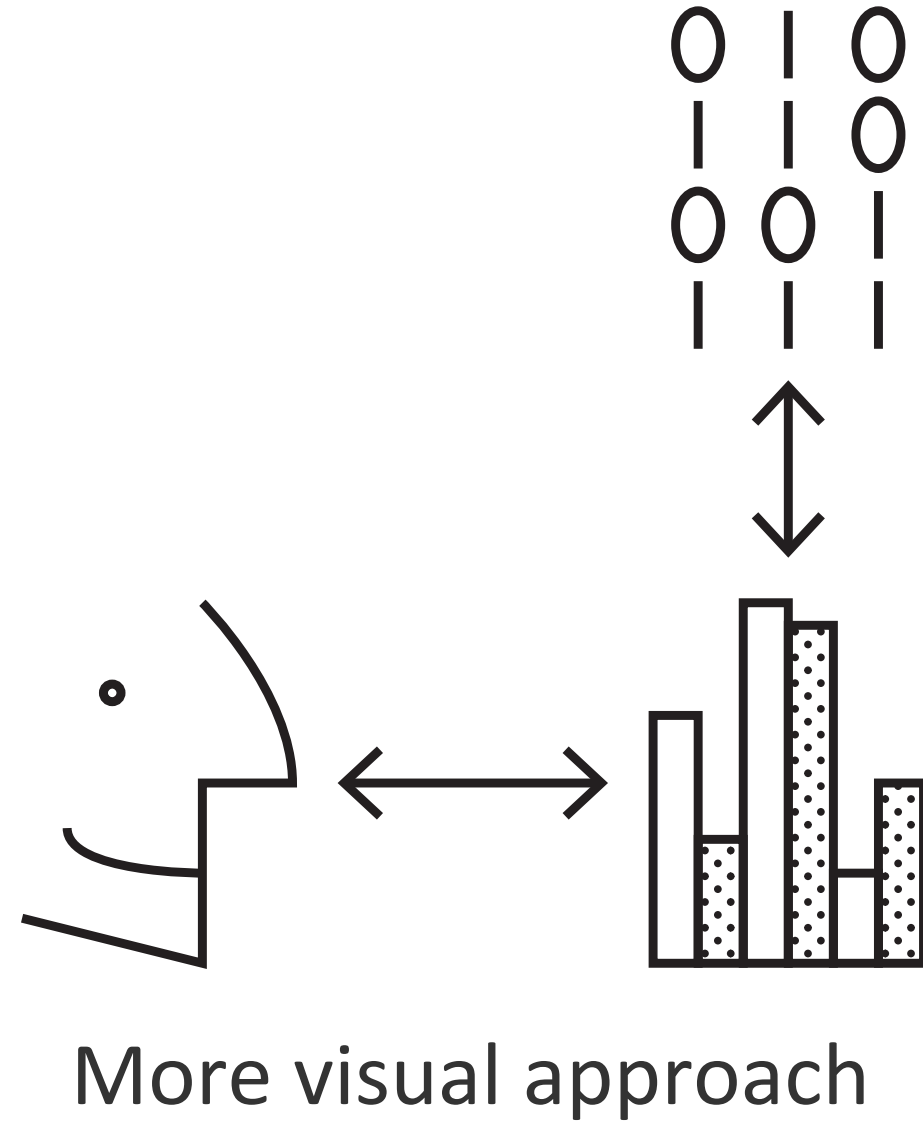
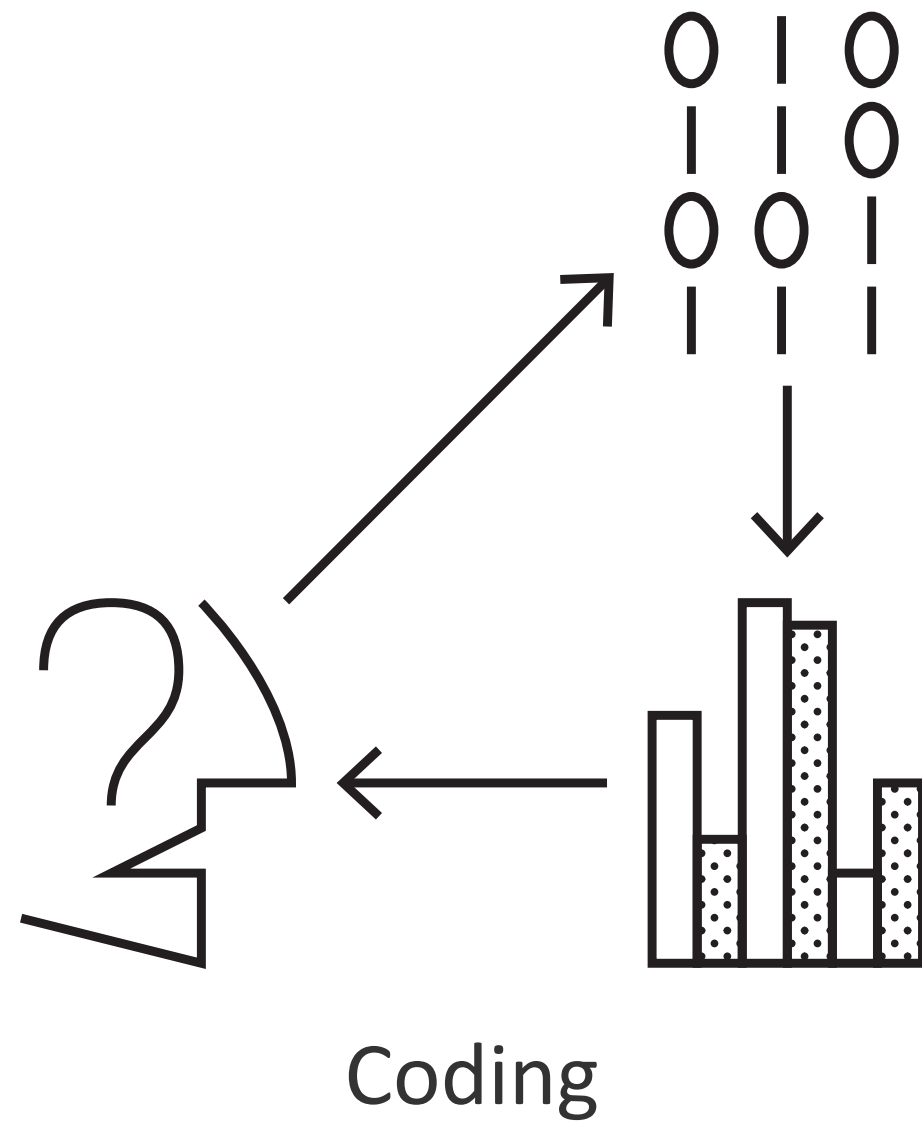


SketchPad^{N-D}: WYDIWYG Sculpting and Editing in High-Dimensional Space



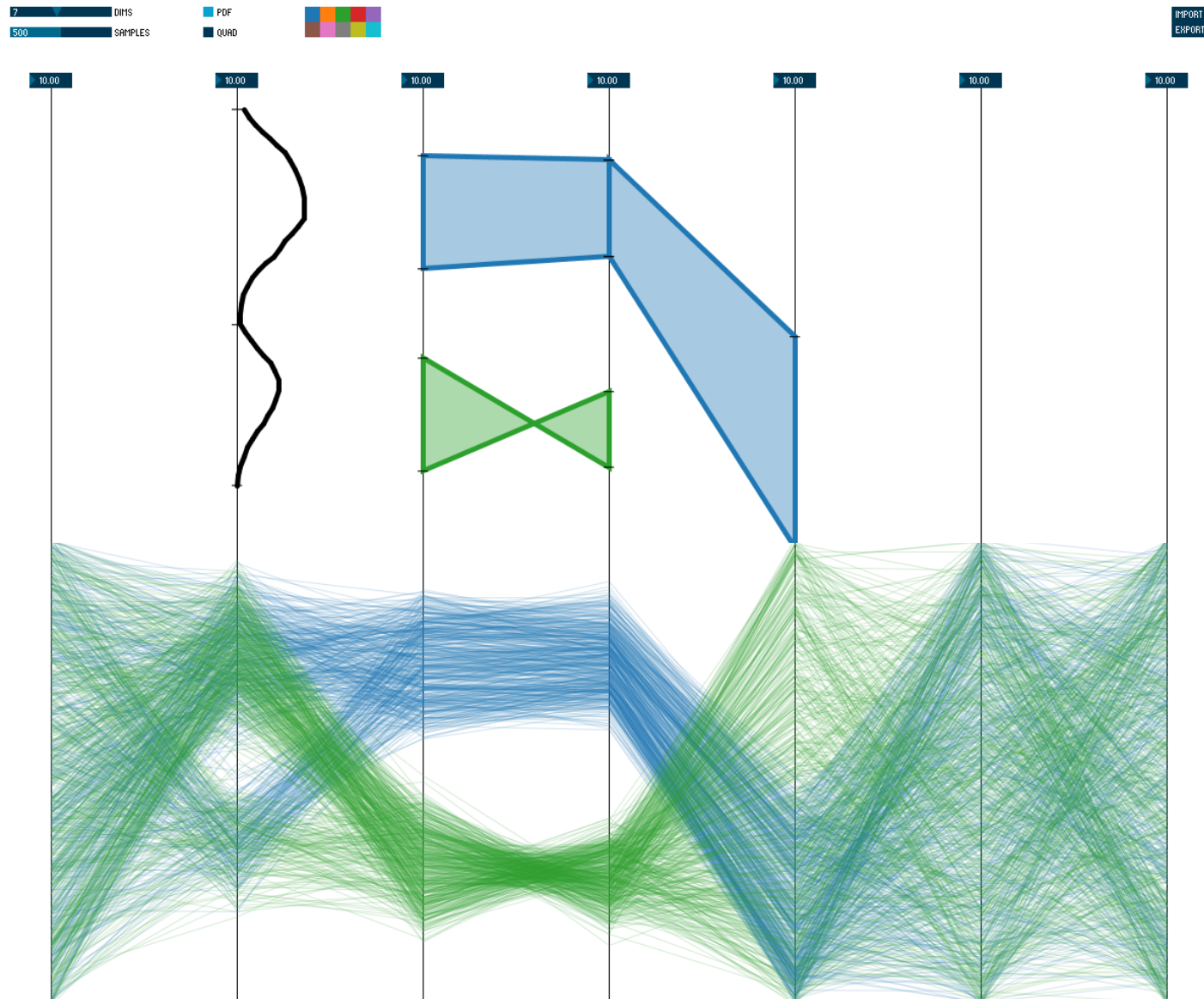
Bing Wang
Puripant Ruchikachorn (Joe)
Klaus Mueller

How to generate a high-dimensional dataset?

