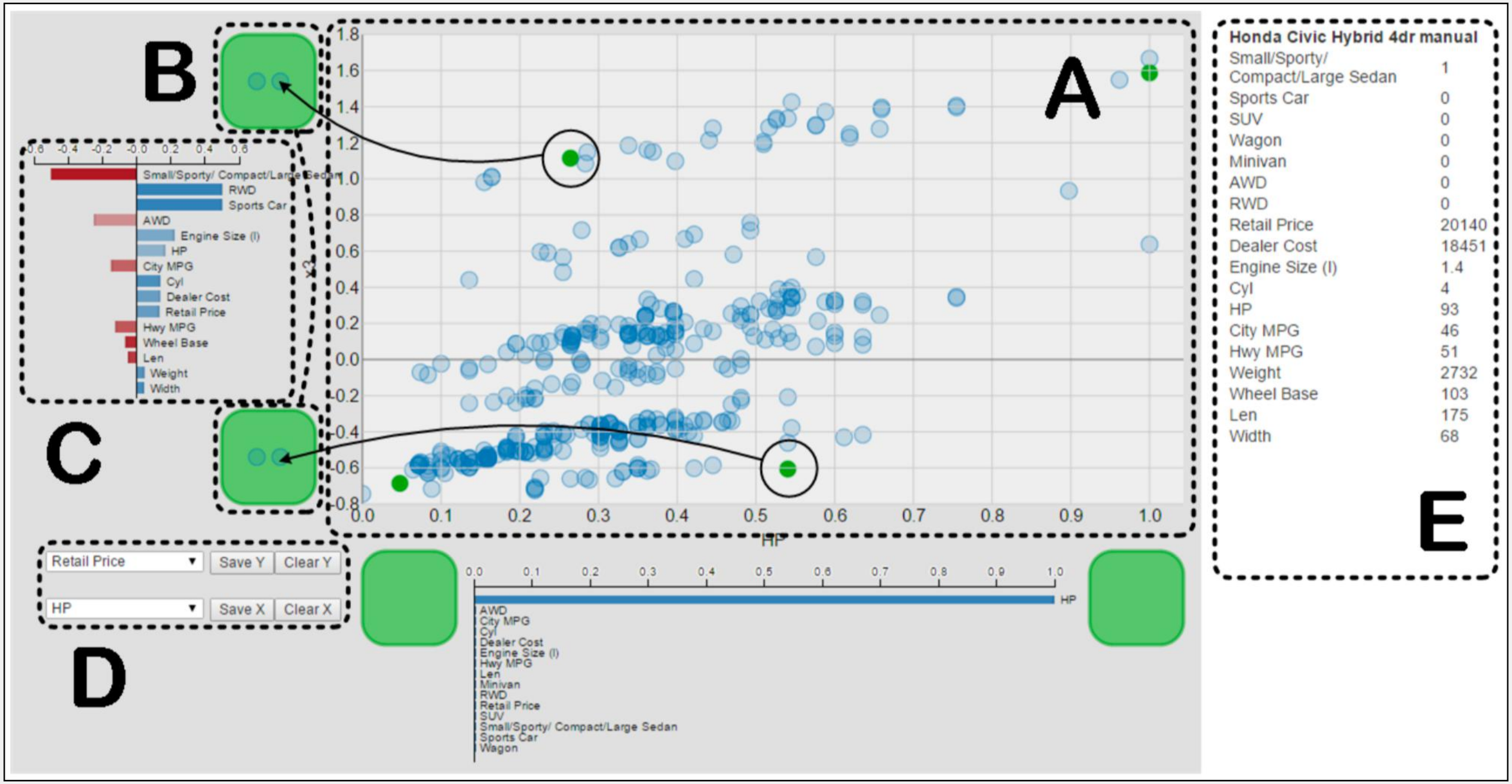
# InterAxis

**[Kim et al. 2015]**

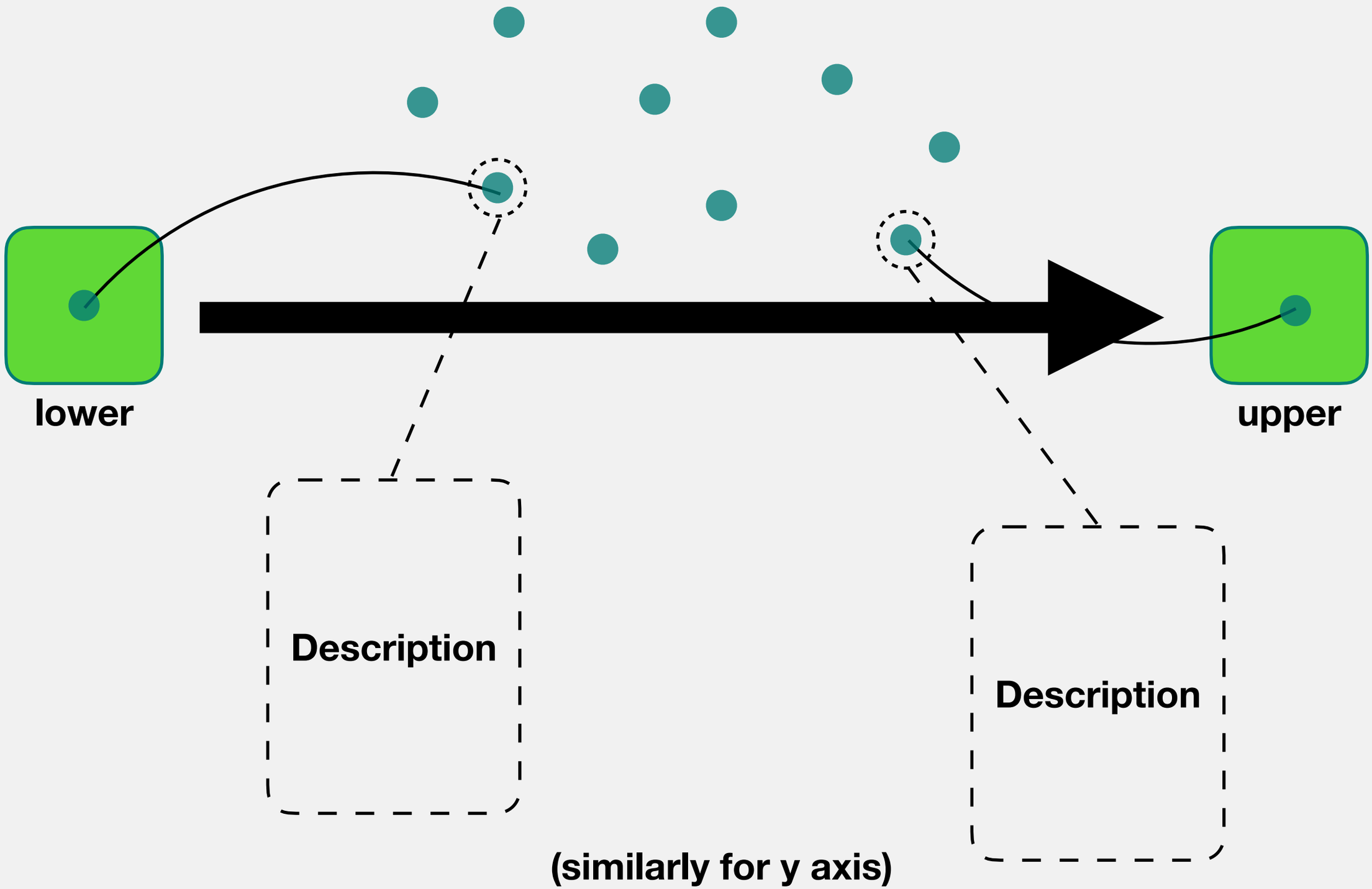
- Treat the **axes** in a 2D scatterplot as the main objects of interest, objects of modification

