Radial Projection Techniques

InfoVis SS2020

G4

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Radial Projection Basics

- Also known as: Radial Axis Projection
- Multidimensional data is mapped to a 2D plane.
- Data records are represented as 2D points.
- Dimensions are represented as radially laid out base vectors.
- Different methods provide additional functionalities:
  - Normalized mapping
  - Optimization steps
  - Clustering

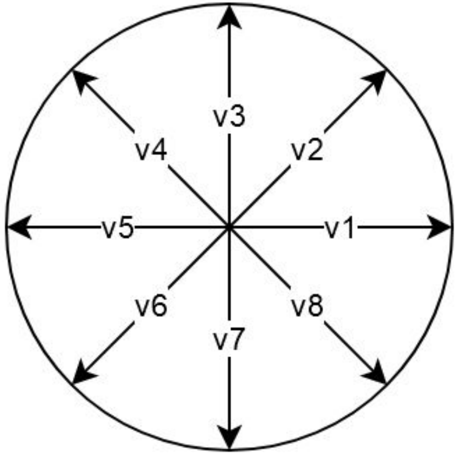


Figure 1: Radial axis layout
[Graphic created by Georg Regitnig using draw.io]

Coarse vs. Exact Mappings

- Coarse mappings
    - Data is represented as a single point on a 2D plane.
    - Not trivial to recover the exact values from this point.
    - This includes the radial projection techniques we will present.
    - Provide a simplified view, but introduce ambiguity.
- Exact mappings
    - Data records are represented by one visual per dimension.
        - For example: Multiple line segment intersections.
    - Exact data values can be recovered.
    - Examples include:
        - Parallel Coordinates
        - Star Plots: Are not a radial projection even though the axes are layed out radially.

Radial Projection Techniques Covered

- We will present:
  - Star Coordinates
  - RadViz
  - Dust and Magnet
- There exist more:
  - GBC Plot
  - Gravi++
  - FreeViz
  - ...

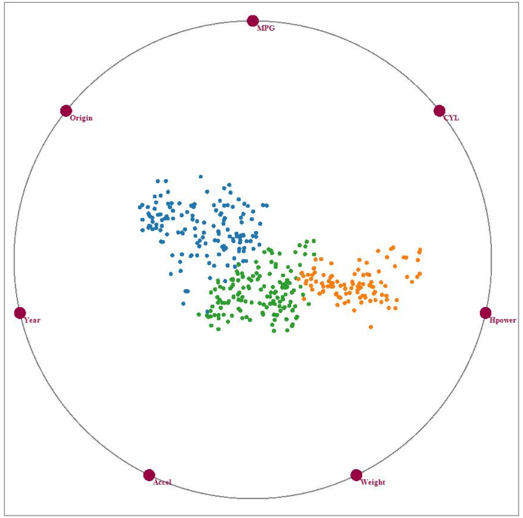


Figure 2: Basic radial projection using GBC Plot
[Graphic created by Lukas Neuhold using GBC Error Explorer]

- Cheng, Shenghui, and Klaus Mueller. "Improving the fidelity of contextual data layouts using a generalized barycentric coordinates framework." *2015 IEEE Pacific Visualization Symposium (PacificVis)*. IEEE, 2015.

The Cereals Dataset

- Classic dataset
- It is a dataset about cereals, their manufacturer and nutritional values.
- ~16 dimensions
- 78 data entries