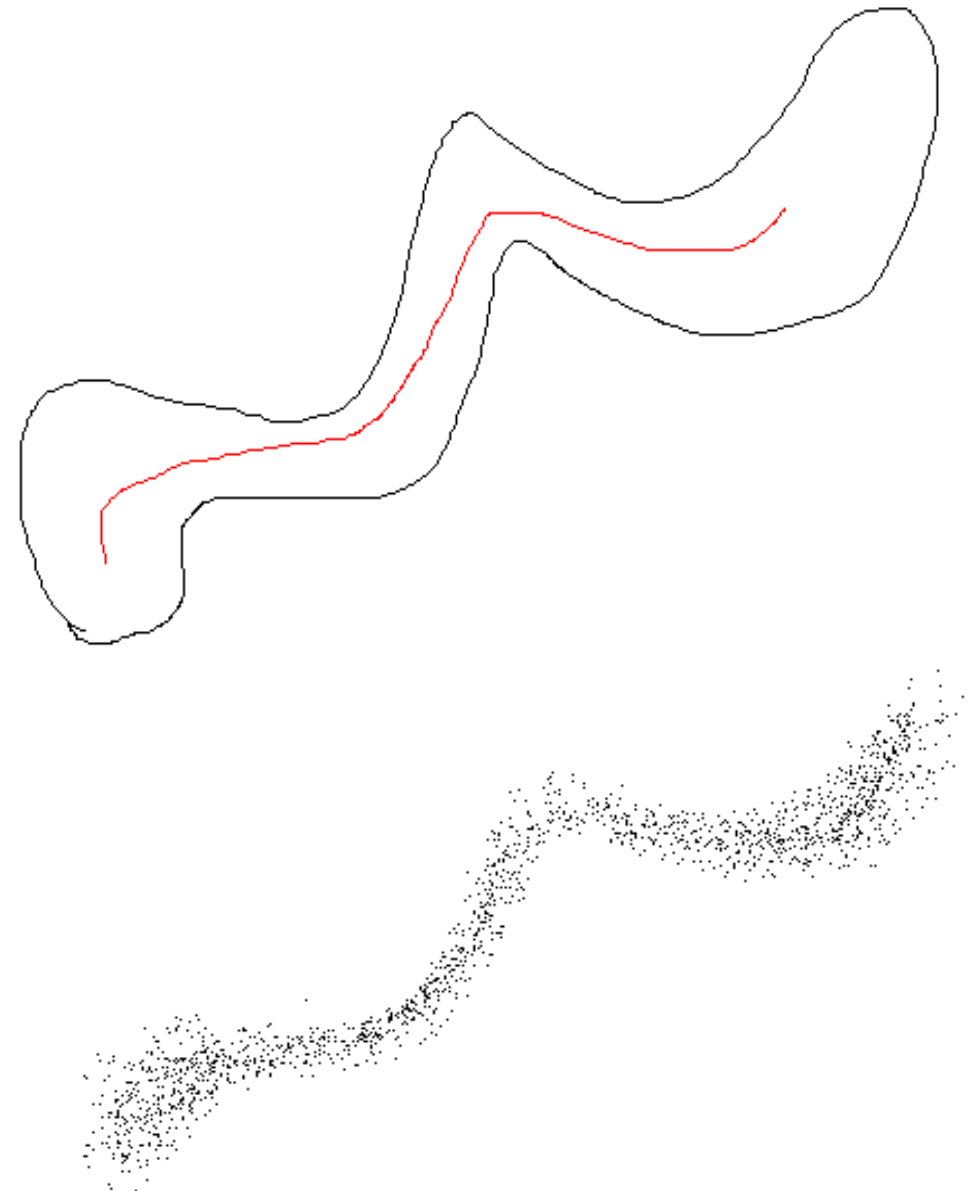


SketchPad^{N-D}: WYDIWYG Sculpting and Editing in High-Dimensional Space

Parallel Coordinates Plot

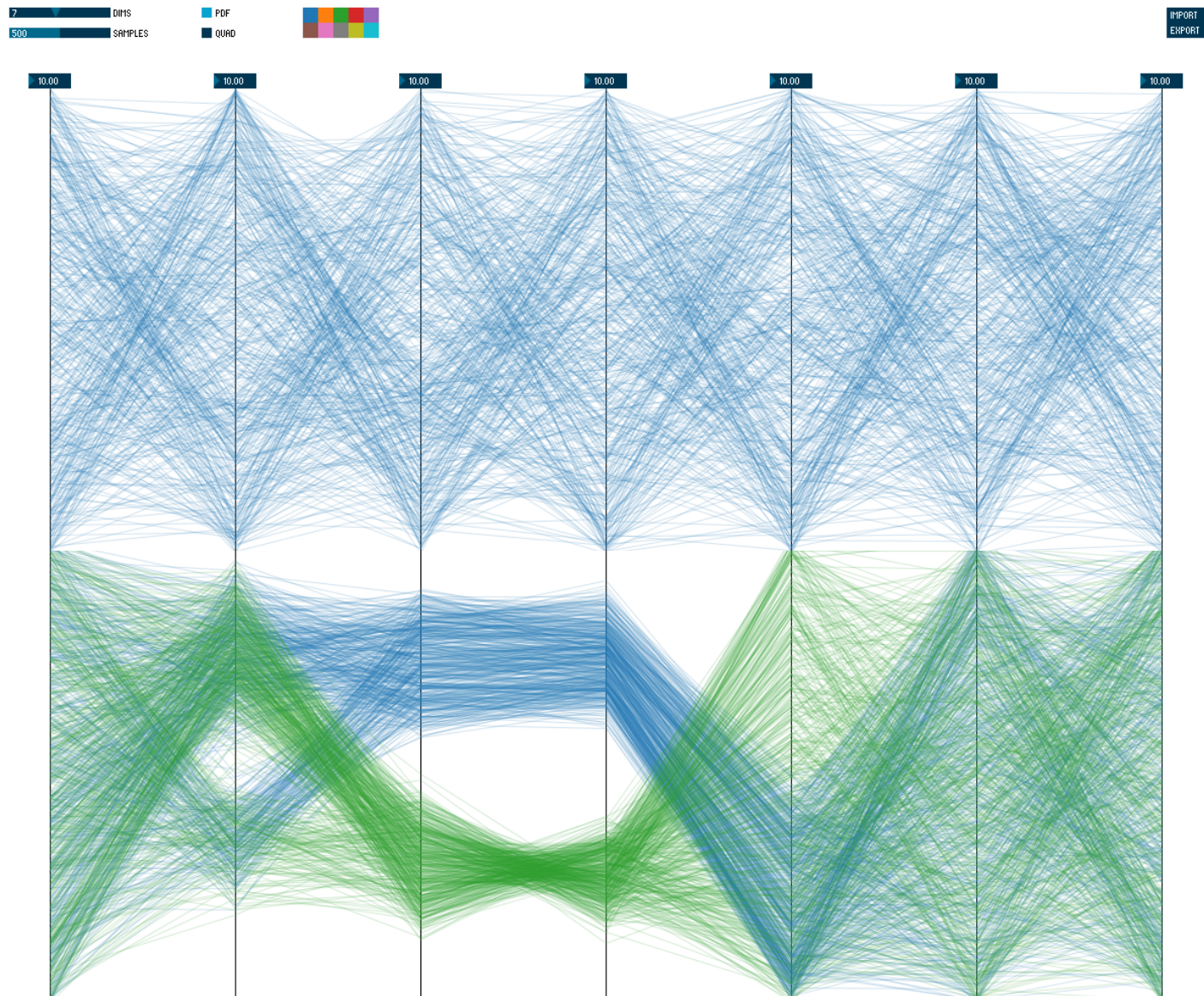


Scatterplot (Matrix) via Touchpad^{N-D}

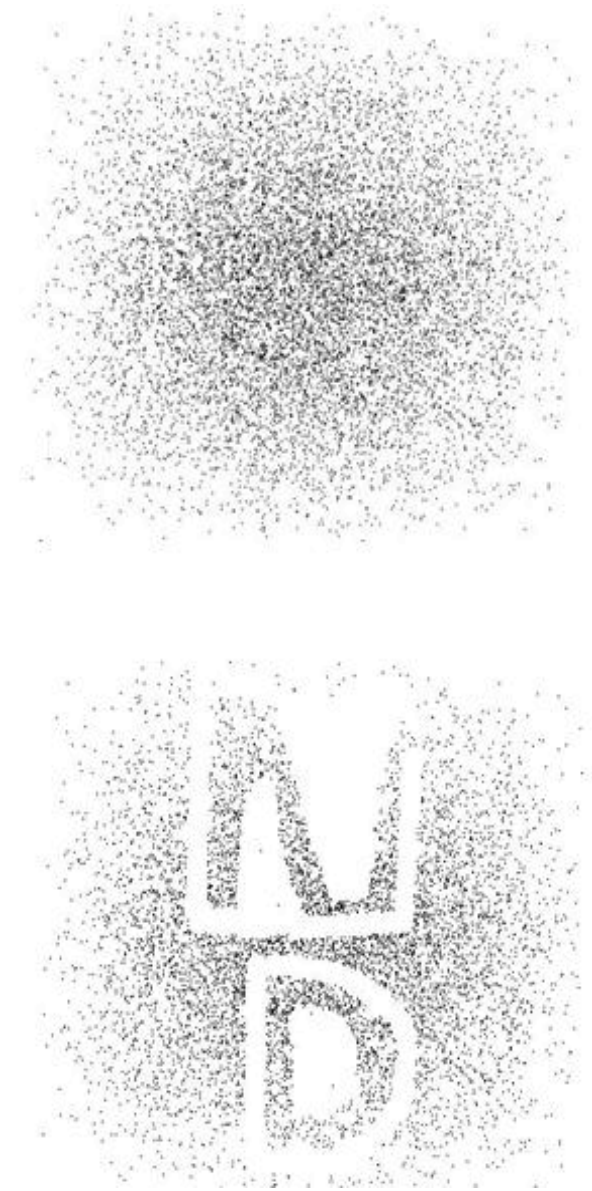


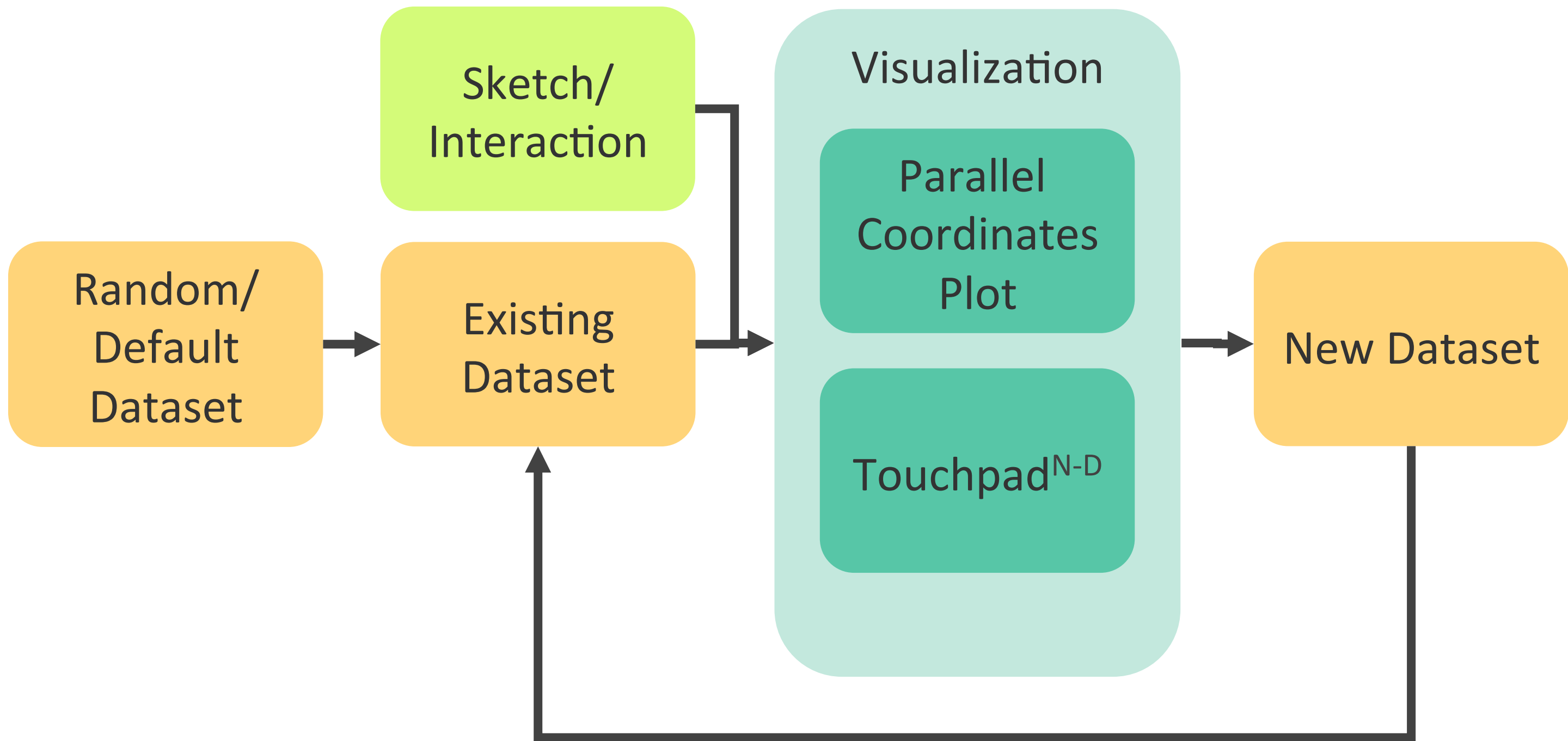
SketchPad^{N-D}: WYDIWYG Sculpting and Editing in High-Dimensional Space