- Attribute-level *and* item-level direct manipulation to form axes

# InterAxis: Visualization Design



# Interactively Constructing Axes



# Axis Representation

- Simply a vector (in the original data space)

$$T_x = \frac{1}{n_{x,u}} \sum_{i=1}^{n_{x,u}} a_i^{x,u} - \frac{1}{n_{x,l}} \sum_{i=1}^{n_{x,l}} a_i^{x,l}$$

upper

lower

**(vector is subsequently normalized)**

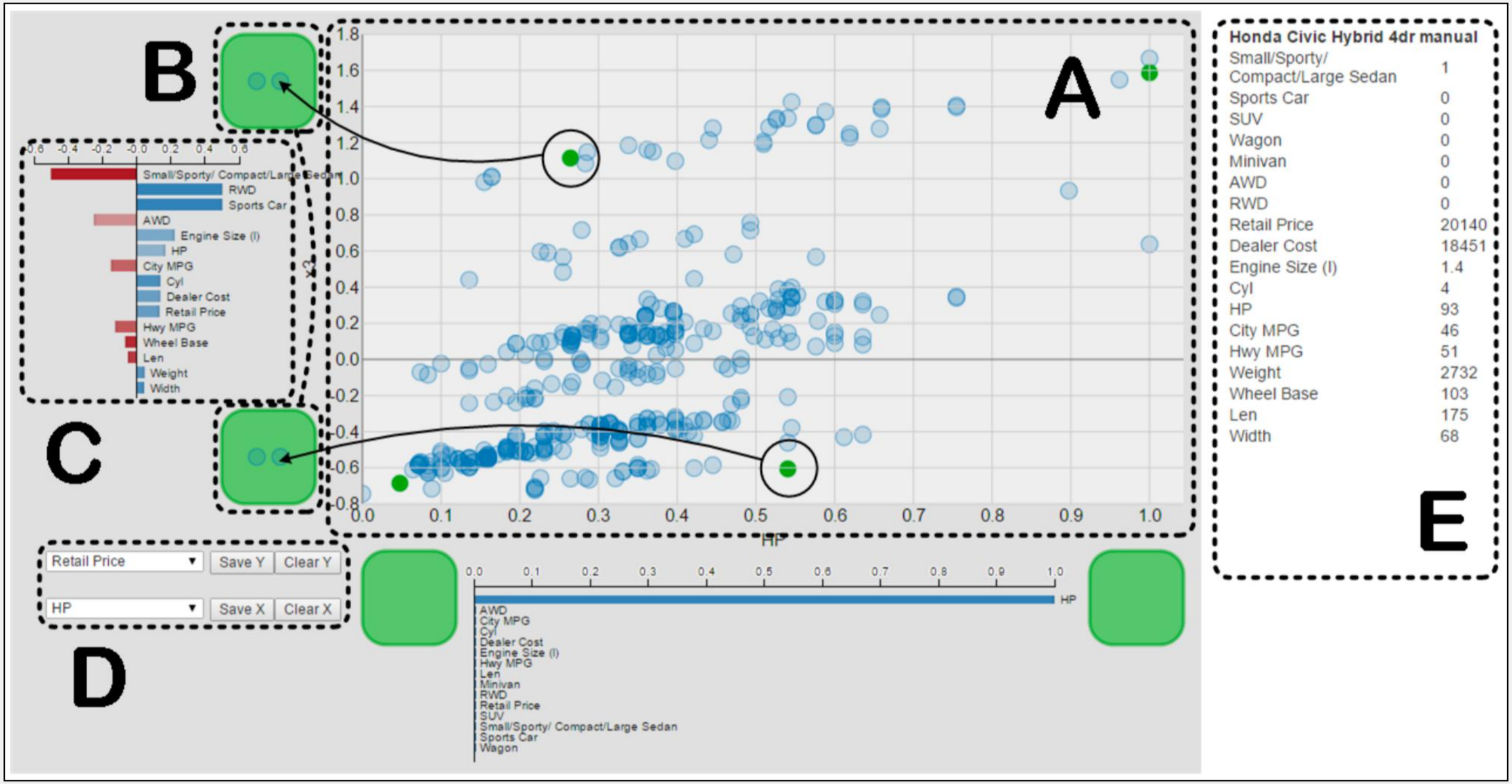
# Data Projection

- The x and y vectors, corresponding to the axes, subsequently form a 2D linear subspace: **projection**

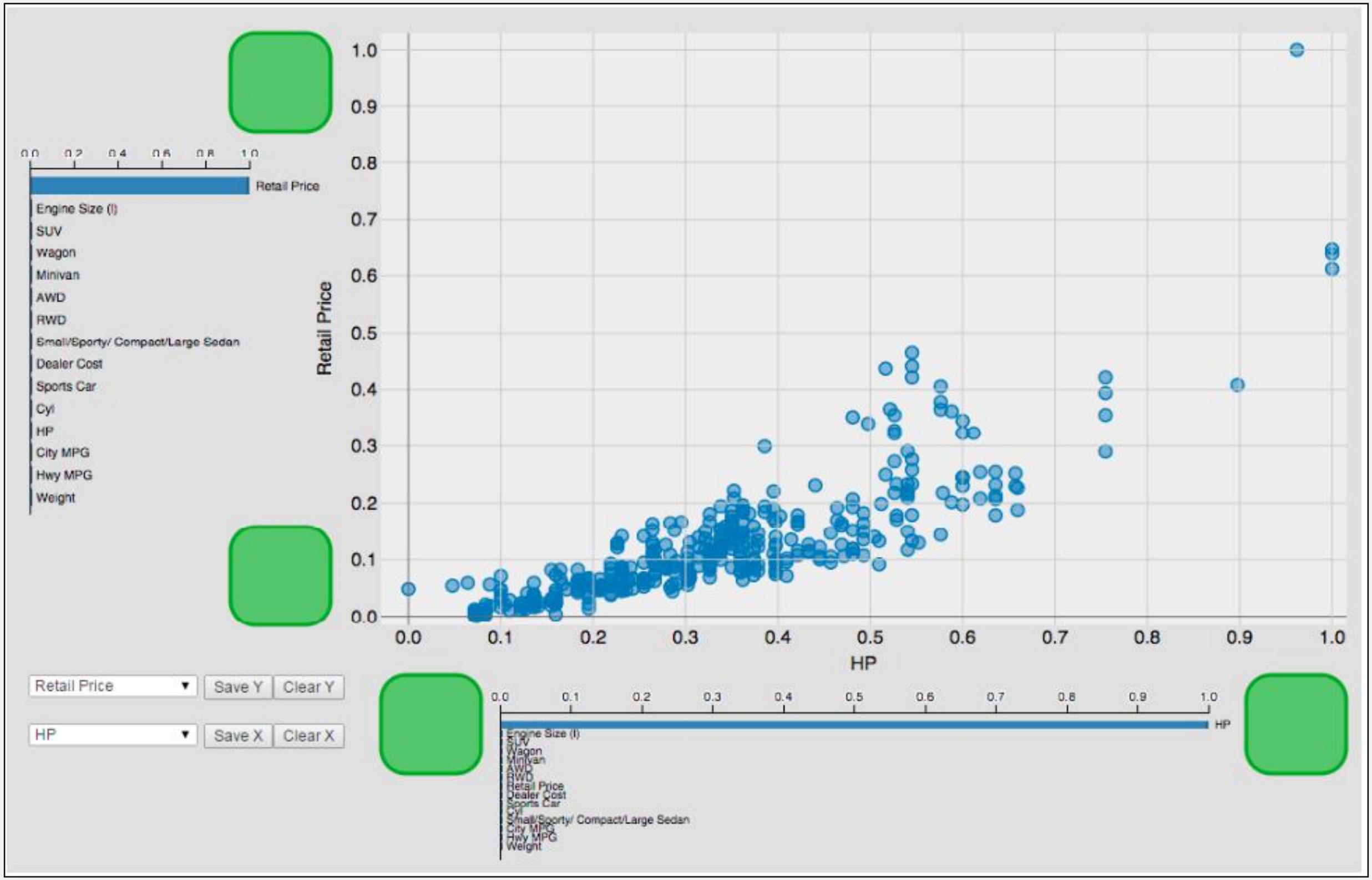
$$\left( (T_x)^T a_i, (T_y)^T a_i \right)$$

- Questions:
  - What is the interpretation of this projection?
  - Suppose the selected data points for each axis had identical values in all dimensions, except for one (unique) dimension - what does that give us?