	name	calories	protein	fat	sodium	fiber	carbo	sugars	potass	vitamins	weight	cups	rating
1	100% Bran	70	4	1	130	10	5	6	280	25	1	0.33	68.402973
2	100% Natural Br	120	3	5	15	2	8	8	135	0	1	1	33.983679
3	All-Bran	70	4	1	260	9	7	5	320	25	1	0.33	59.425505
4	All-Bran with Ext	50	4	0	140	14	8	0	330	25	1	0.5	93.704912
5	Almond Delight	110	2	2	200	1	14	8	-1	25	1	0.75	34.384843
6	Apple Cinnamon	110	2	2	180	1.5	10.5	10	70	25	1	0.75	29.509541
7	Apple Jacks	110	2	0	125	1	11	14	30	25	1	1	33.174094
8	Basic 4	130	3	2	210	2	18	8	100	25	1.33	0.75	37.038562
9	Bran Chex	90	2	1	200	4	15	6	125	25	1	0.67	49.120253
10	Bran Flakes	90	3	0	210	5	13	5	190	25	1	0.67	53.313813
11	Cap'n'Crunch	120	1	2	220	0	12	12	35	25	1	0.75	18.042851
12	Cheerios	110	6	2	290	2	17	1	105	25	1	1.25	50.764999
13	Cinnamon Toast	120	1	3	210	0	13	9	45	25	1	0.75	19.823573
14	Clusters	110	3	2	140	2	13	7	105	25	1	0.5	40.400208
15	Cocoa Puffs	110	1	1	180	0	12	13	55	25	1	1	22.736446
16	Corn Chex	110	2	0	280	0	22	3	25	25	1	1	41.445019
17	Corn Flakes	100	2	0	290	1	21	2	35	25	1	1	45.863324
18	Corn Pops	110	1	0	90	1	13	12	20	25	1	1	35.782791

Figure 3: Tabular overview of the cereal dataset

Star Coordinates

- Each dimension in a sample is multiplied with respective axis' unit vector.
- The mapped point is the sum of all these vectors (Vector Sum).
- Values can be negative.
- The mapping is linear, no normalization is done.
- Records can be mapped to points outside the unit circle.
- Showcase Video: https://youtu.be/s6BtKPkK6gs

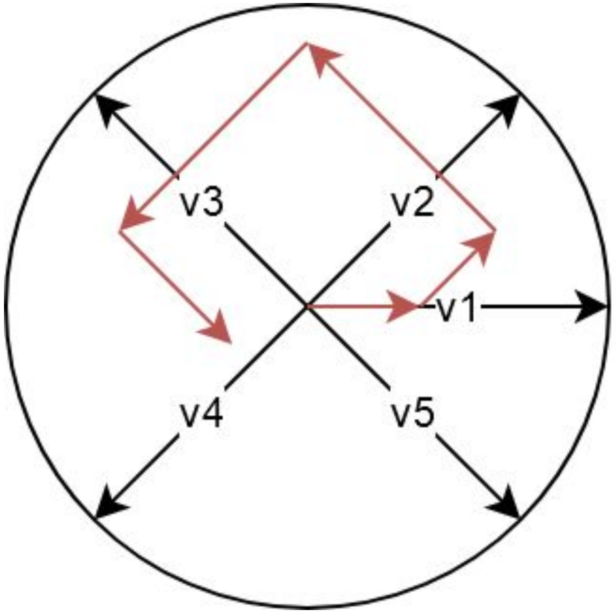


Figure 4: Star Coordinates Vector Sum
[Graphic created by Georg Regitnig using draw.io]

- Kandogan, Eser. "Star coordinates: A multi-dimensional visualization technique with uniform treatment of dimensions." *Proceedings of the IEEE Information Visualization Symposium*. Vol. 650. Citeseer, 2000.