Parallel Coordinates Plot



Scatterplot (Matrix) via Touchpad^{N-D}





Sketching on Parallel Coordinates Plot

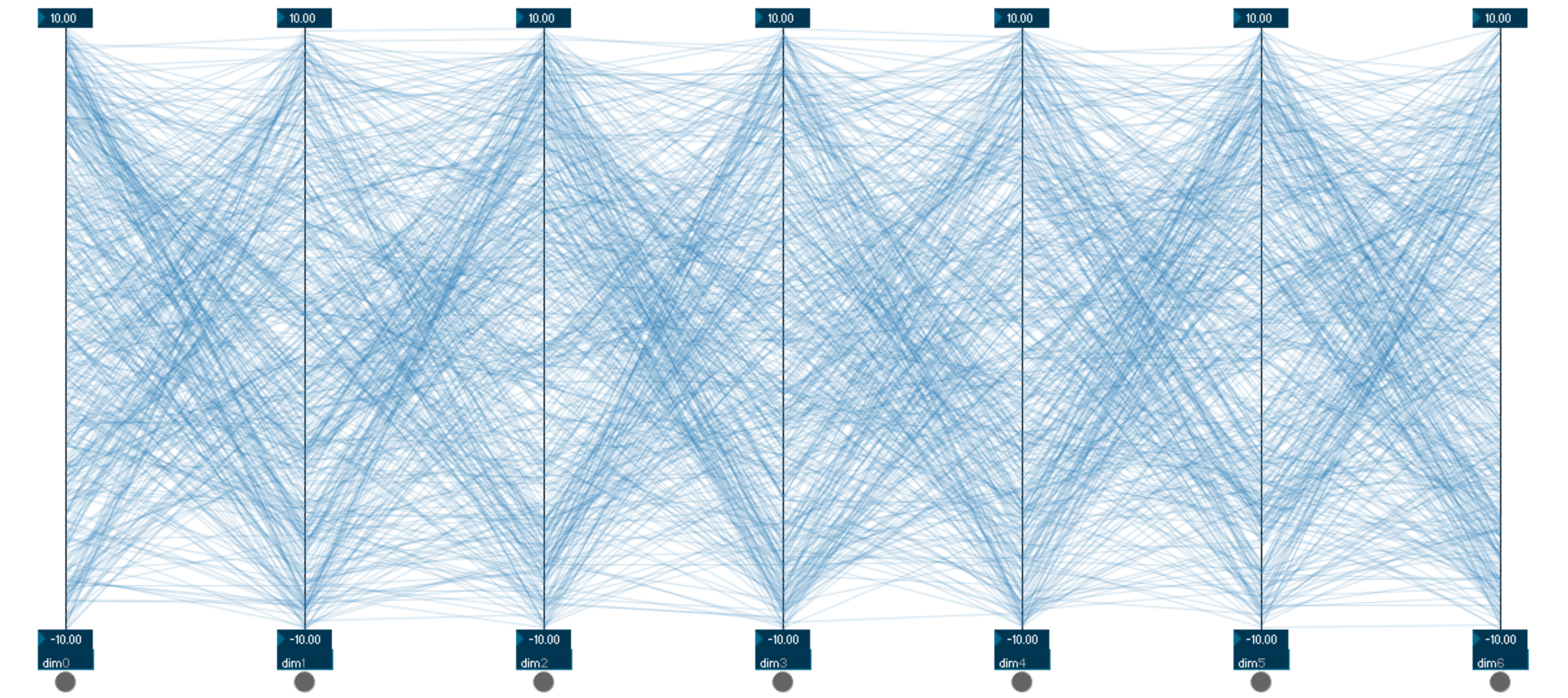
Probability Density Function (PDF) Sketch
and Data Connection Quadrilateral