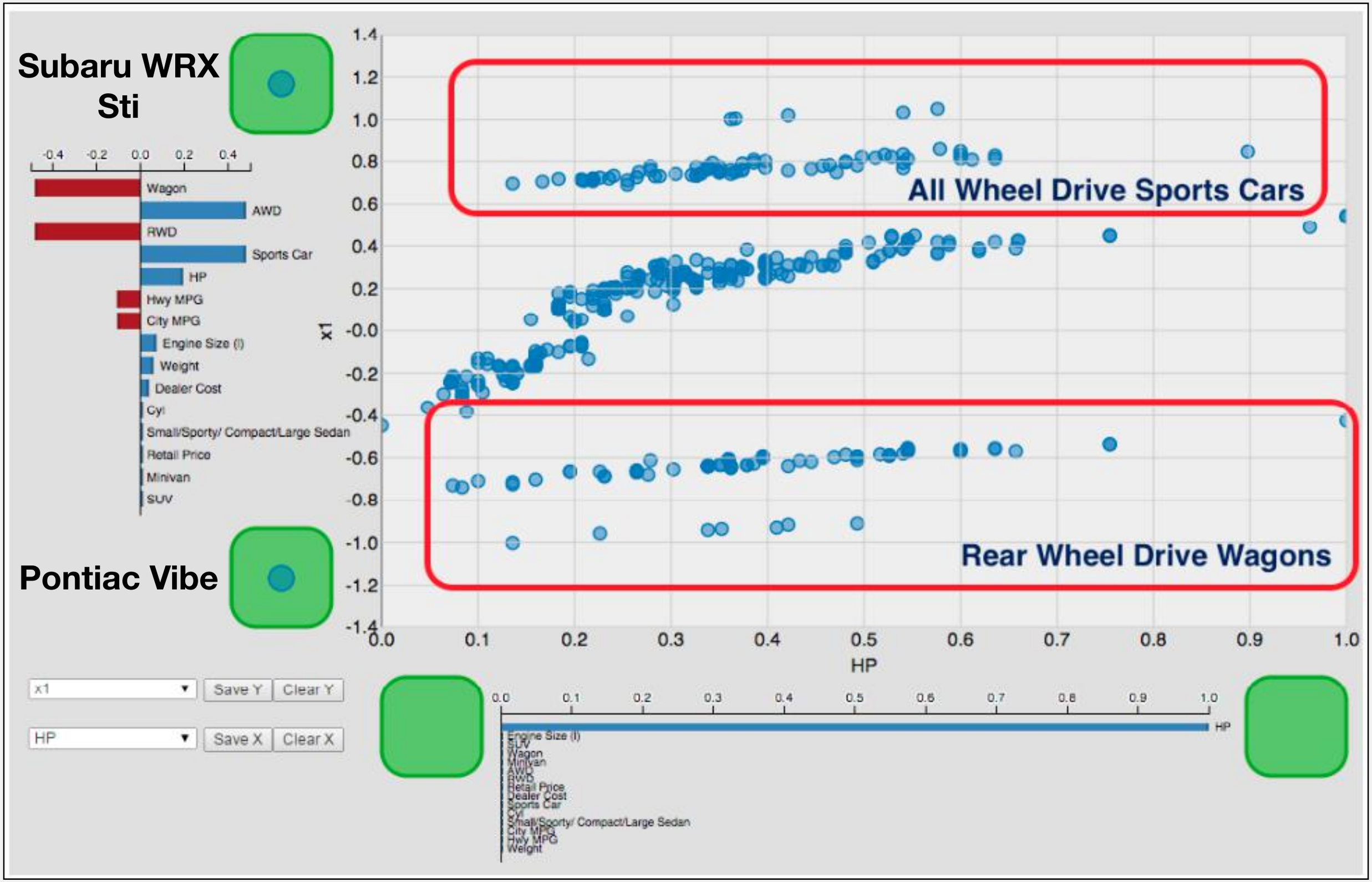
# InterAxis: Interface



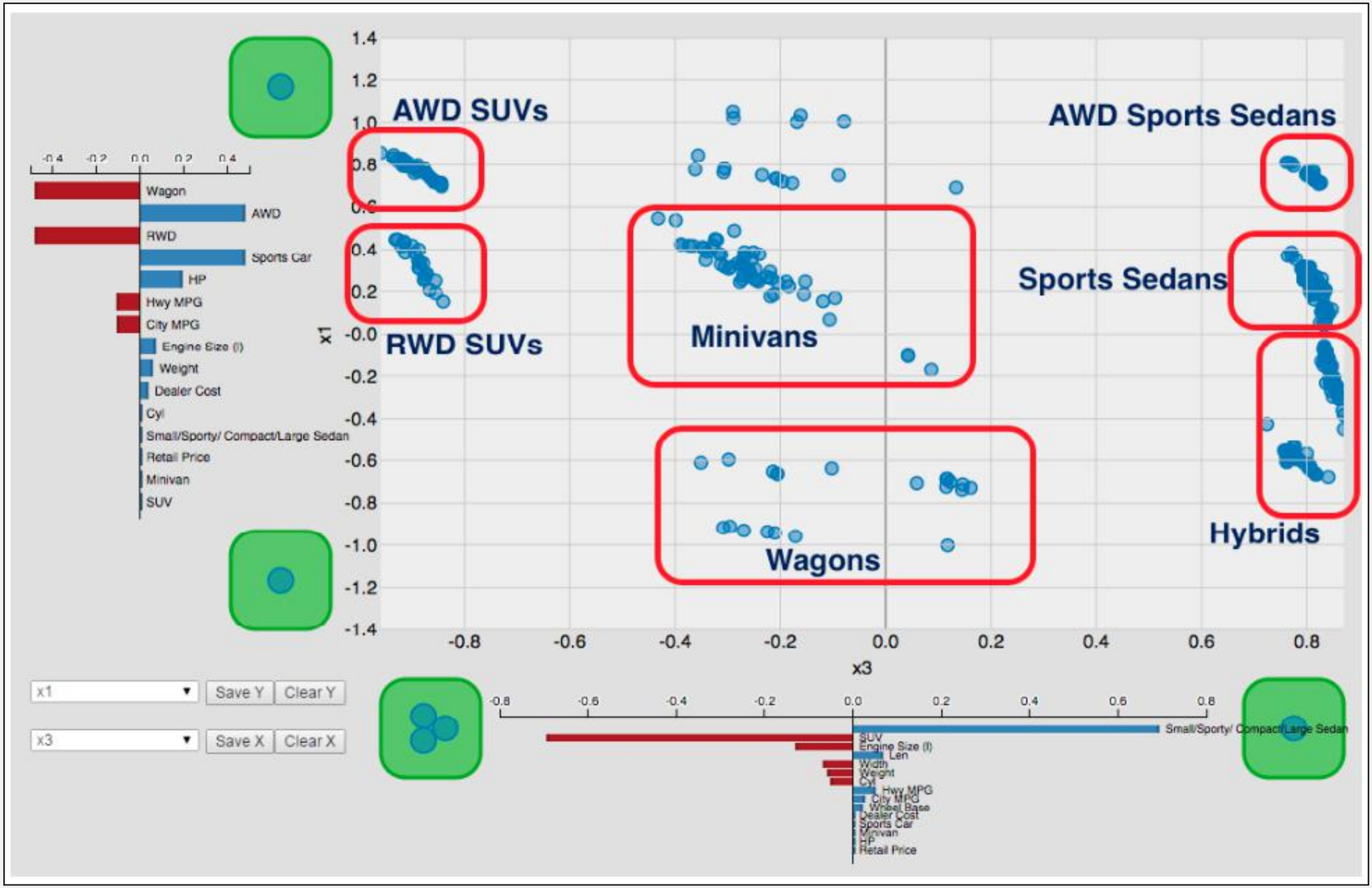
# InterAxis: Example



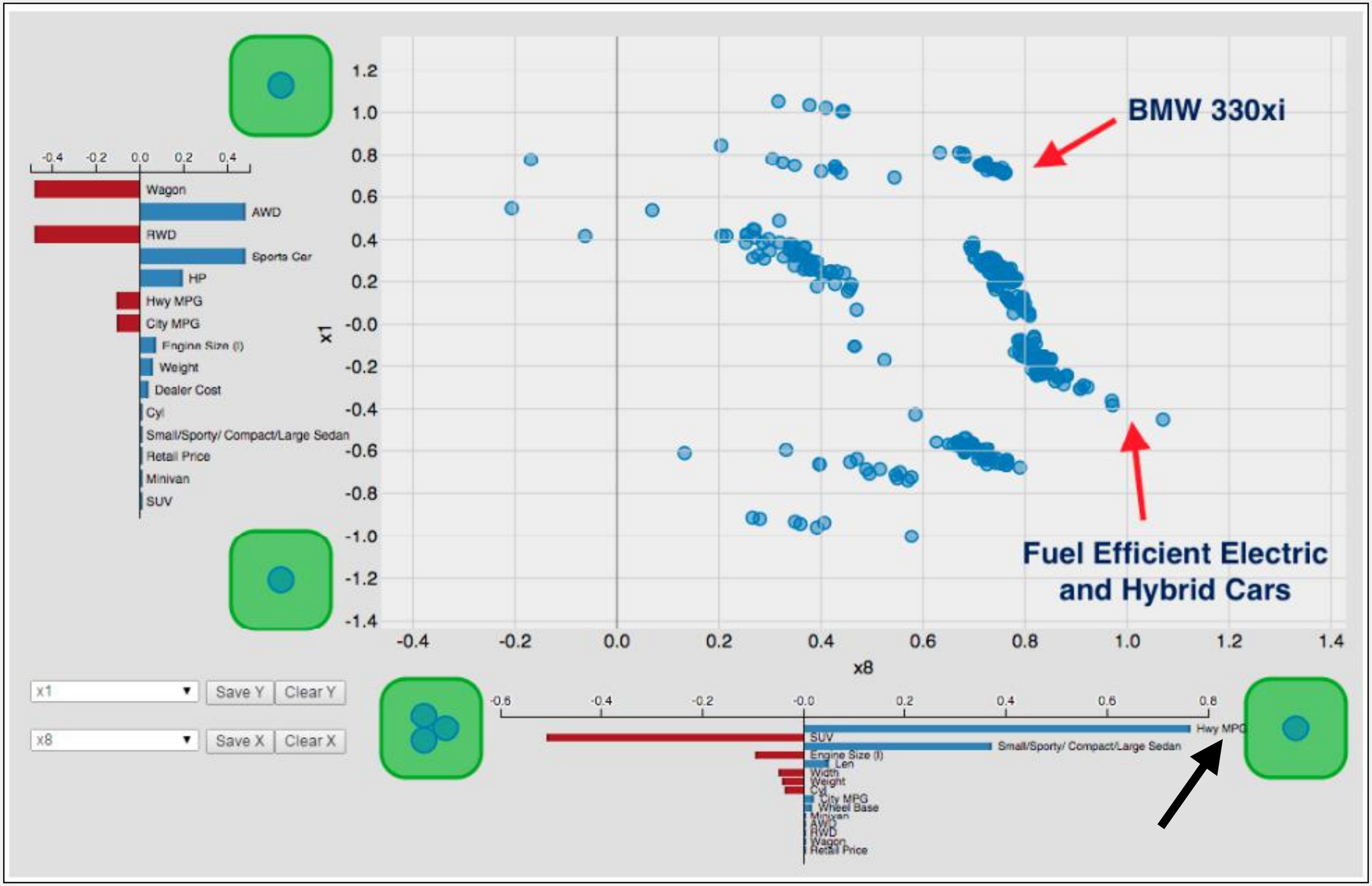
# InterAxis: Example



# InterAxis: Example



# InterAxis: Example



# InterAxis: Demo

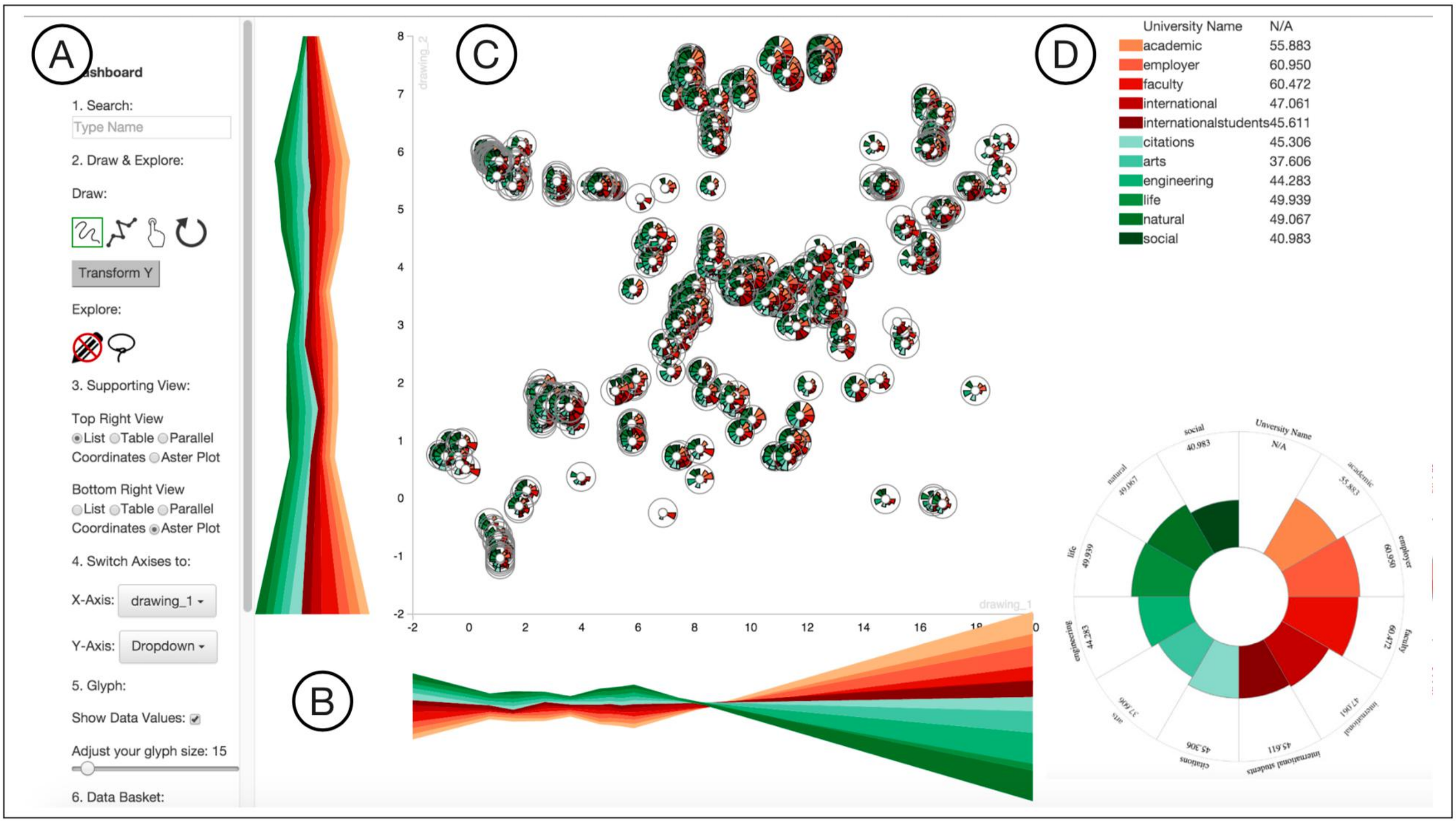
**http://va.gatech.edu/live-projects/interaxis/**

# InterAxis: Limitation

- Restricted to *linear projections*. This might not be an appropriate representation for certain datasets.
- How can we provide support for *nonlinear projections*?
- Problems to address:
  - How does a user express a nonlinear axis?
  - How do we project data onto the axis?