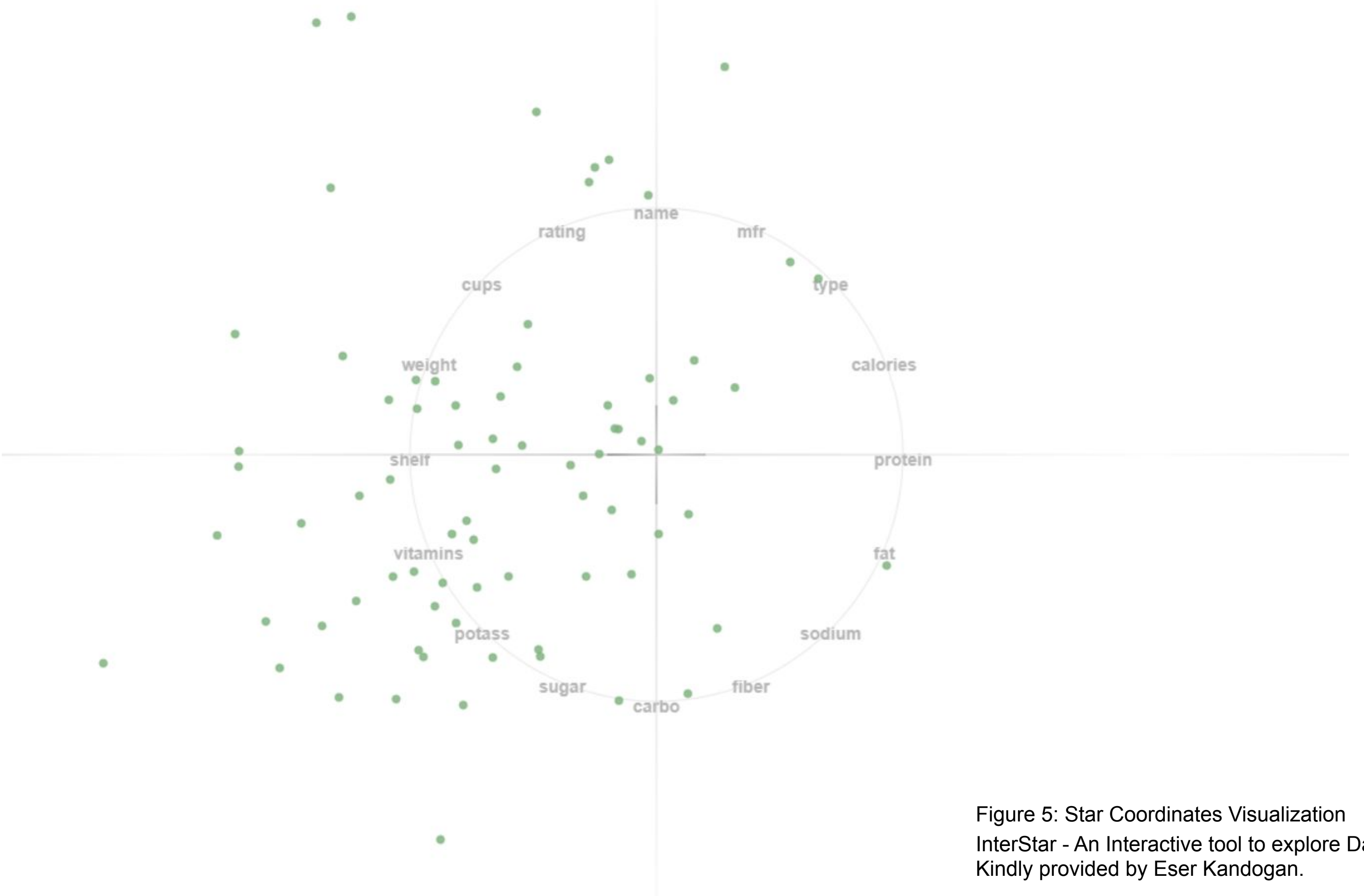


Figure 5: Star Coordinates Visualization
InterStar - An Interactive tool to explore Data.
Kindly provided by Eser Kandogan.