7 DIMS
500 SAMPLES
CORRELATION

PDF
QUAD



IMPORT
EXPORT

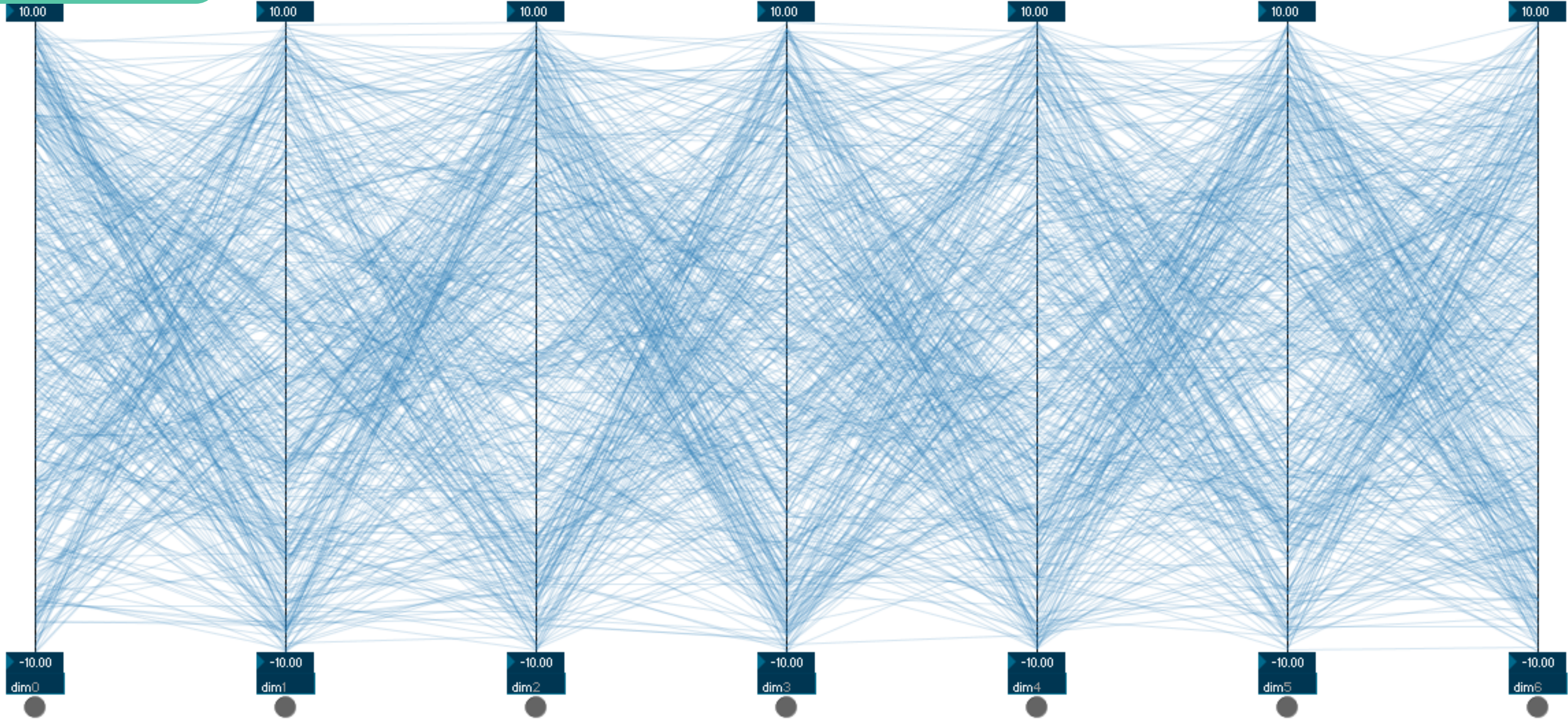


7 DIMS
500 SAMPLES
CORRELATION

PDF
QUAD



IMPORT
EXPORT

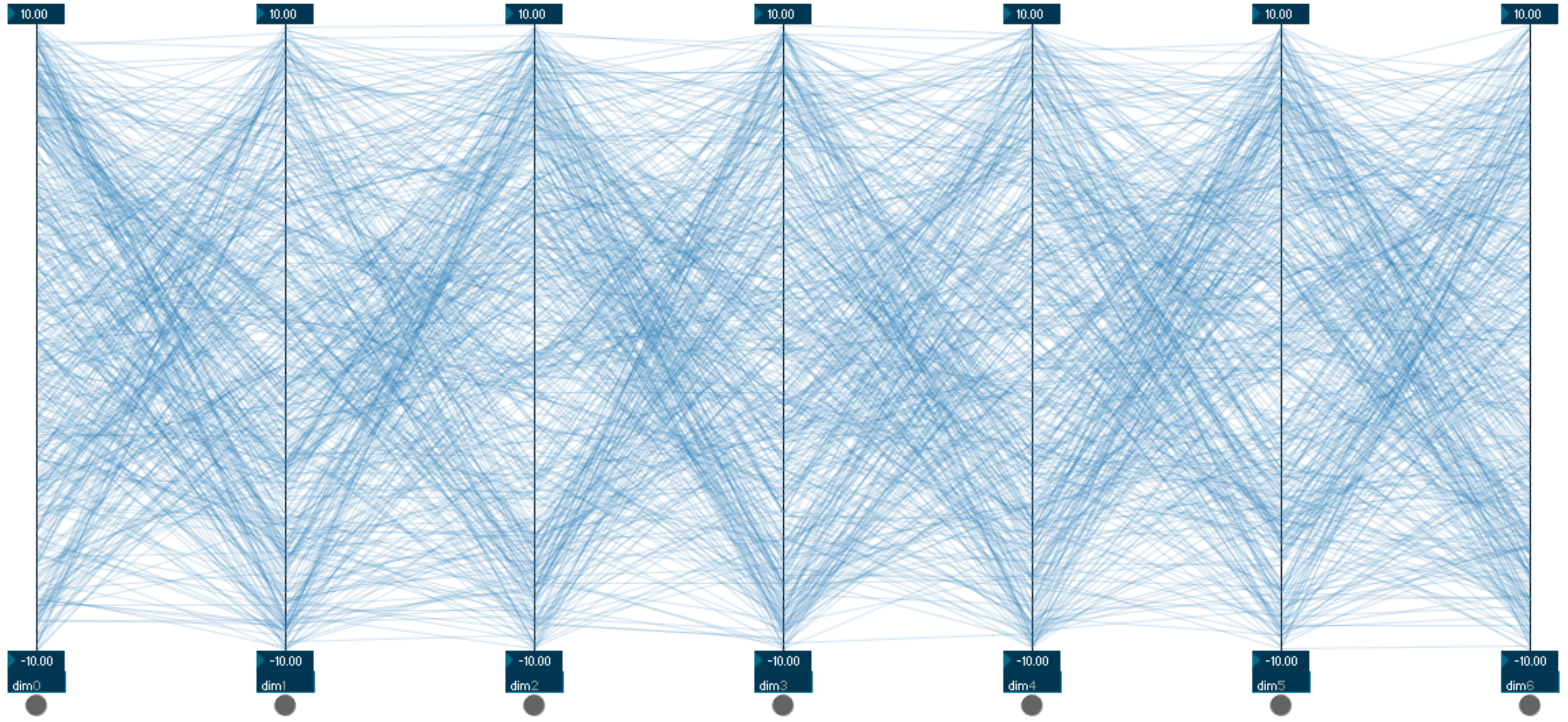


7 DIMS
500 SAMPLES
CORRELATION

PDF
QUAD



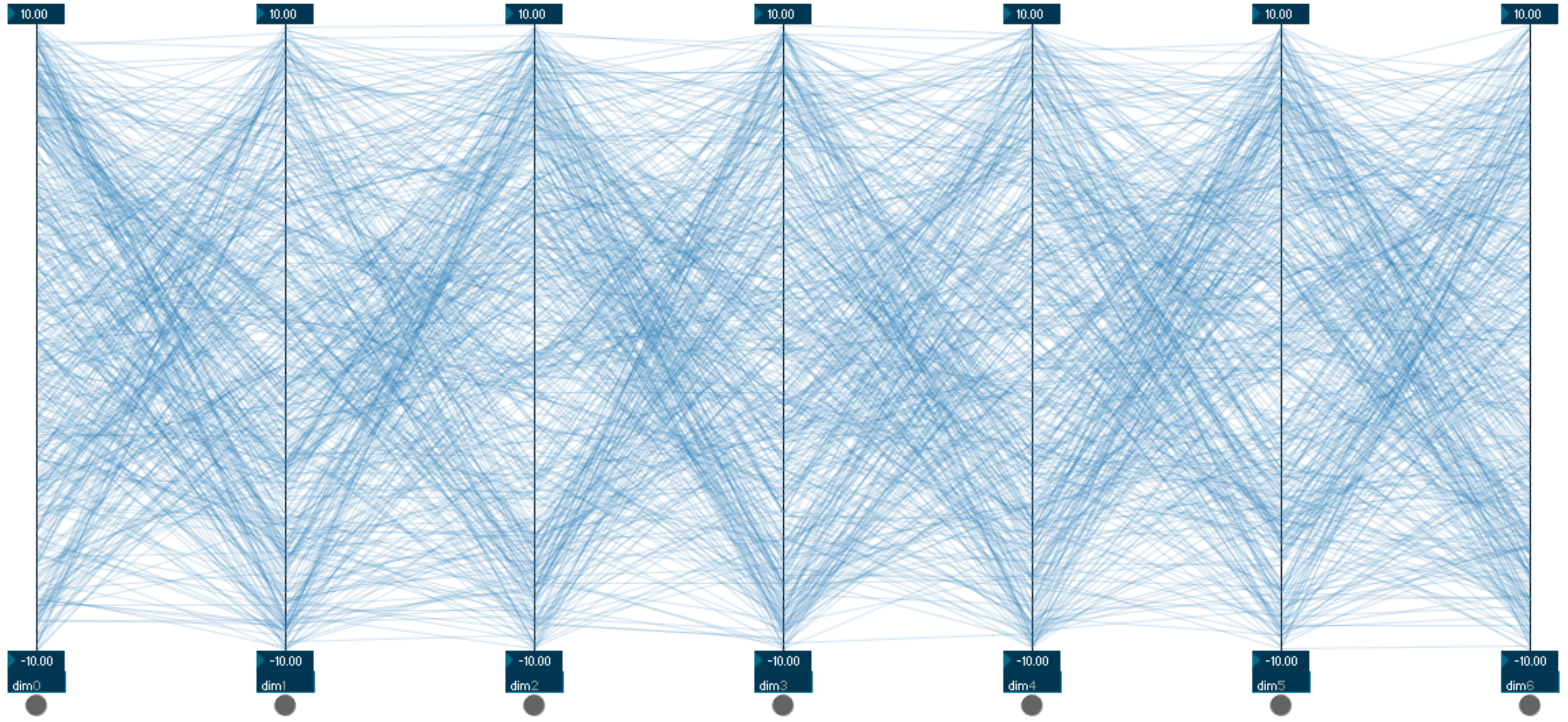
IMPORT
EXPORT



IMPORT
EXPORT

7 DIMS
500 SAMPLES
CORRELATION

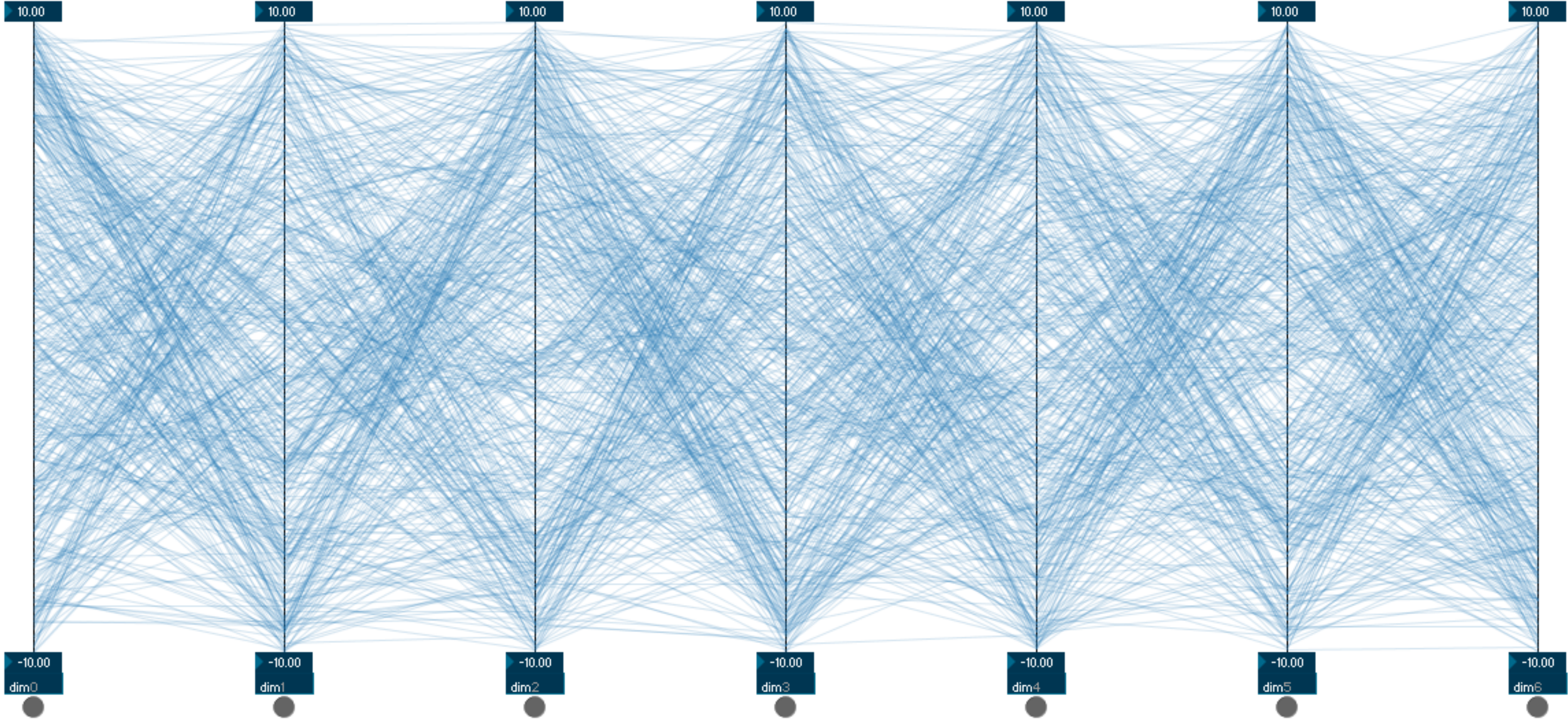
PDF
QUAD





7 DIMS
500 SAMPLES
CORRELATION

PDF
QUAD



IMPORT
EXPORT

7 DIMS