# AxiSketcher

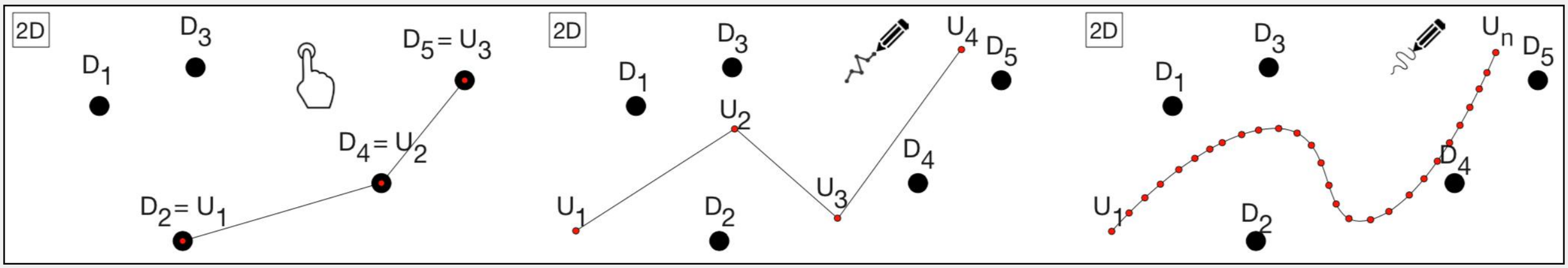
**[Kwon et al. 2016]**



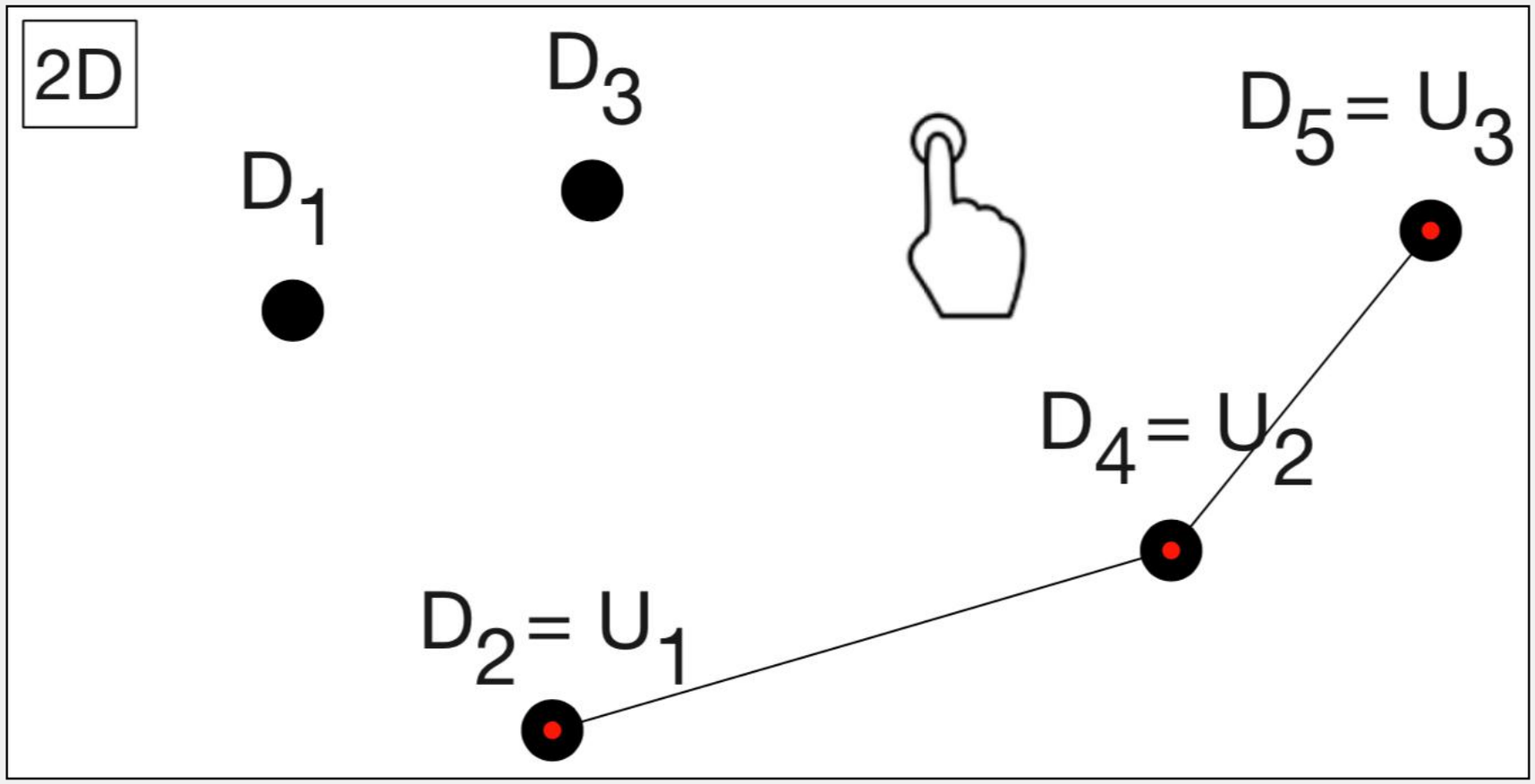
# Axes

- Each axis is backed by a **curve** defined in the original high-dimensional space.

- A curve is specified by a user directly sketching in the 2D domain.

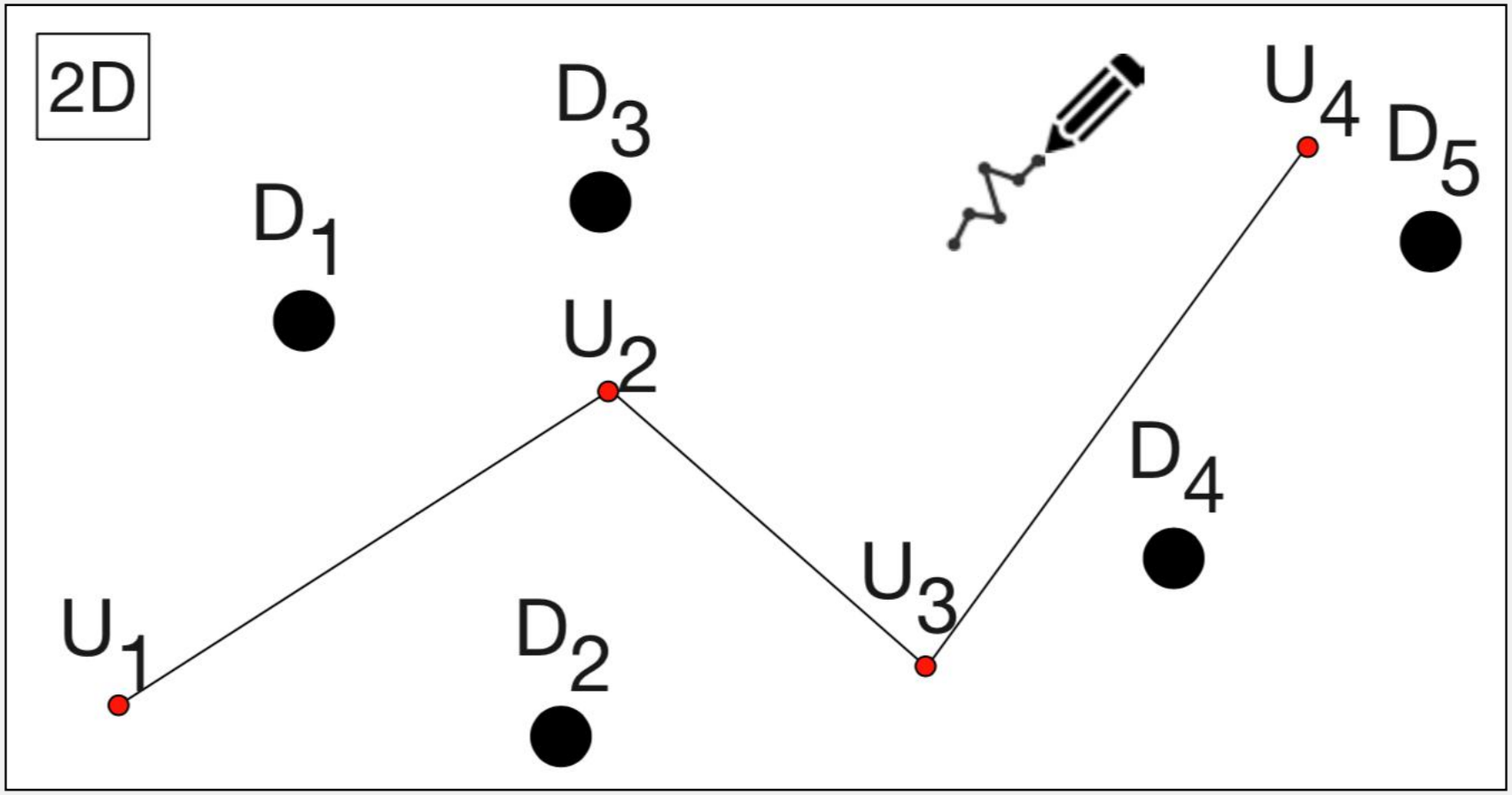


# Curve: Point Selection




- User selects a sequence of points: the sequence implicitly orders the points, giving us a poly-line in 2D, and the high-dimensional curve is taken via replacing 2D points with corresponding high-dimensional points.

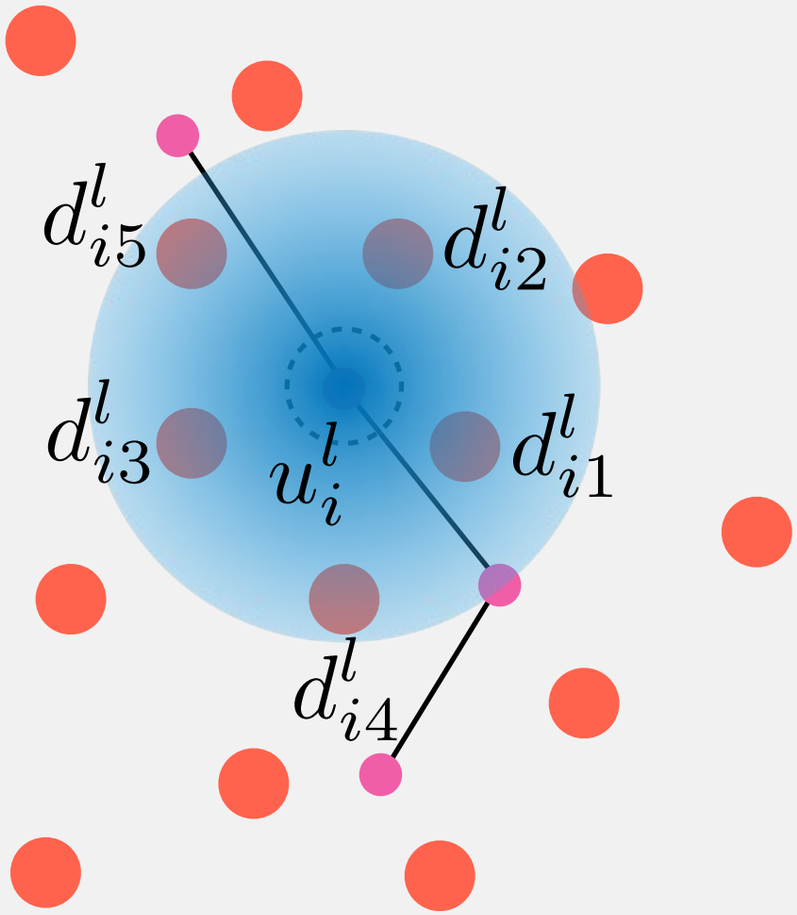
# Curve: Polyline Selection




- Free-form polyline sketch in 2D.