InterStar - Showcase Video

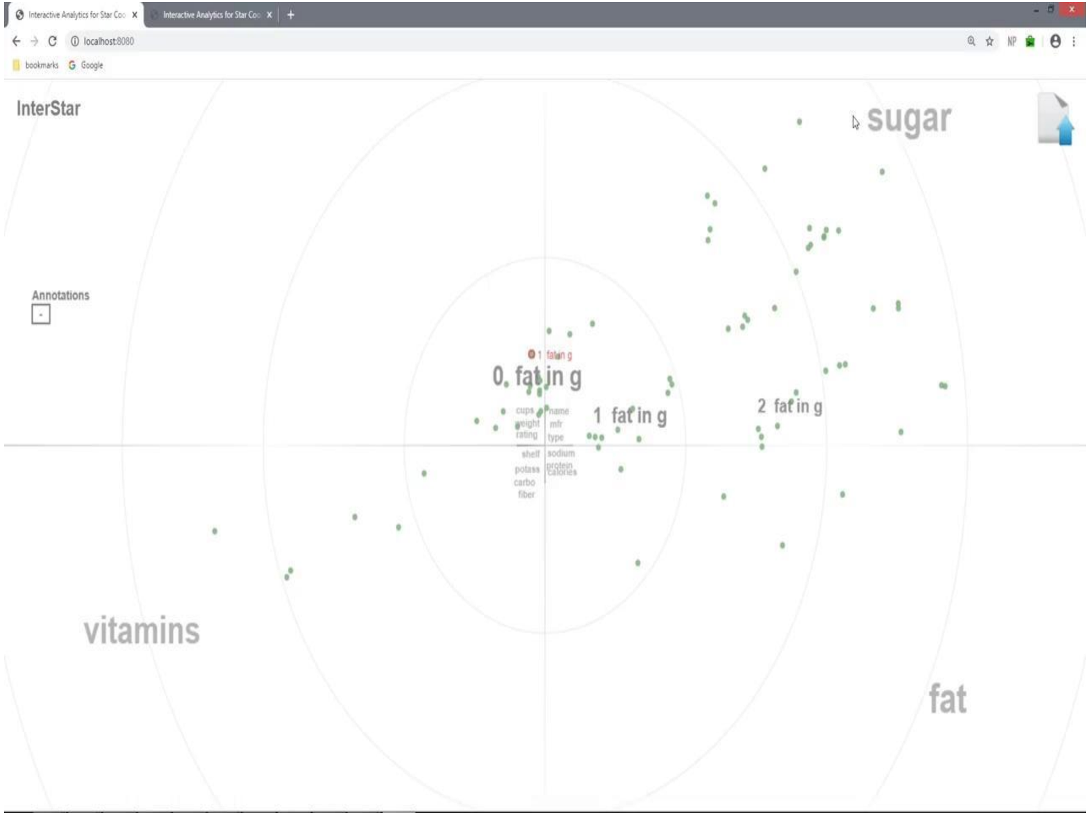


Figure 6: Star Coordinates - Example Mapping
InterStar - An Interactive tool to explore Data.
Kindly provided by Eser Kandogan.

RadViz

- Projection follows a physical spring model.
- Values must be non-negative.
- Value in one dimension defines how strong the point is pushed towards the anchor.
- Mapping contains a normalization step:
  - Value is considered with respect to all other dimensions of the record.
  - If all dimensions have the same value, a sample maps to the anchor points’ center of mass.
- All mappings are inside the circle.

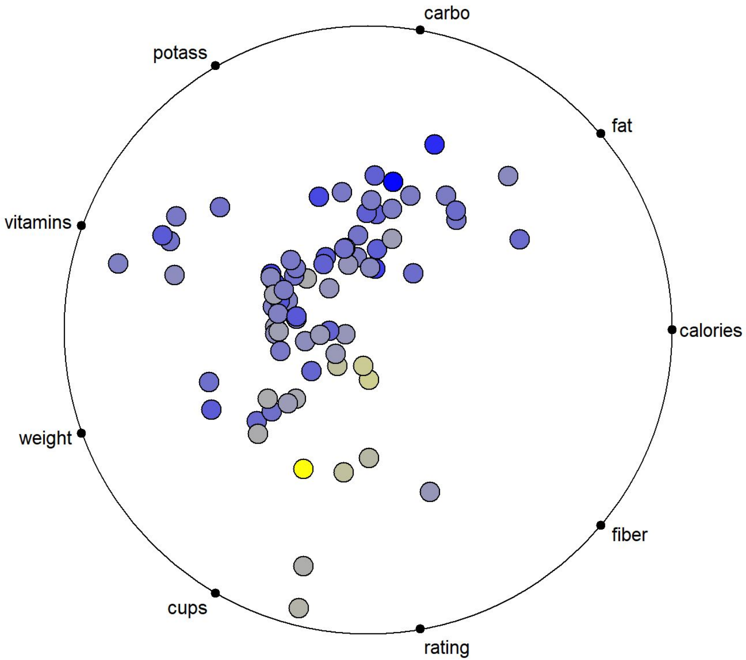


Figure 7: Basic RadViz visualization
[Screenshot made by Georg Regitnig from RadVizX]

- Patrick E. Hoffman “Table Visualizations: A Formal Model and its Applications”. PhD Thesis, University Massachusetts Lowell, 1999

RadVizX Tool

- Columns can be reordered.
- Color and size mapping can be assigned to a specific dimension.
- Shapes can be assigned to a certain interval within a specific dimension.
- Software (.jar files and .exe) available at http://www.cs.uml.edu/~phoffman/Radviz/
- Showcase video: https://youtu.be/t6XFbNVmXHc