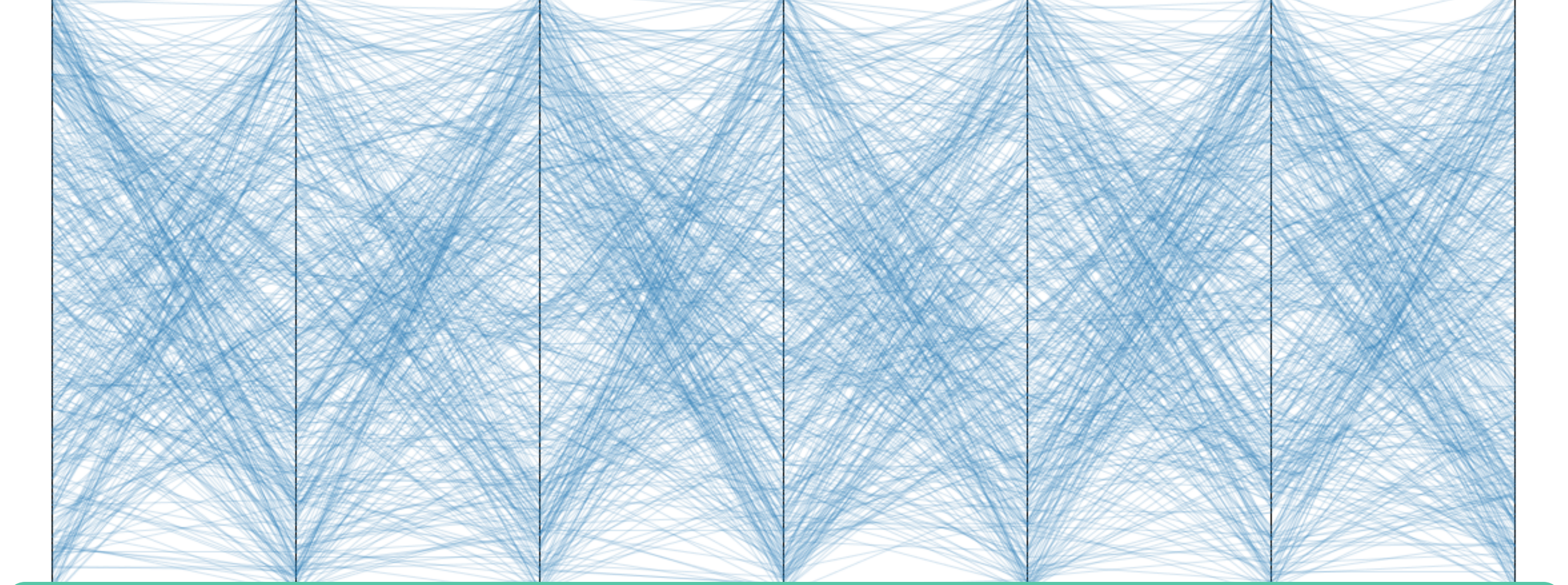
PDF



500 SAMPLES

QUAD

CORRELATION

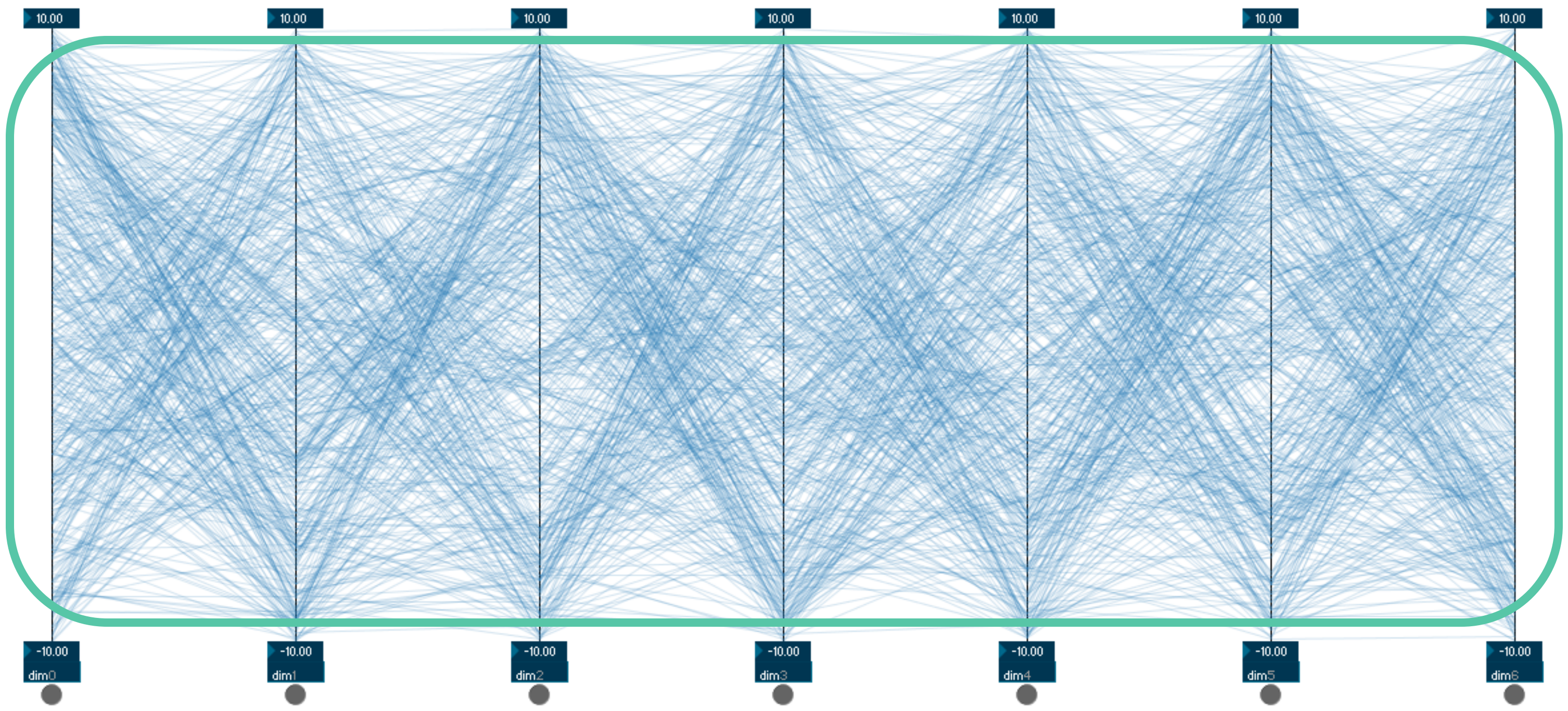


7 DIMS
500 SAMPLES
CORRELATION

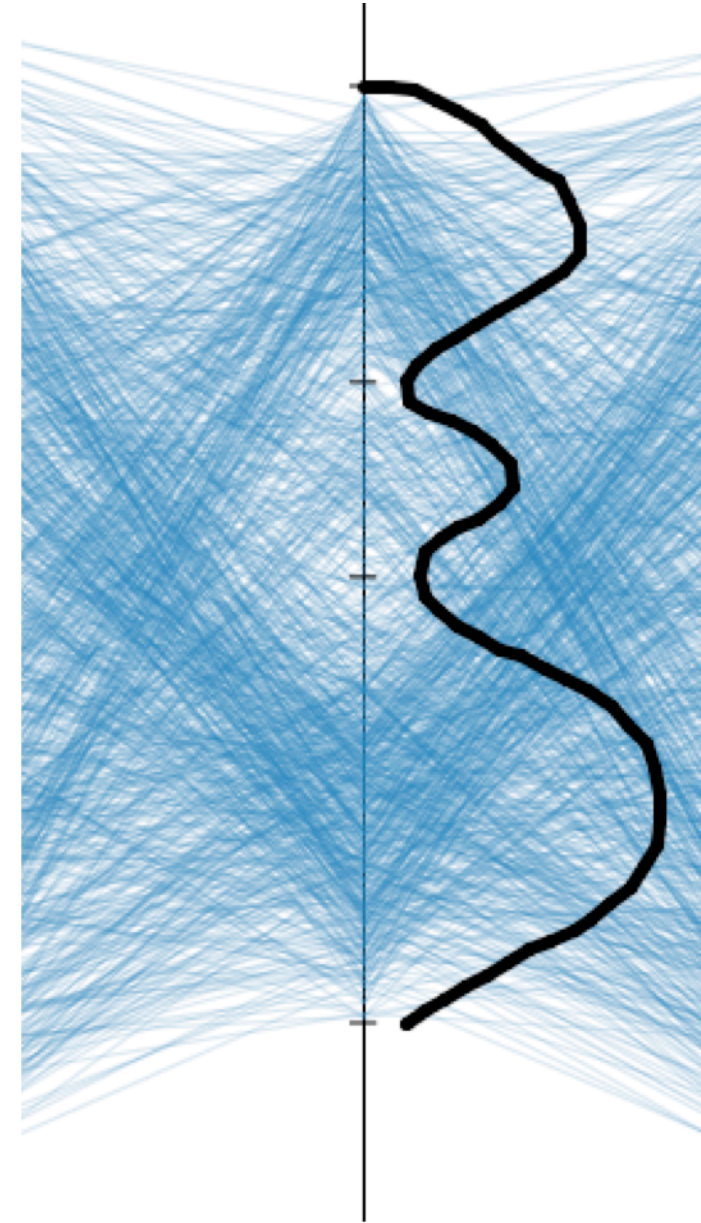
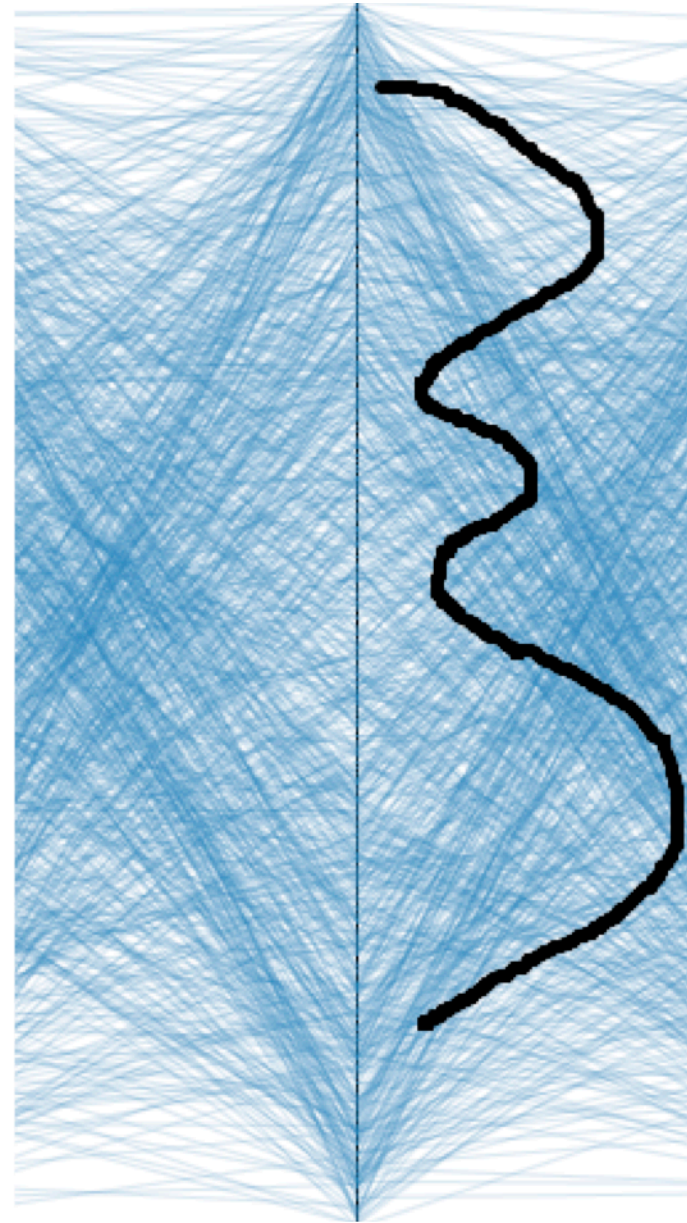
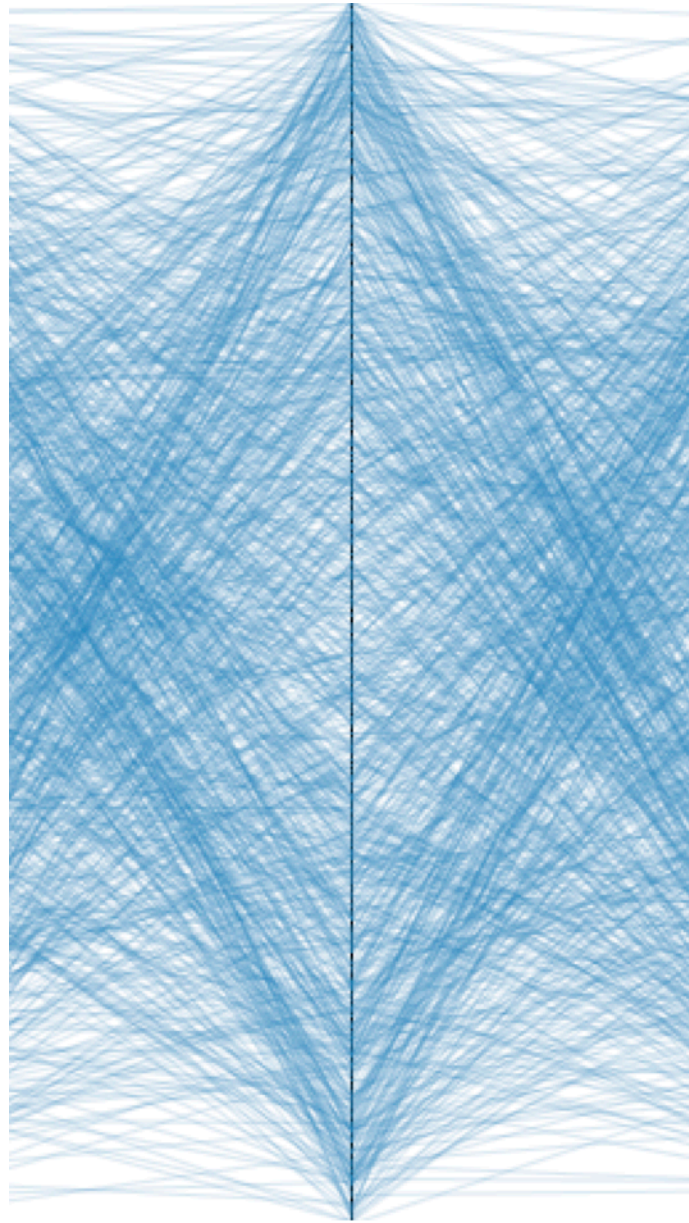
PDF
QUAD



IMPORT
EXPORT

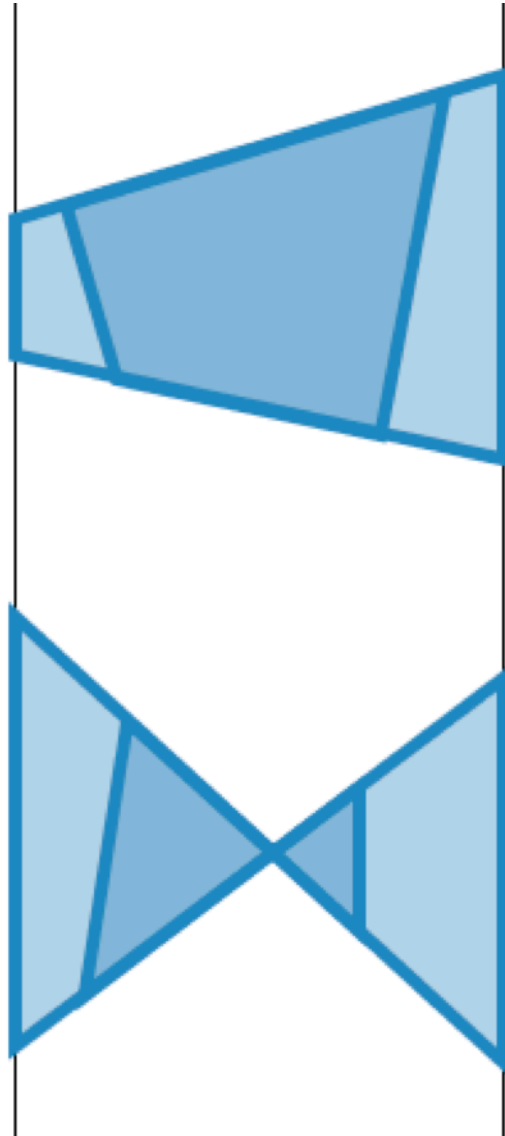


Probability Density Function (PDF) Sketch

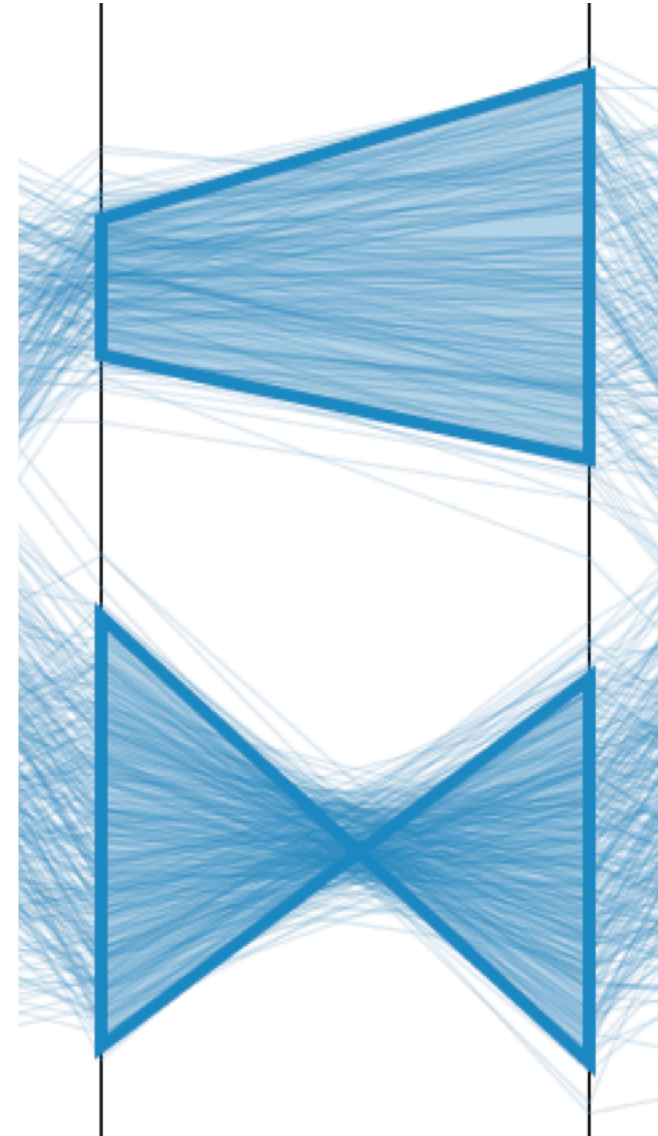
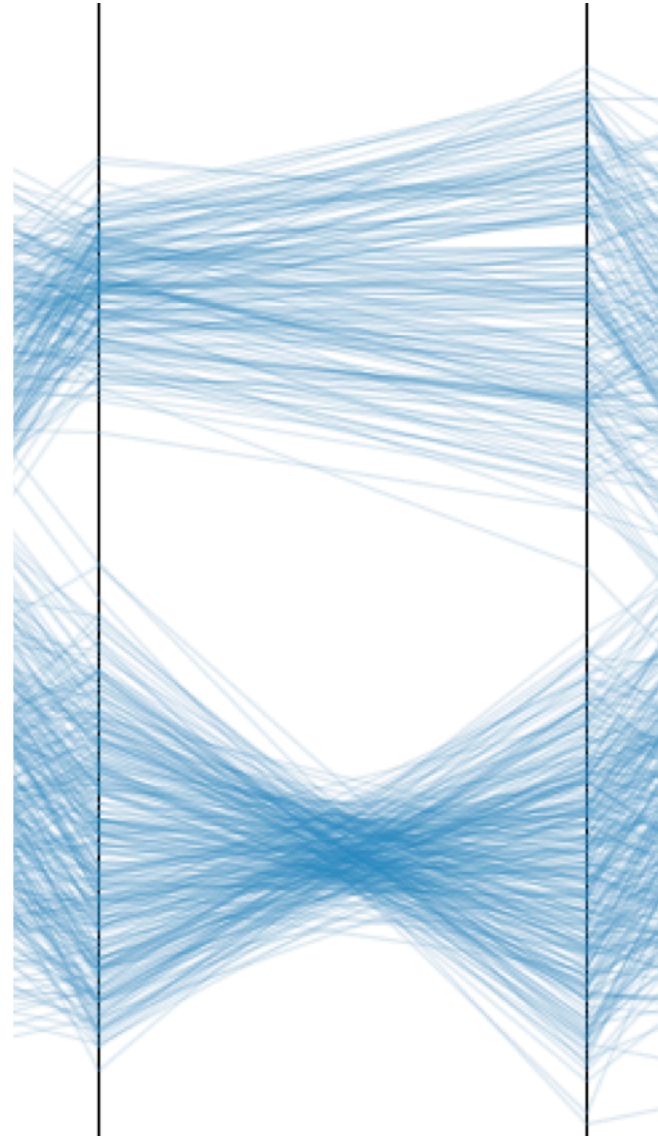
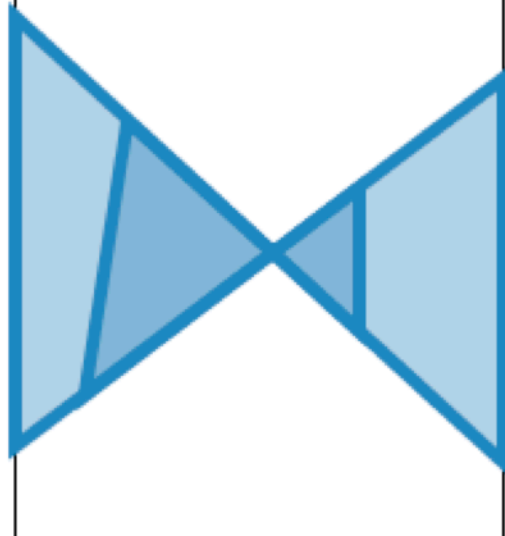