- Challenge: what should an arbitrary point in 2D correspond with in the high-dimensional space?

# Scattered Data Interpolation

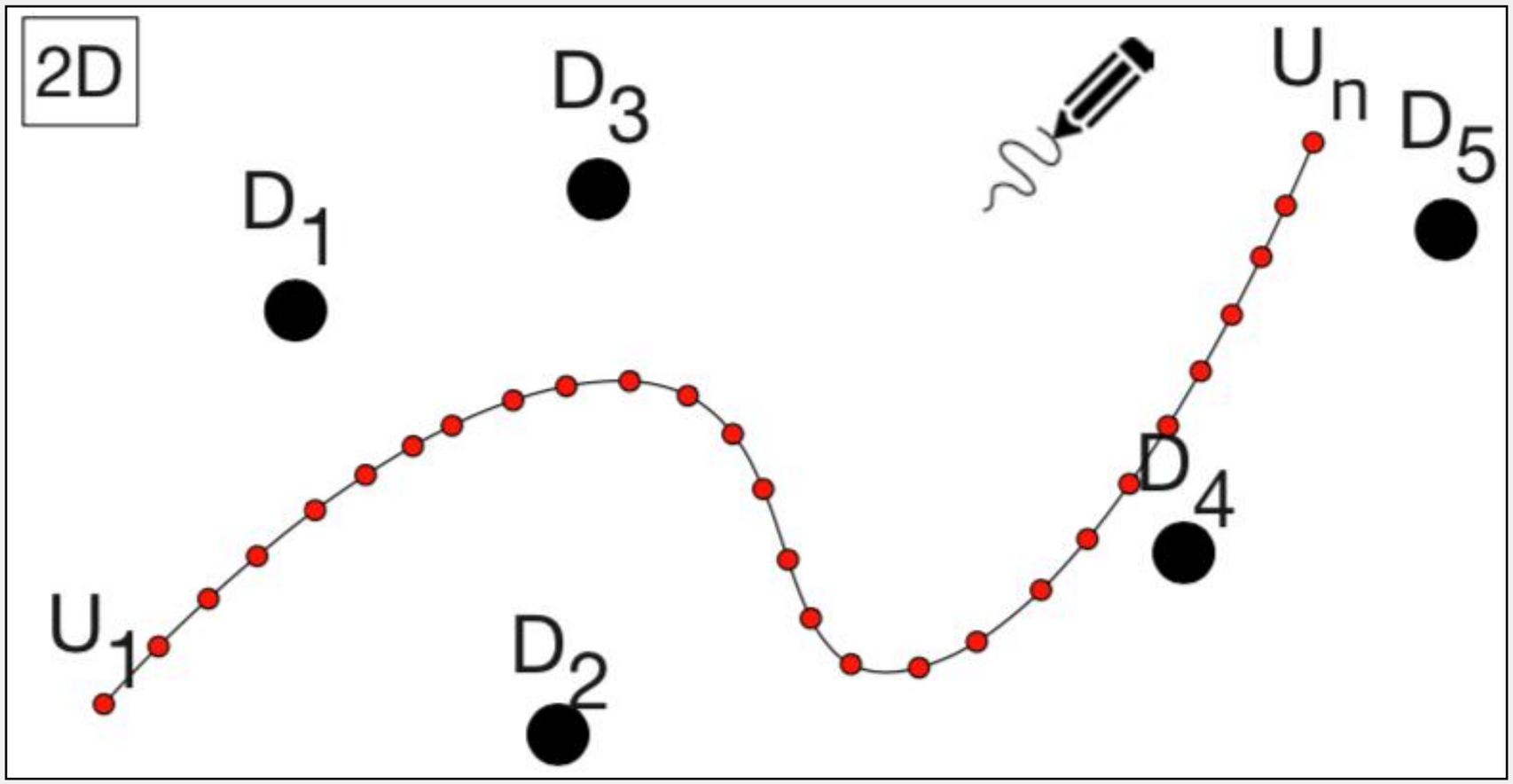



$$w_{ij} = \frac{1/\|u_i^l - d_{ij}^l\|^2}{\sum_{m=1}^{k} 1/\|u_i^l - d_{im}^l\|^2}$$

$$u_i^h = \sum_{j=1}^{k} w_{ij} d_{ij}^h$$

- Principal curve **[Hastie & Stuetzle 1989]** fit to produce a smoother curve (though not completely necessary).

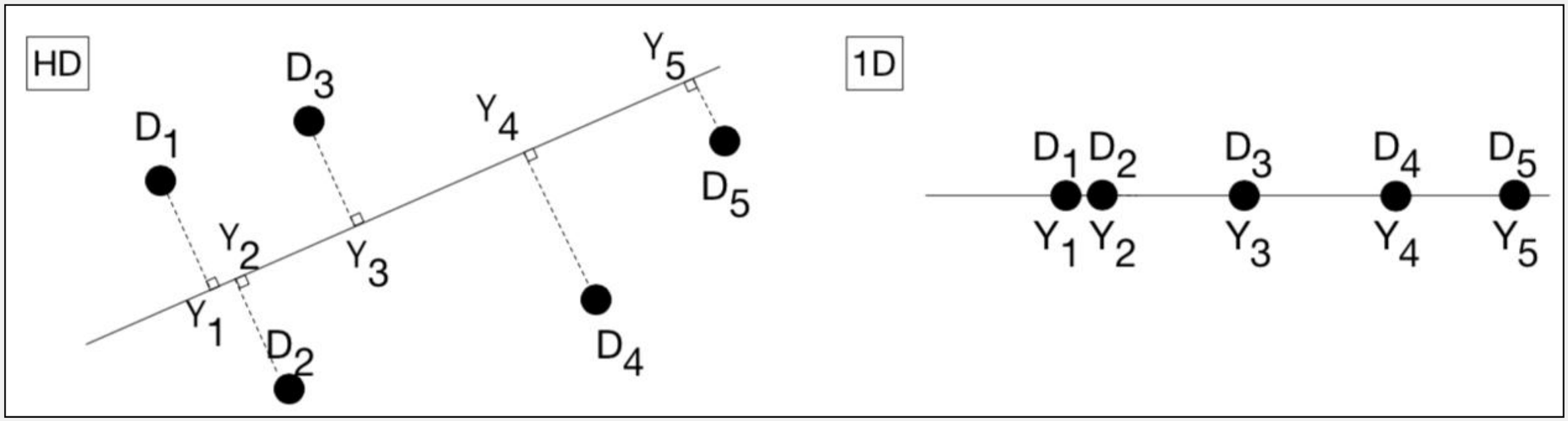
# Curve: Freeform Sketch




- Continuous curve sampled at uniform intervals.
- Process used for polylines applied to this sampled curve.