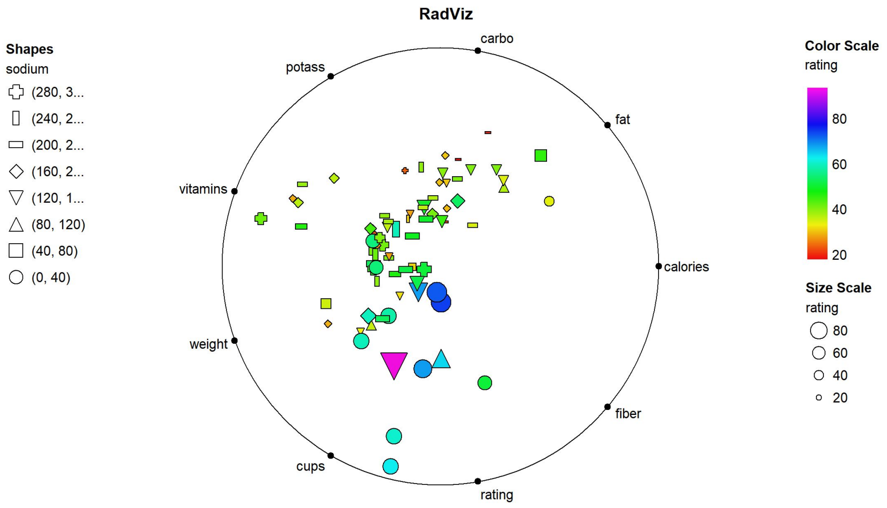


Figure 8: Different features of RadViz visualizations (color, size and shape)
[Screenshot made by Georg Regitnig from RadVizX]

Dust & Magnet

- Easily understood metaphor.
- Dimensions are magnets.
- Data records are dust.
- Animated over time to help understand data.
- Magnets can repulse dust as well as attract it.
- Tool from Ji Soo Yi's github: github.com/yijisoo/DnM

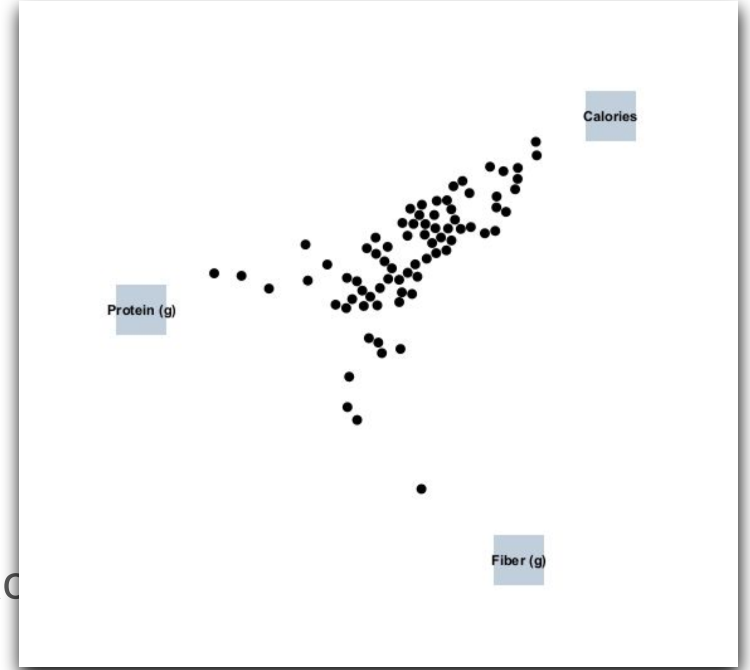


Figure 9: A simple visualization using Dust & Magnet [Graphic created by Lukas Neuhold using Dust & Magnet developed by Ji Soo Yi]

- Soo Yi, Ji, et al. "Dust & magnet: multivariate information visualization using a magnet metaphor." Information visualization 4.4 (2005): 239-256.

Dust & Magnet Tool - Magnets

- Choose which features appear as magnets.
- Place them freely in a scene.
- Drag them around to observe how data is affected.
- Change the magnitude of attraction or repulsion.