Data Connection Quadrilateral

Trapezoid



Bowtie

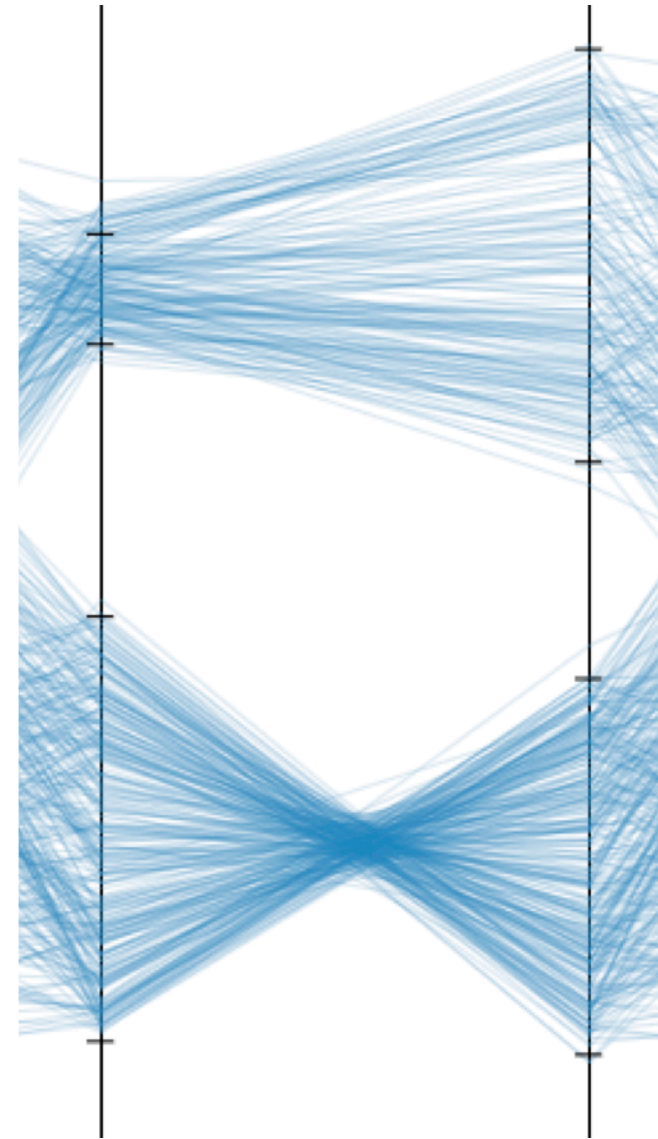
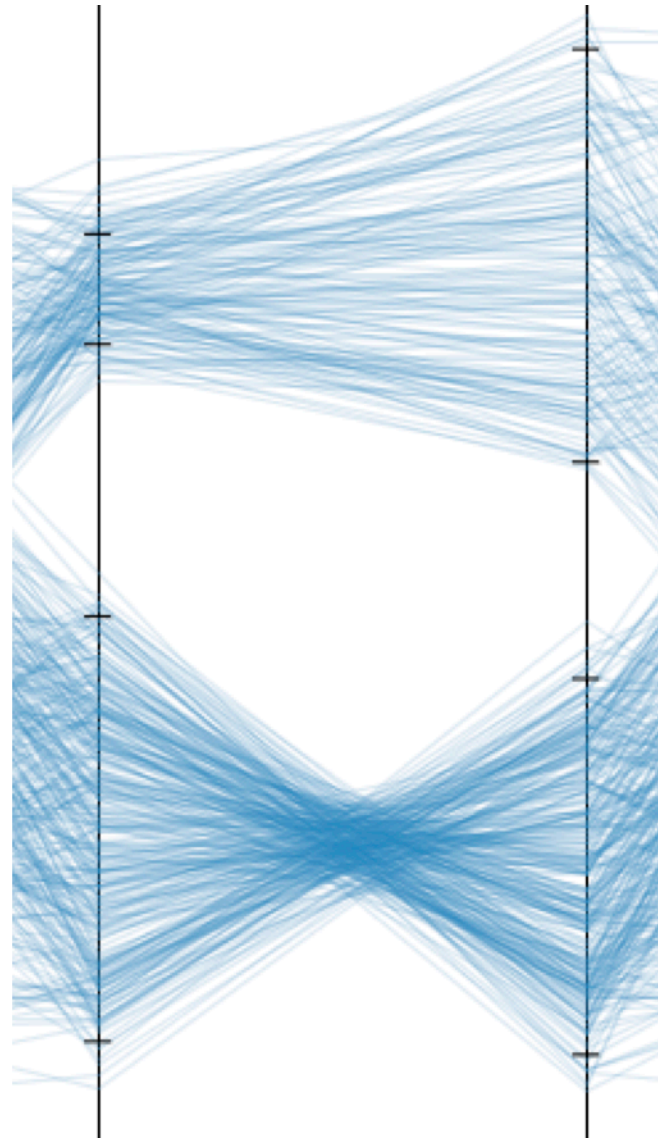
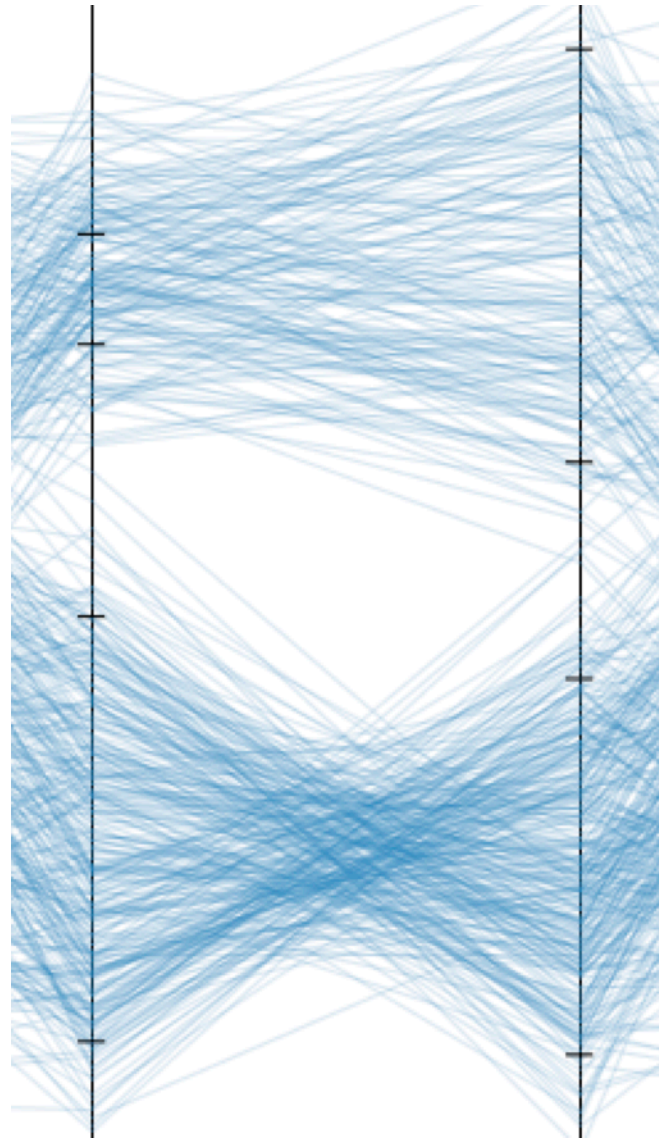


