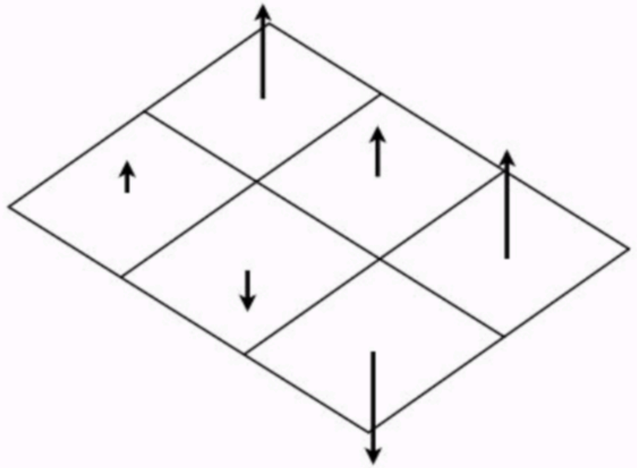




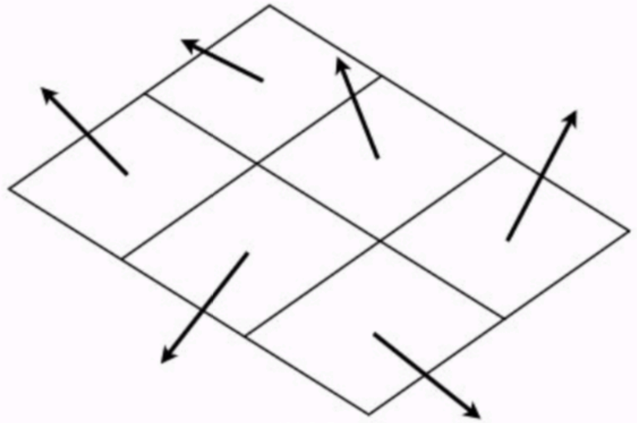
- **Scalar:**
  - Color mapping
  - Contouring
- **Vector:**
  - Lines, glyphs, streams
- **Tensor:**
  - Complex problem; active area of research

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

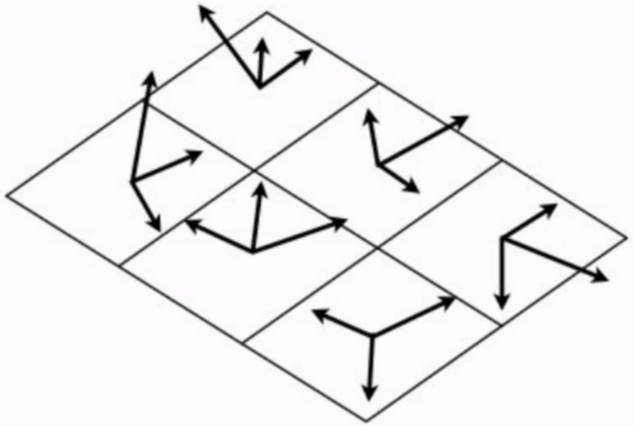
Scalar field



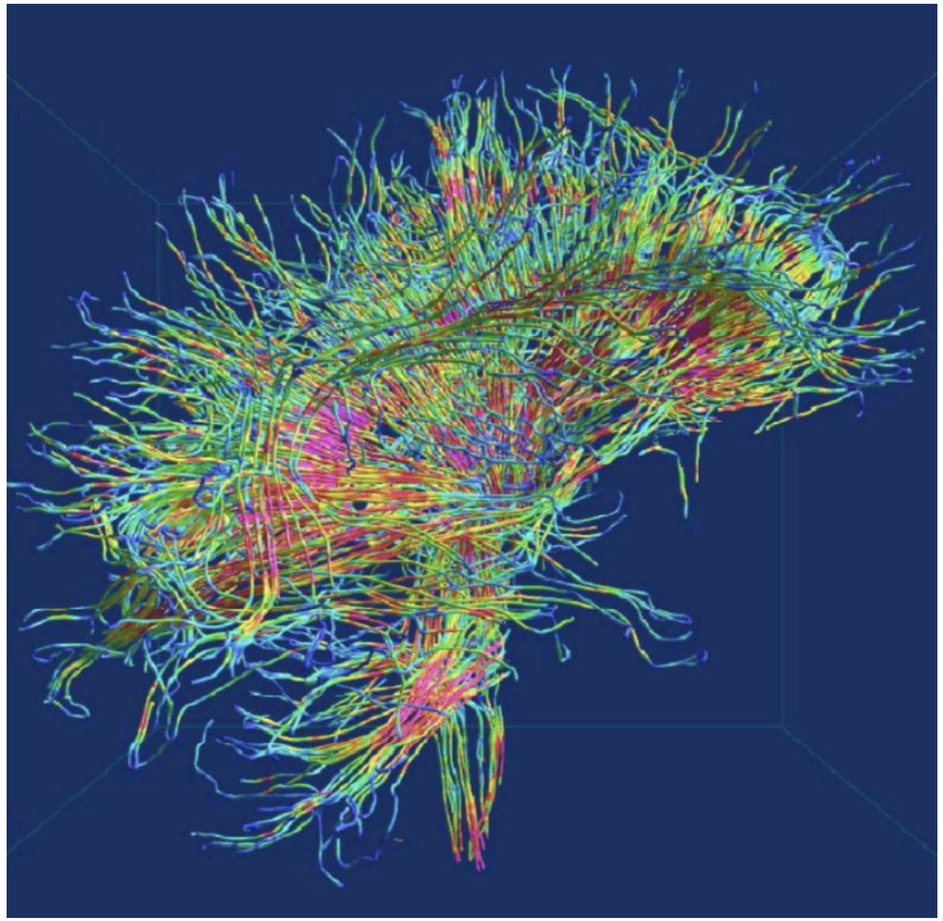
Vector field



Tensor field (Rank 2)



Tensors: **Visual Examples**



Tensors: **Visual Examples**

https://www.youtube.com/watch?v=wvsE8jm1GzE&feature=youtu.be&t=18s

https://github.com/emilyfuhrman/datavis_design/blob/master/2018_Fall/Studios/05_Building_Wind_Vector_Maps_in_R.md