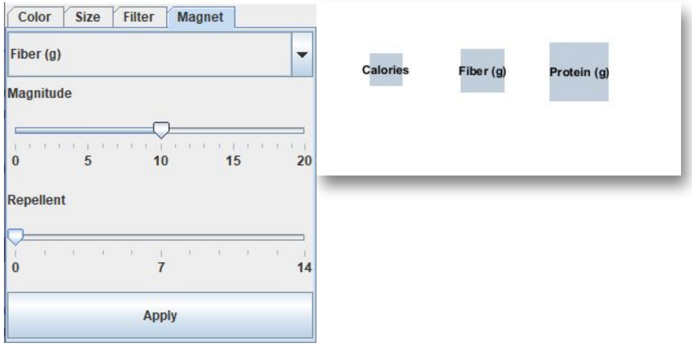


Figure 10: Attraction magnitude and repellent and how magnet size is affected

[Graphic created by Lukas Neuhold using Dust & Magnet developed by Ji Soo Yi]

Dust & Magnet Tool - Dust

- Simulated over time.
- Different Actions:
    - Filter data into subsets
    - Change size
    - Change color
    - Inspect to get detailed information
    - Spread dust out to minimize overlap
    - Animate manually
    - Recenter to restart simulation

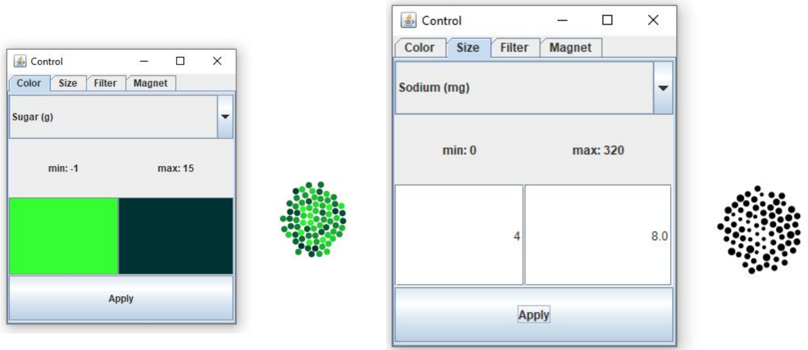


Figure 11: Color and size changes of dust particles
[Graphic created by Lukas Neuhold using Dust & Magnet developed by Ji Soo Yi]

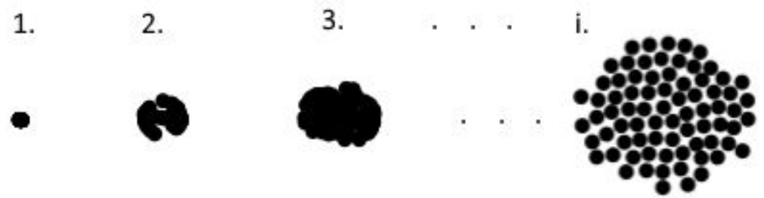
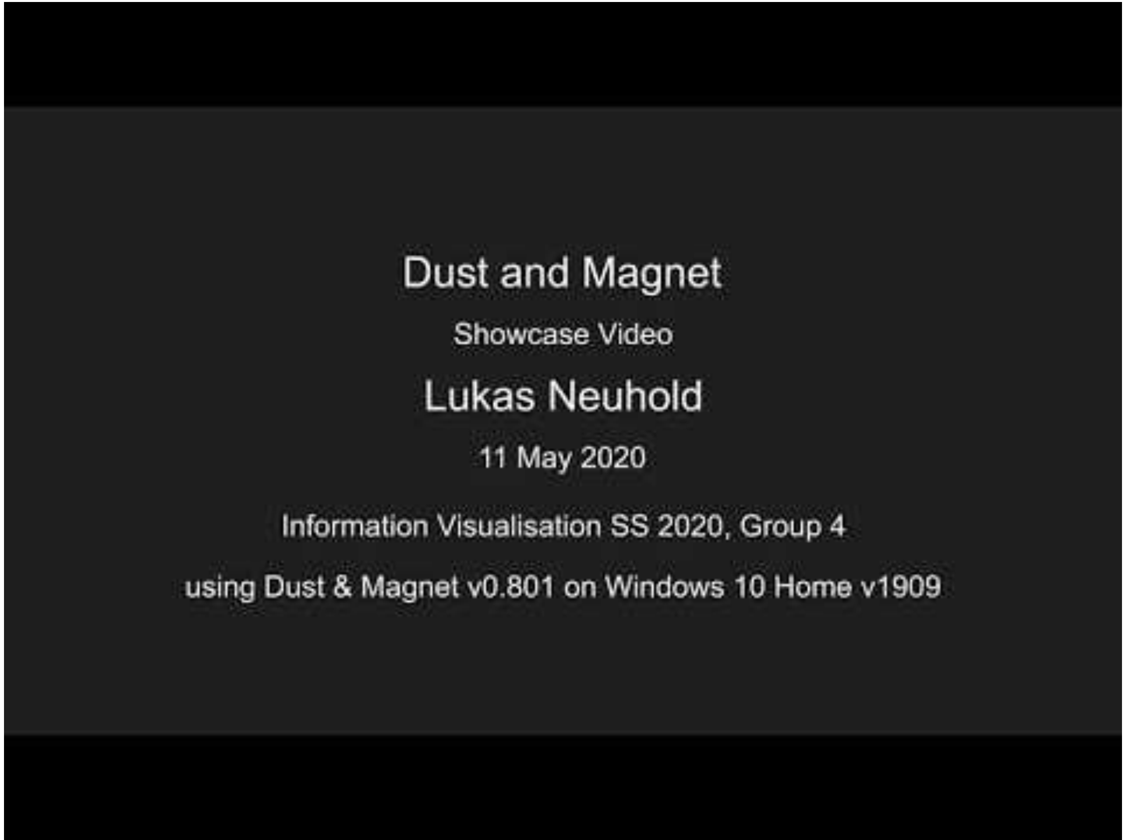