Positive
Correlation

Negative
Correlation

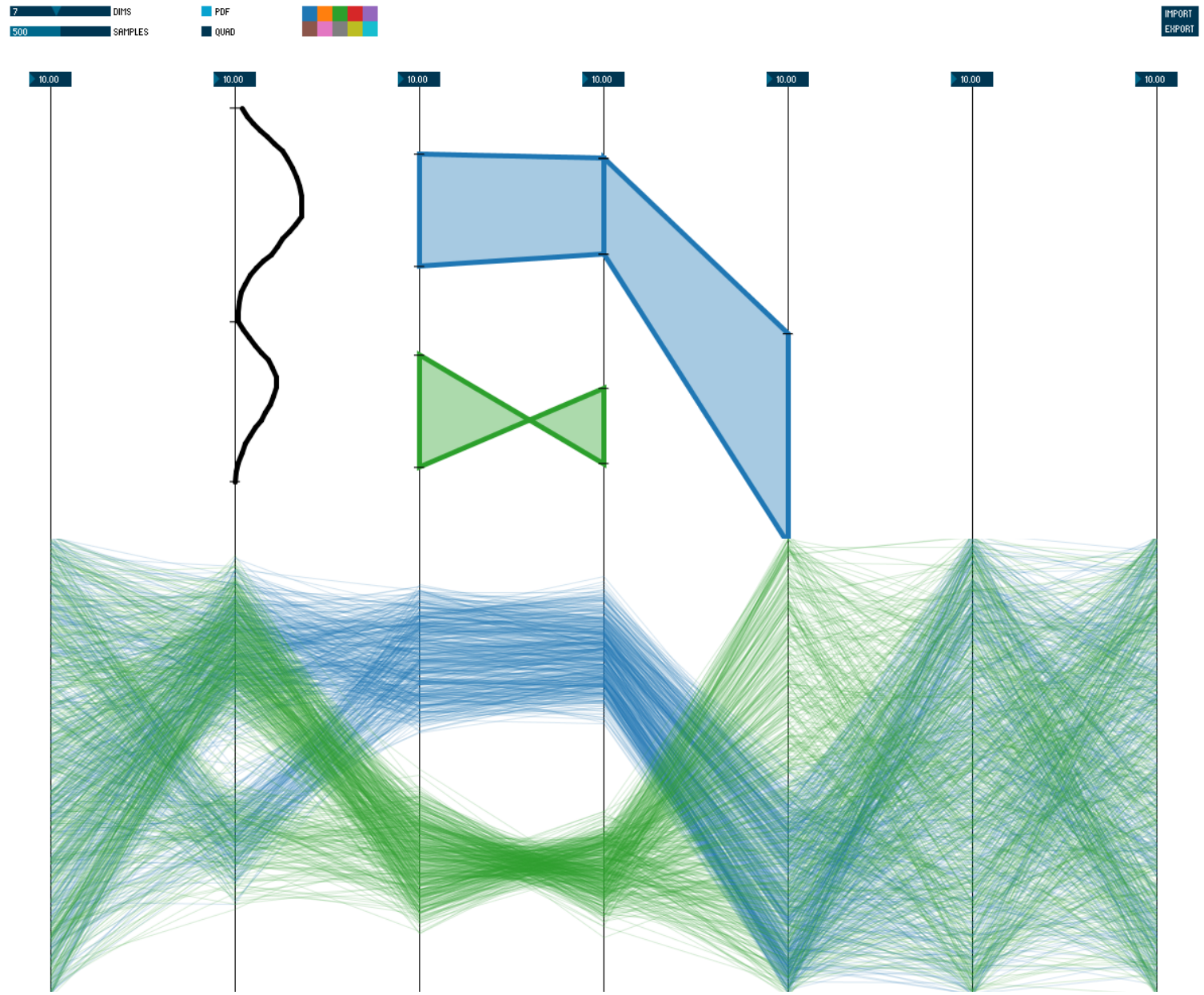
Correlation Adjustment

Weak

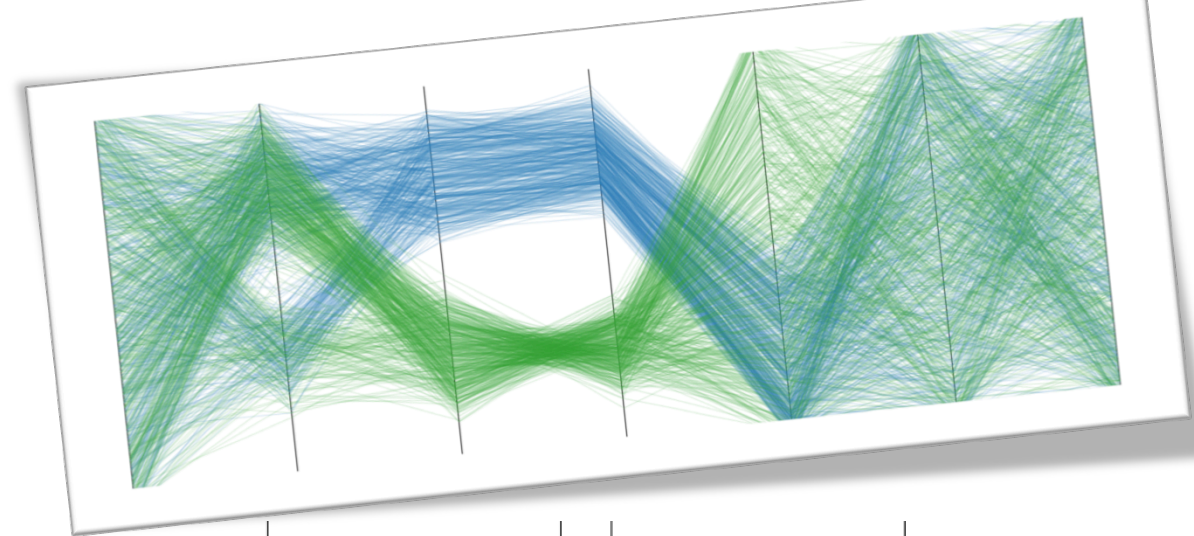
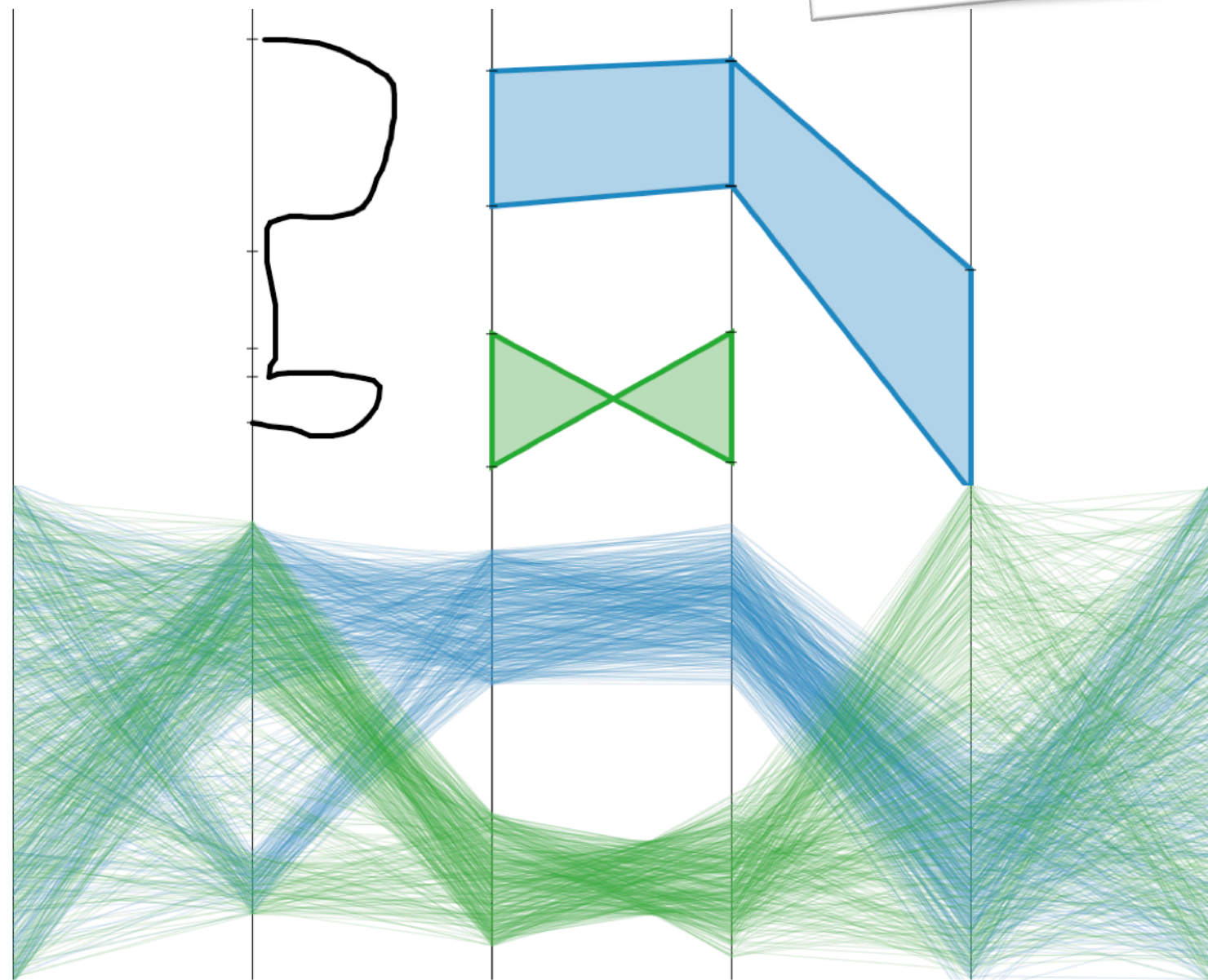


Strong

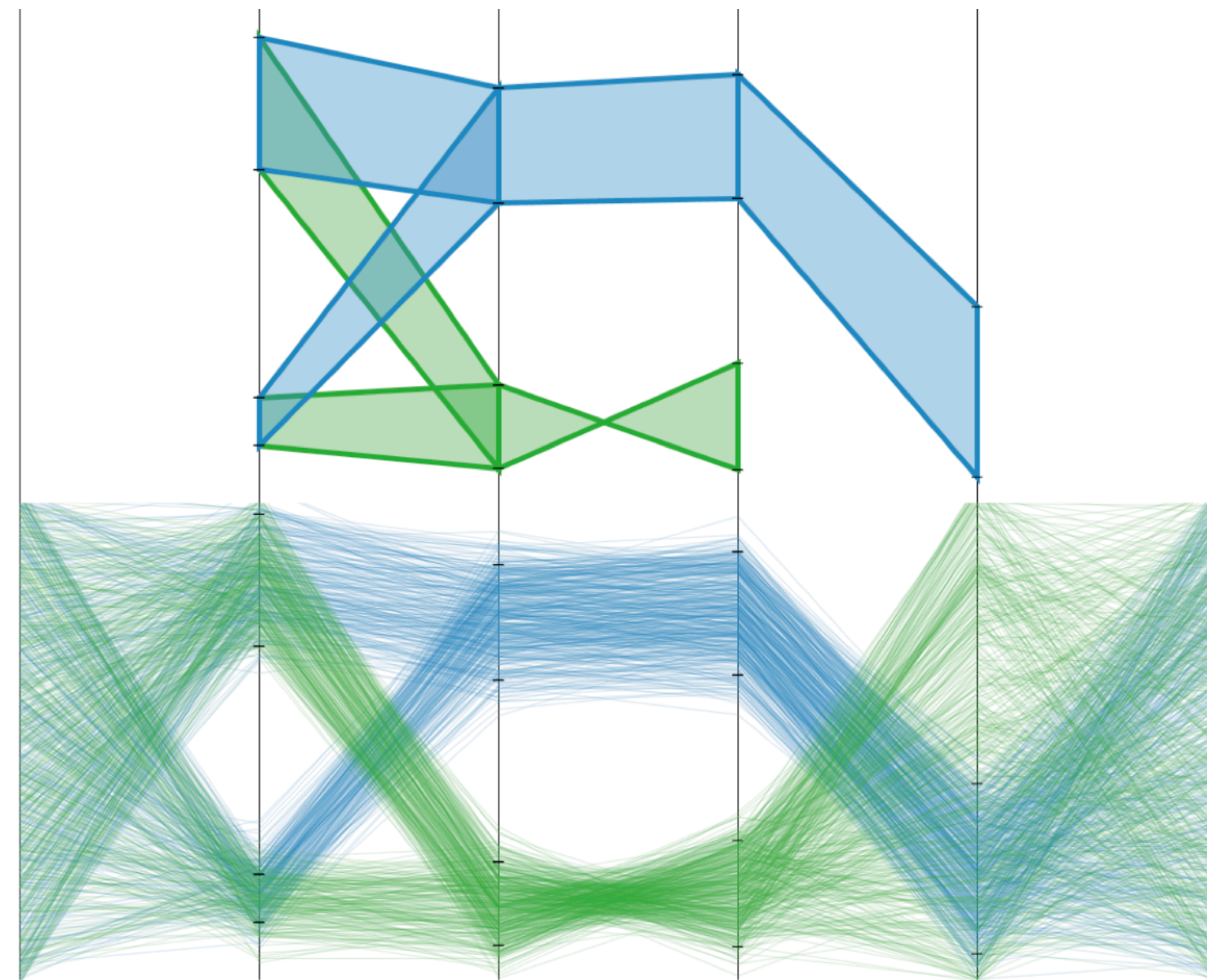
PDF Sketch & Data Connection Quadrilateral