# Finding Projections

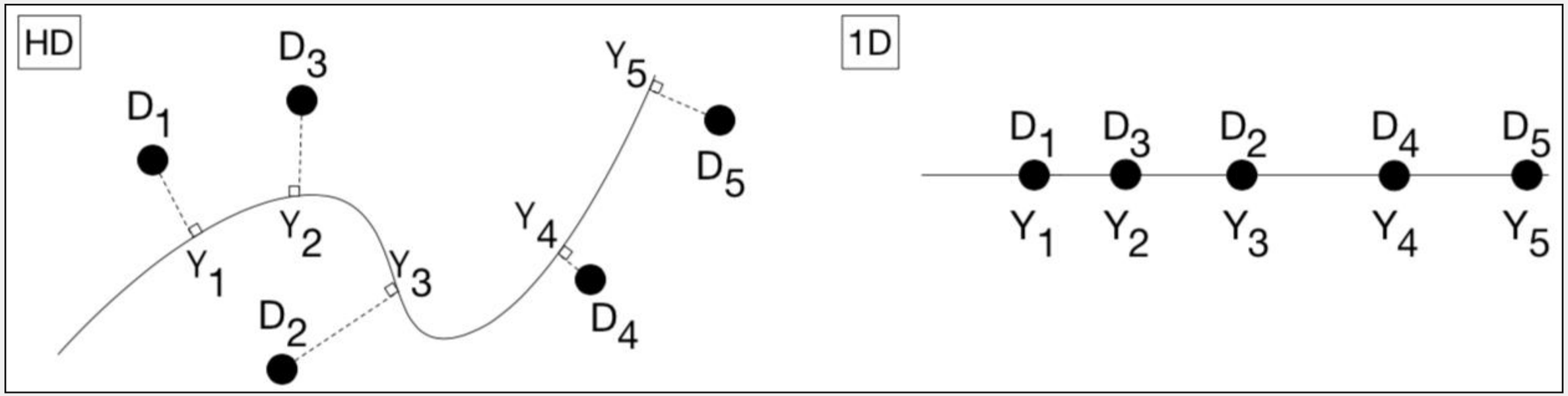
- Consider linear projection:




$$\hat{\mathbf{x}} = \mathbf{v}\underline{\mathbf{v}^T\mathbf{x}} \quad , \quad \|\mathbf{v}\| = 1$$

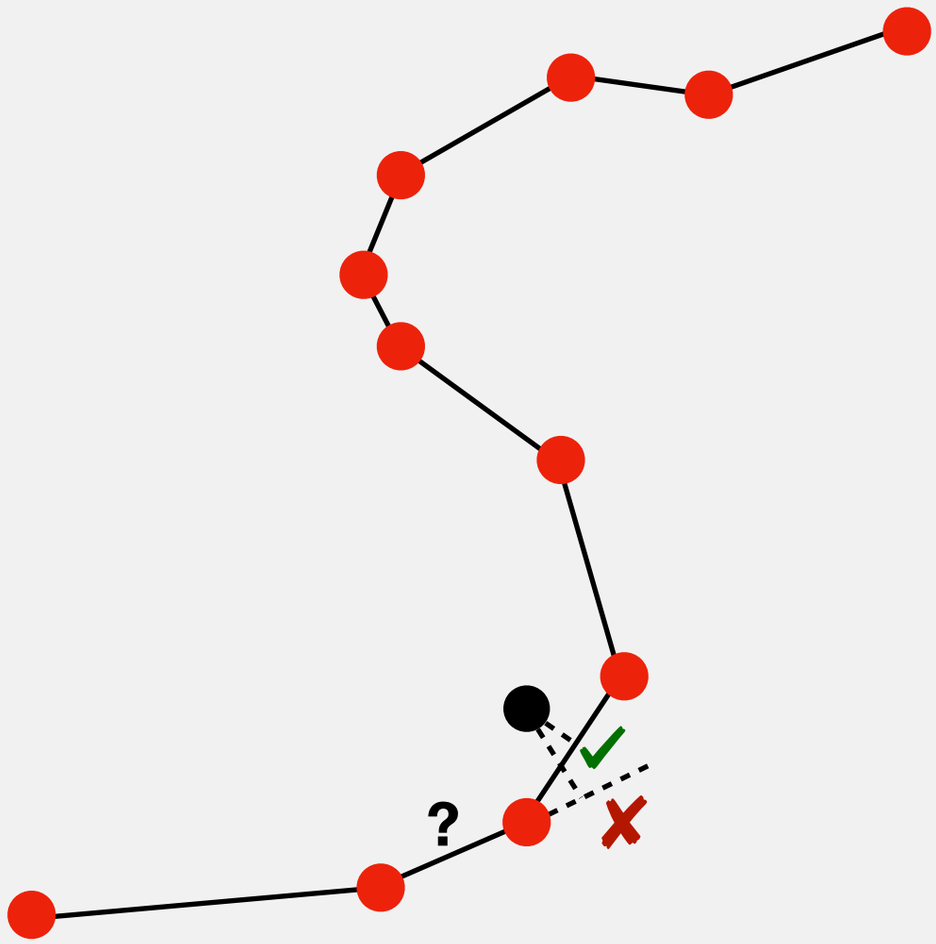
- What is the analog when we have a curve?

# Nonlinear Projection



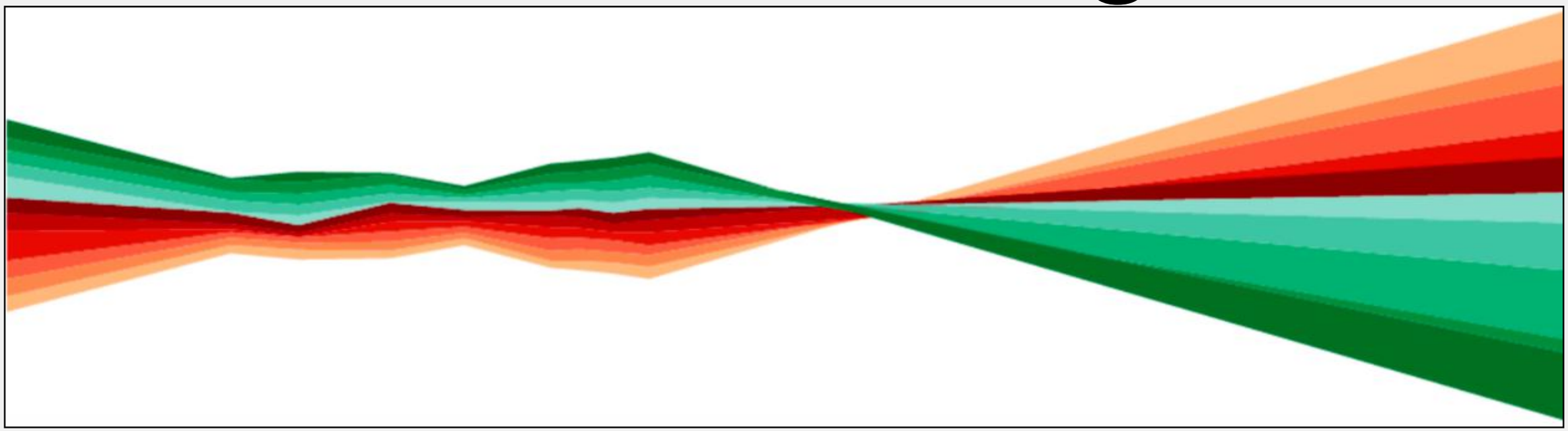

- Ok, so how do we compute this from our polyline?

# Piecewise Projection



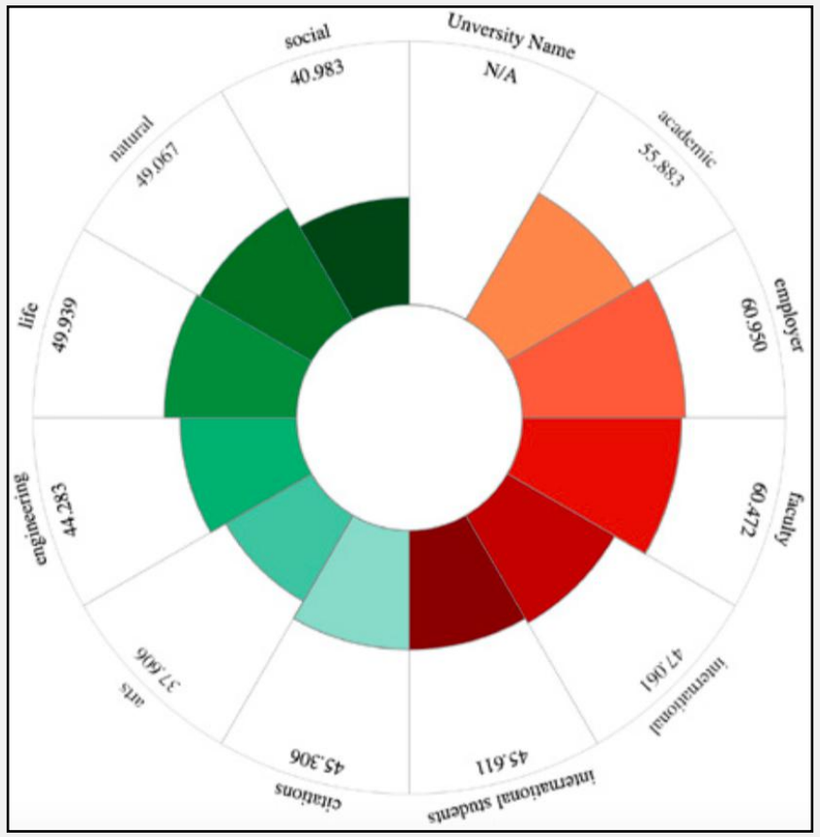

- Some issues:
  - What if the point is far from the curve?
  - Keep this information around, visually encode it later.
  - Larger issue (not addressed): uniqueness?