Figure 12: Spreading dust iteratively
[Graphic created by Lukas Neuhold using Dust & Magnet developed by Ji Soo Yi]

Dust & Magnet - In use



Dust & Magnet Tool

- Easy to use and learn.
- Quick and easy to find clusters.
- No support for common data formats.
- No easy way to reproduce results later.
    - Alleviated with snapshots feature

Further Optimizations

- FreeViz:
  - Clusters data based on optimization steps
- Orthographic Star Coordinates:
  - Better retain cluster shape from n-dimensional space to 2D space.

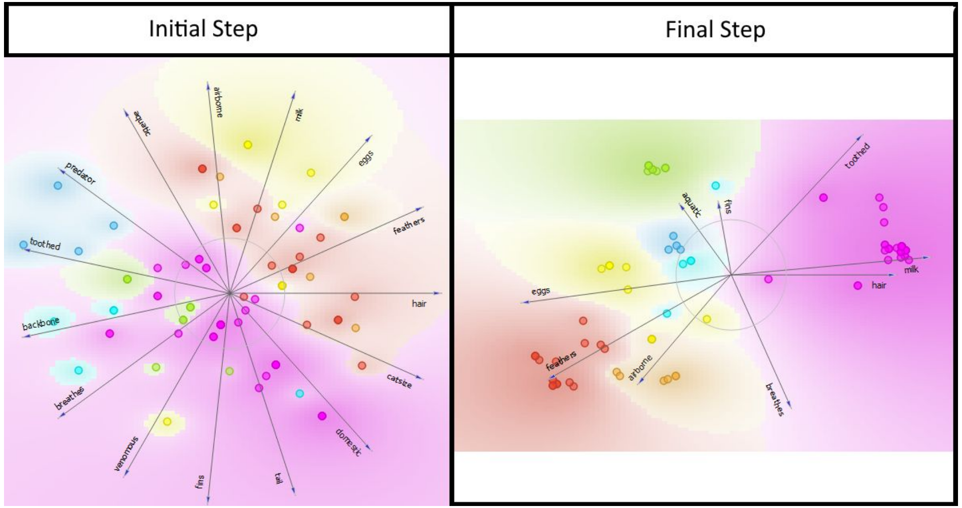


Figure 13: FreeViz clustering on the animals data set [Graphic created by Ridvan Aydin and Lukas Neuhold using Orange 3]

- Lehmann, Dirk J., and Holger Theisel. "Orthographic star coordinates." *IEEE Transactions on Visualization and Computer Graphics* 19.12 (2013): 2615-2624.
- Demšar, Janez, Gregor Leban, and Blaž Zupan. "FreeViz—An intelligent multivariate visualization approach to explorative analysis of biomedical data." *Journal of biomedical informatics* 40.6 (2007): 661-671.
- orange.biolab.si

Conclusion

- Different methods offer different advantages:
  - Star Coordinates and Radviz easier to find clusters and correlation.
  - Dust & Magnet better to find specific data points and clusters.
- Know your aim before deciding on a technique.

Questions?