One participant



Another participant

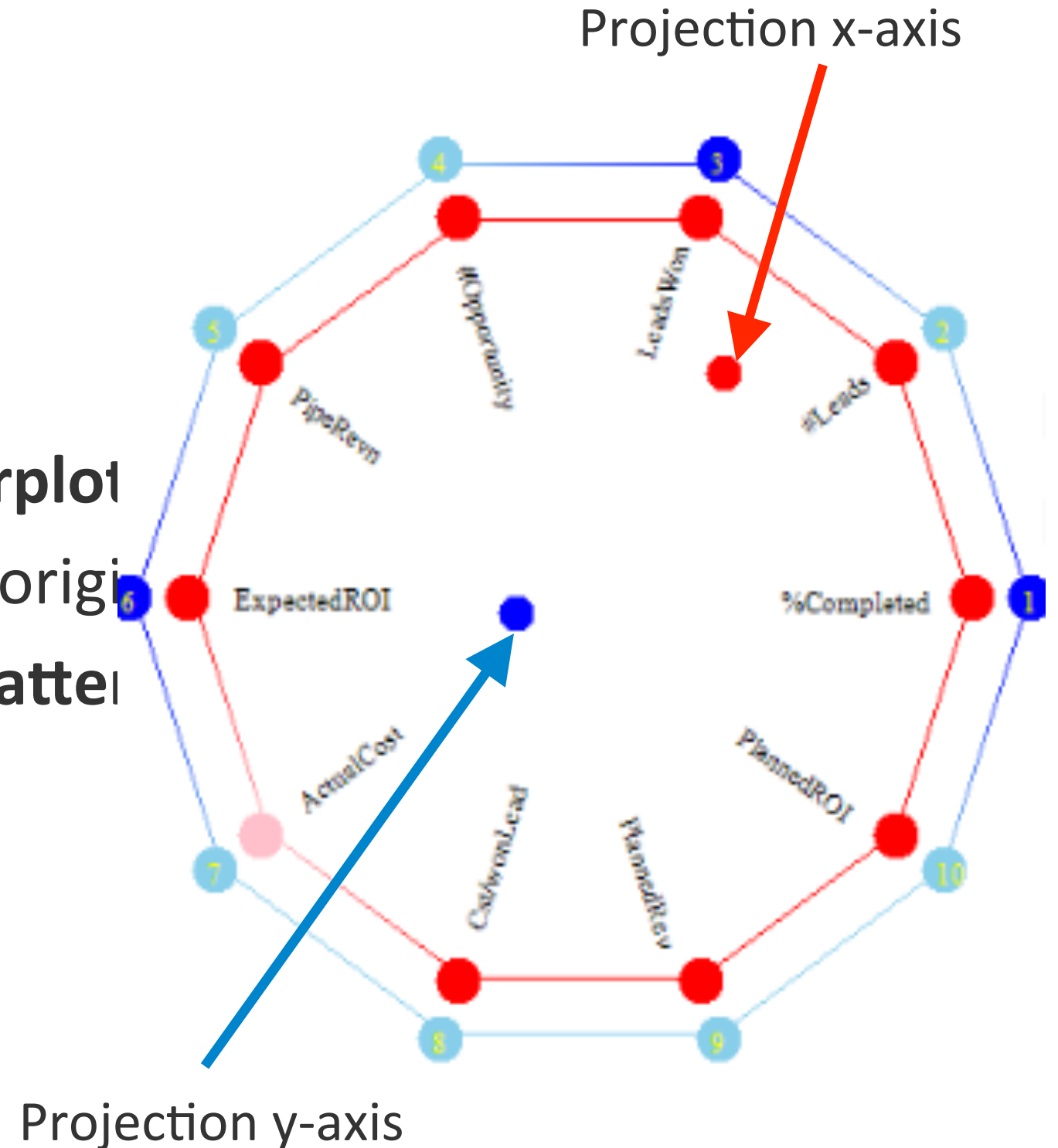


Sketching on Scatterplots

Interactions with Axis-aligned Scatterplots
and Non-axis Aligned Scatterplots

Sketching on Scatterplots

- **Why Scatterplots?**
 - 'Shape' of the data
- **Interactions with Axis-aligned scatterplot**
 - Projection x-axis and y-axis are all original
- **Interactions with non axis-aligned scatterplot**
 - Arbitrary projection planes



Scatterplot based Data Generation Algorithm

Point Generation

- ◆ Distribution painting in 2D
- ◆ Distribution backprojection
- ◆ Repeat as desired

Point Sculpting

- ◆ Distribution carving
- ◆ Distribution repair
- ◆ Repeat as desired

ProjectorPanel

Drawing

Axis

Axis

Yaxis

t of dim 4

t of pts 1000

Sketching

Original Data

View Path

Orth

NonO

Modify

X vector


Y vector

F1

Density

Axis-Aligned Case
Modify backprojected points

ProjectionPanel



Axis
 Xaxis
 Yaxis

of dim 4

of pts 1000

Sketching
Original Data
View Path
 Orth
 NonO
Modify

X vector
1.00 0.00 0.00 0.00

Y vector
0.00 0.00 1.00 0.00

PCA
0.45 0.25 0.10 0.20

Brush Density
Point Size 1

Brushing
Erasing
Coordinate [45277772214 0.0419566355]

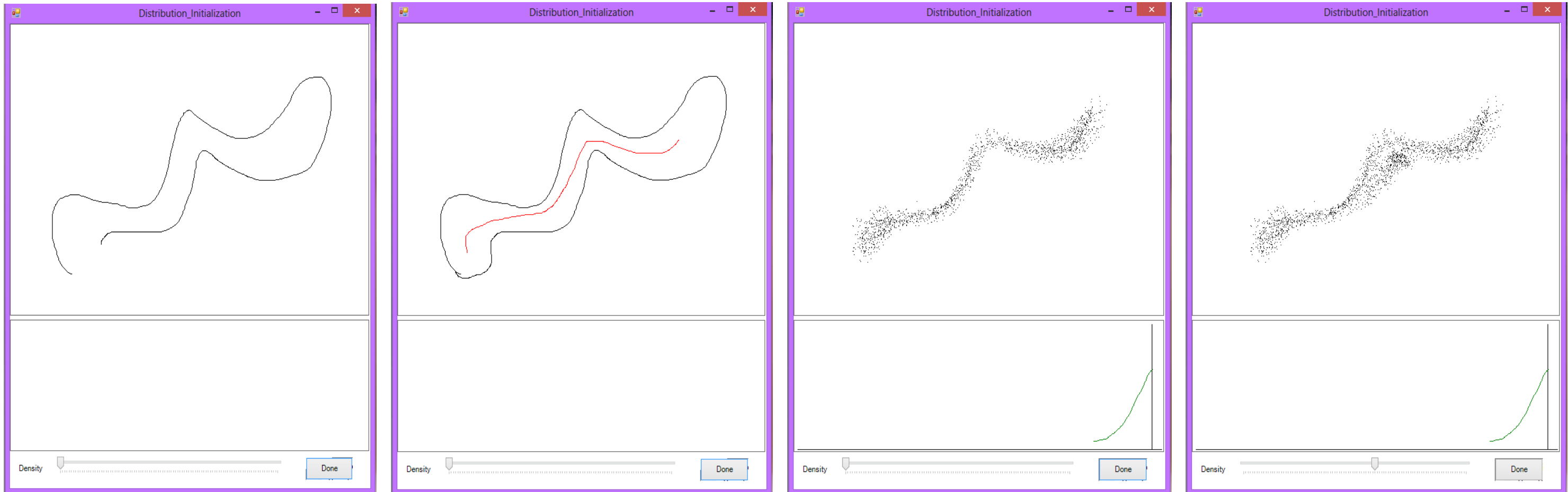
Show Axis On The Map
Show Trajectory
Show Projections



Axis-Aligned Mode
Repair points

Interactions with non Axis-aligned Scatterplots

- **Point Generation**

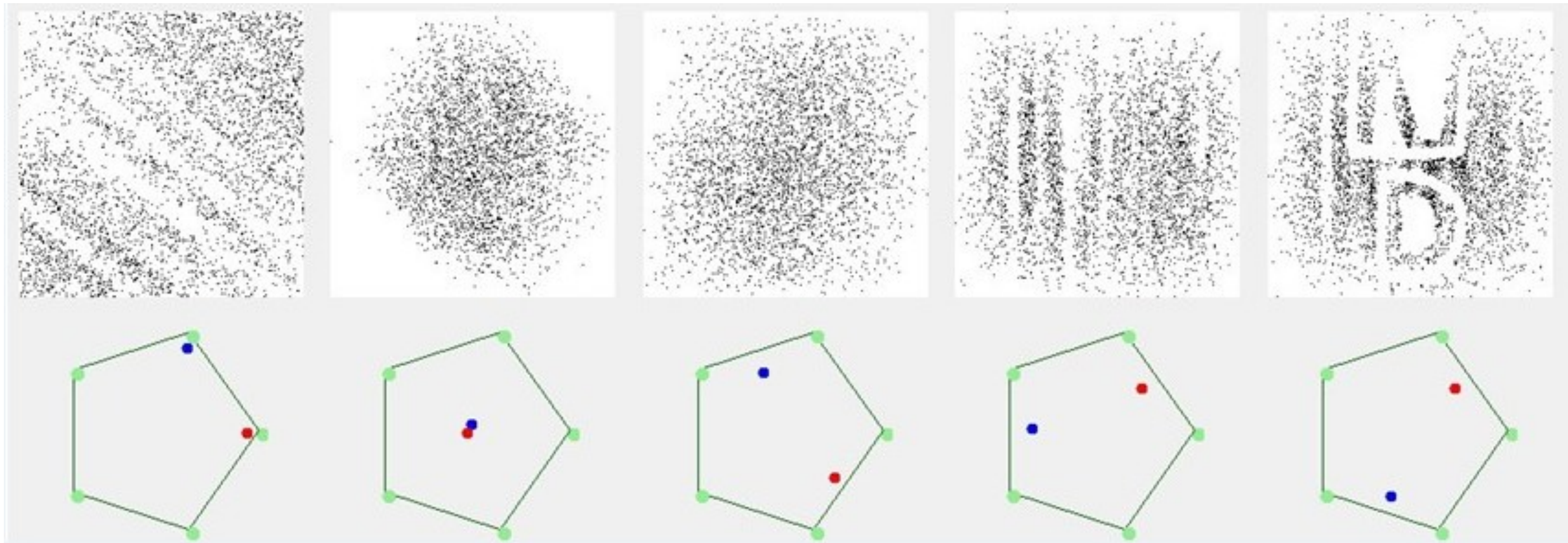


Interactions with non Axis-aligned Scatterplots

- **Point Generation**
 - Distribution Backprojection
 - Gram-Schmidt \longrightarrow new coordinate system
 - Same backprojection algorithm for new system
 - Rotation

Interactions with non Axis-aligned Scatterplots

- **Point Sculpting**
 - Distribution Carving

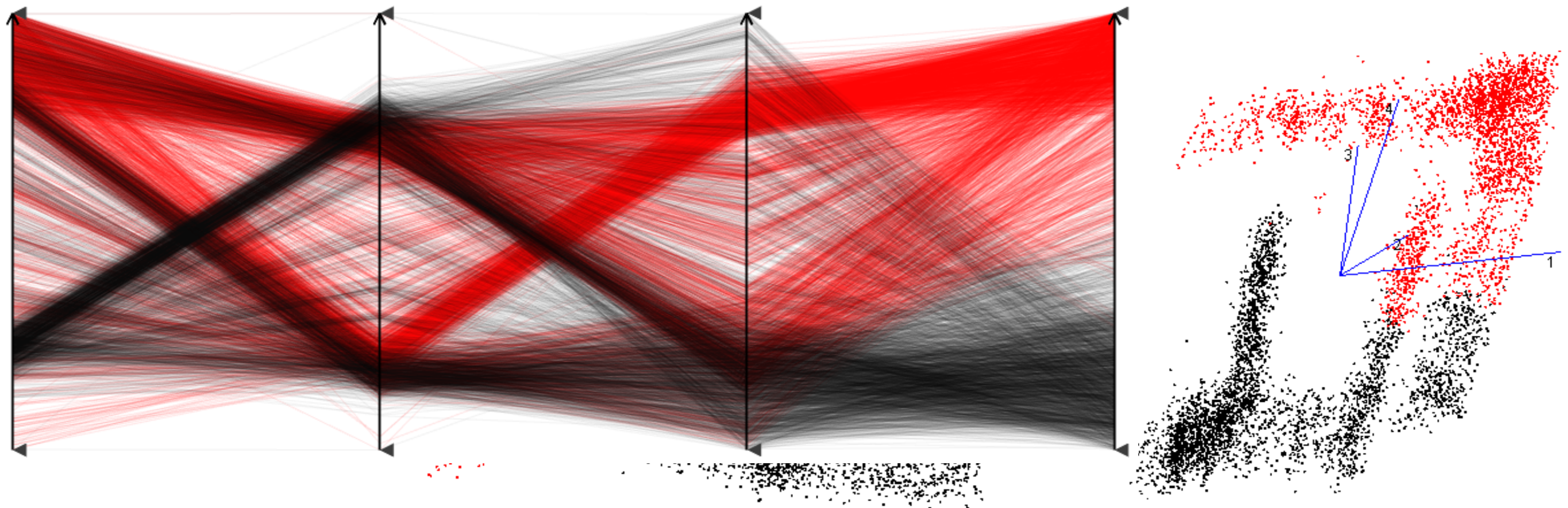


Interactions with non Axis-aligned Scatterplots

- **Point Sculpting**
 - Distribution Repair
 - Problematic since selected projections are not guaranteed to be orthogonal.
 - Current solution: bring all points back

Use Case

- Assume you want to test robustness of a given clustering algorithm
- Use our framework to create a dataset that challenges it



- Now it is clear that a more sophisticated clustering scheme is needed

Conclusion and Future Work

Conclusion and Future Work

- Data generation and data visualization at the same time
 - Precise control
 - Easy to use
 - As opposed to Albuquerque et al. (2.5D) our interface is truly N-D
- Future work
 - Line/Curve drawing widget
 - Better support for categorical data
 - Non axis-aligned distribution repair

Thank you

- Support provided by
 - NSF
 - Ministry of Korea Knowledge Economy
 - Chulalongkorn University
 - Fulbright International Science & Technology Awards