# Visualization Design: Axis



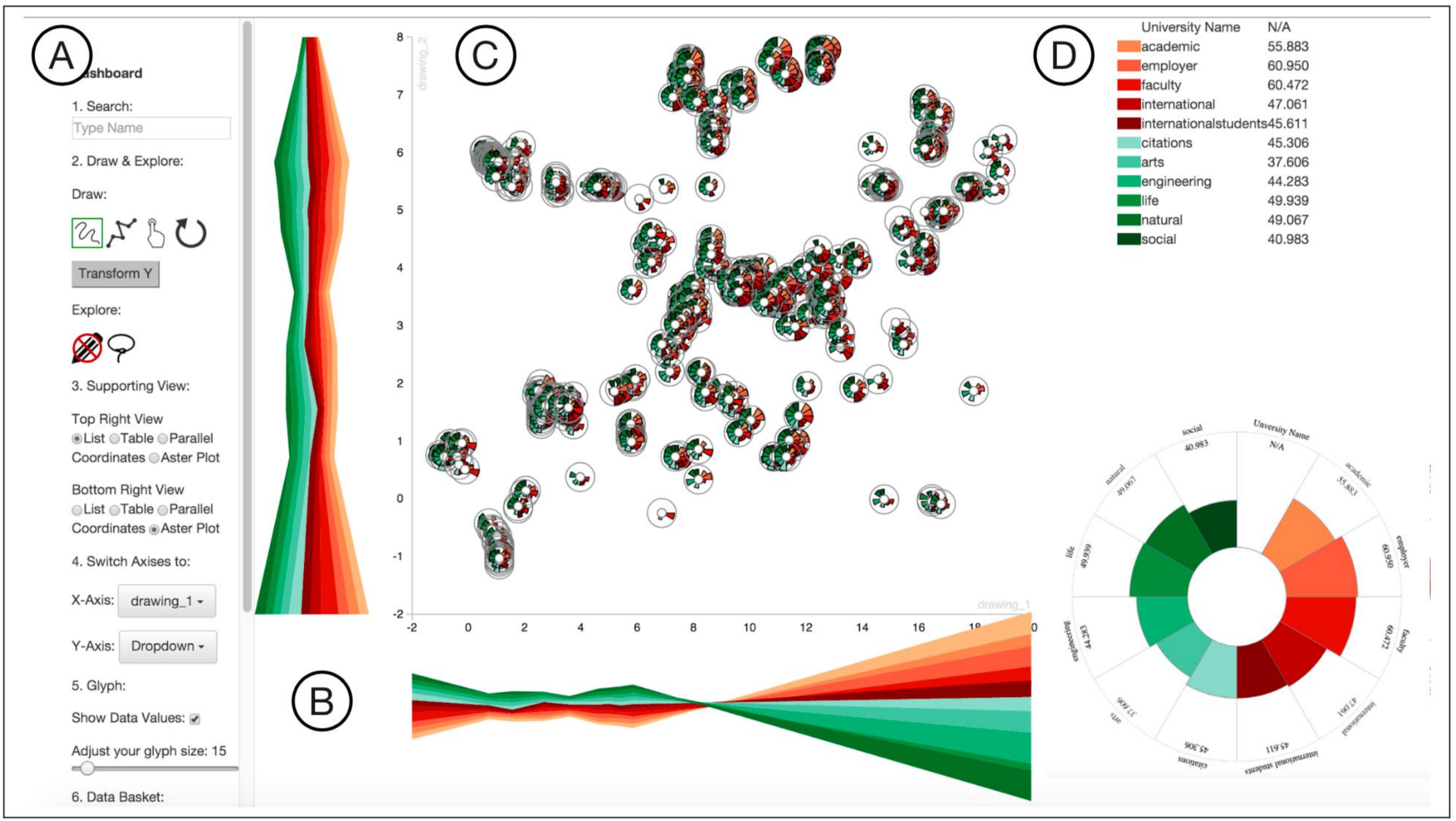
- Visual Encoding:
  - ordinal: points on curve are ordered
  - category: attributes mapped to color *and* y-stacking
  - quantitative: attribute values mapped to length

# Visualization Design: Glyph

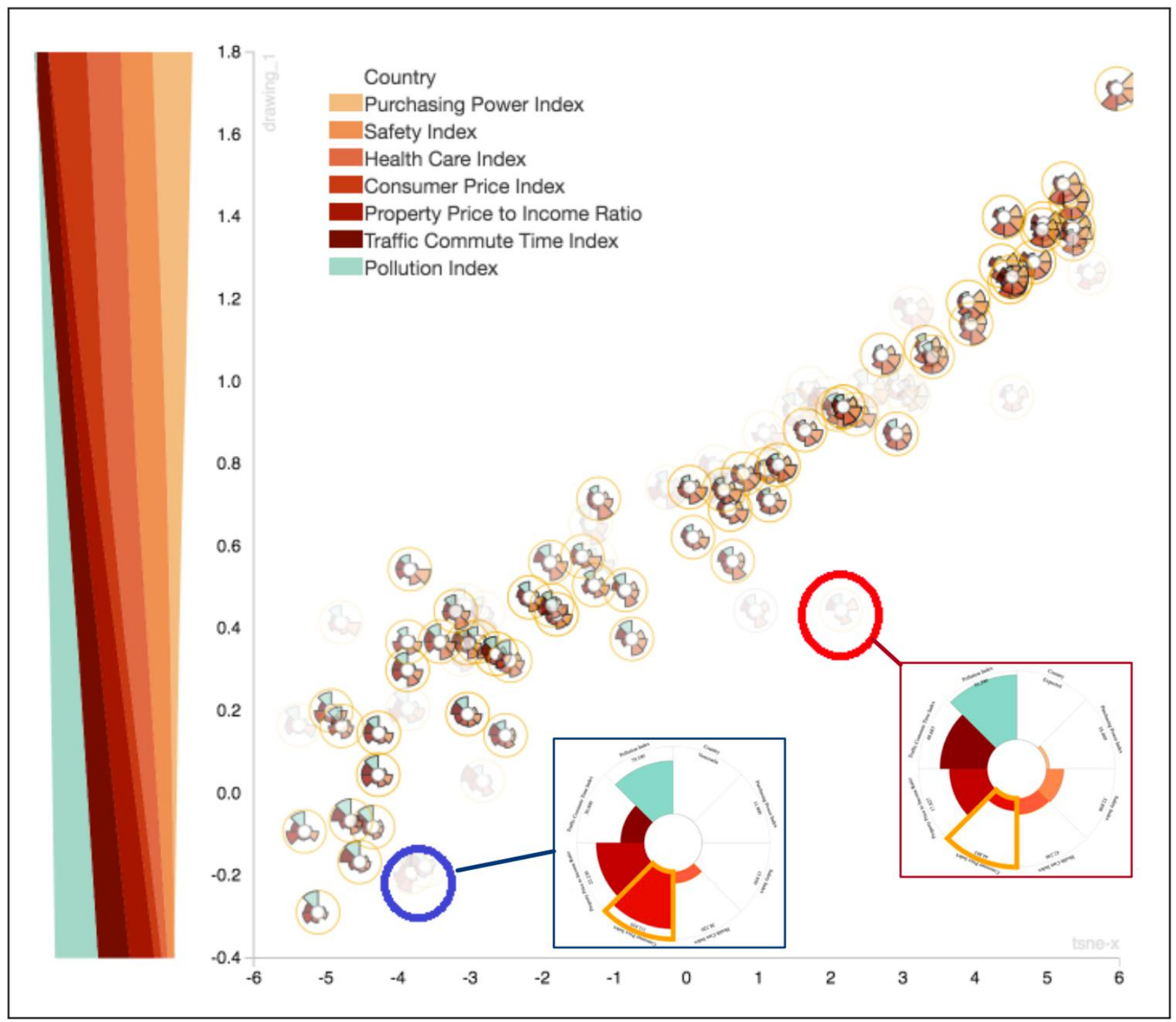



- Known as an aster plot
- Category: attribute mapped to angle *and* color
- Quantitative: value mapped to radius

# Full Interface



# Example: Quality-of-Life Indicators (grain of salt!)



# Limitations with Interaxis, Axisketcher

- The quality of the axes is highly dependent on the usefulness of the given 2D projection
    - Interaxis: necessary to find points of interest
    - Axisketcher: if the 2D projection is not useful to the user, neither will their sketched curve
- How do these methods scale with large amounts of dimensions (e.g. > 100)?