Improving the Fidelity of Contextual Data Layouts Using a Generalized Barycentric Coordinates Framework

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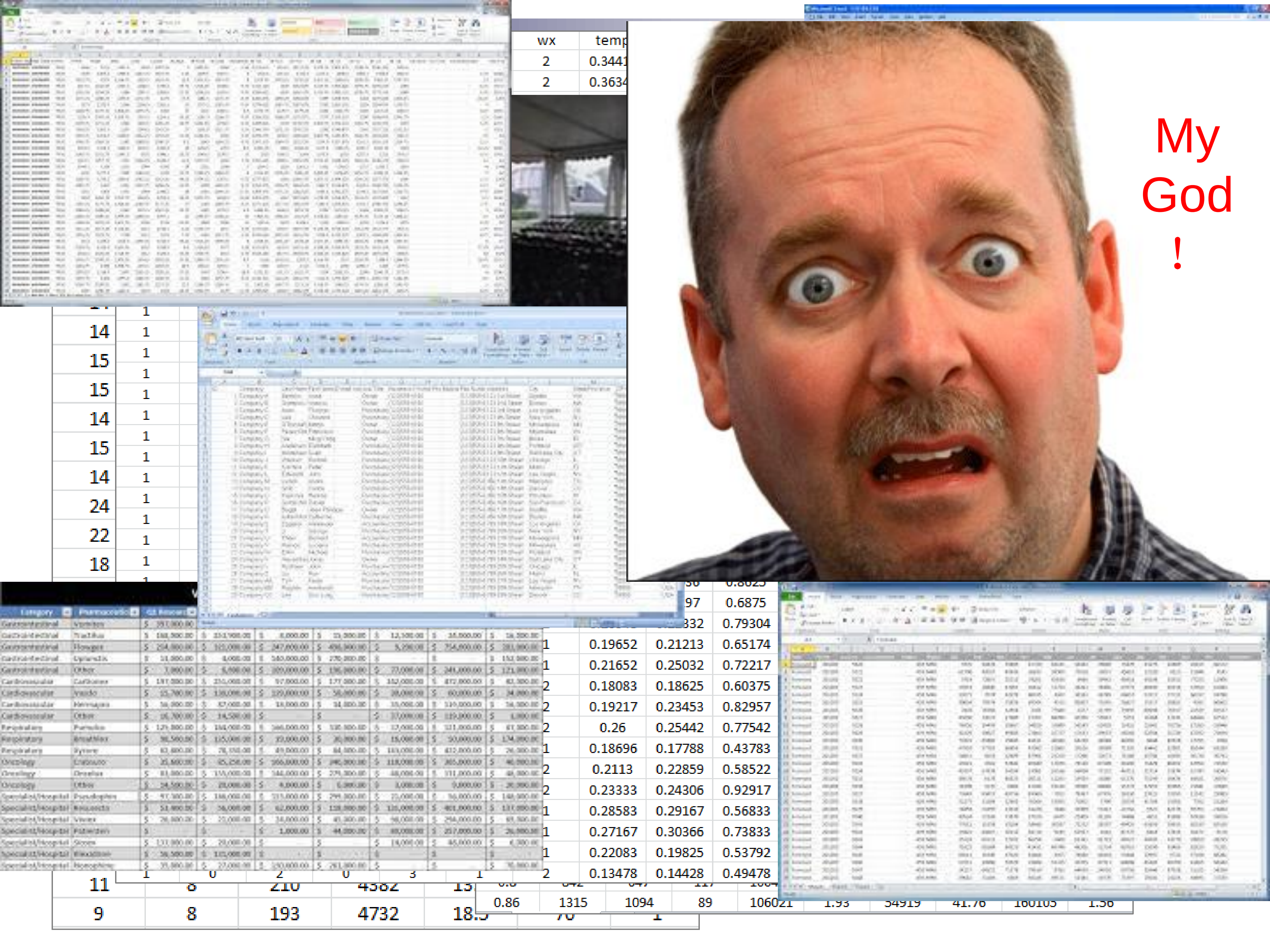
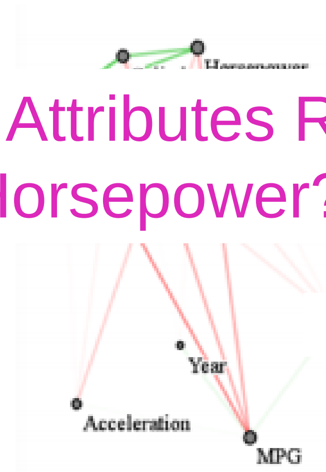

My
God
!

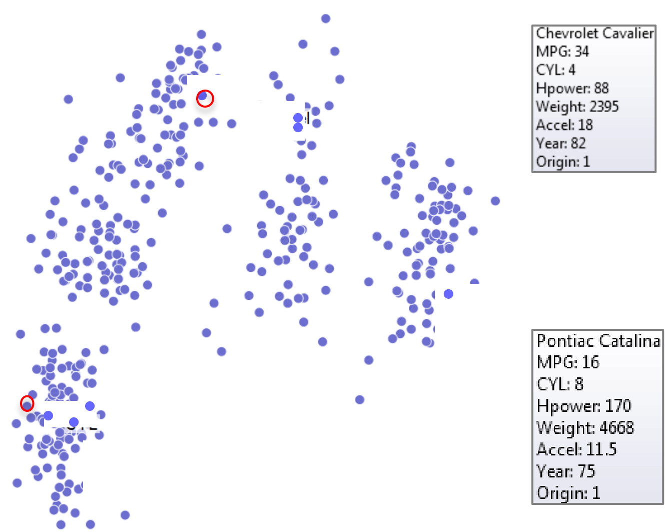
- Attributes (Variables) to Attributes Relation (e.g Horsepower and weight? Positive or negative?)



How to get the context, Data to Attributes Relation ? (which cars have high Horsepower?)

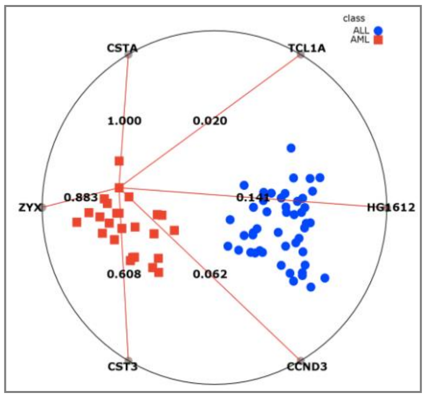
MPG	CYL	Hpower	Weight	Accel	Year	Origin
18	8	130	3504	12	70	1
15	8	165	3693	11.5	70	1
18						
16						
17						
15						
14						
14	8	215	4312	8.5	70	1
14	8	225	4425	10	70	1
15	8	190	3850	8.5	70	1
15	8	170	3563	10	70	1
14	8	160	3609	8	70	1
15	8	150	3761	9.5	70	1
14	8	225	3086	10	70	1
24	4	95	2372	15	70	3
22	6	95	2833	15.5	70	1
18	6	97	2774	15.5	70	1
21	6	85	2587	16	70	1
27	4	88	2130	14.5	70	3
26	4	46	1835	20.5	70	2
25	4	87	2672	17.5	70	2
24	4	90	2430	14.5	70	2
25	4	95	2375	17.5	70	2
26	4	113	2234	12.5	70	2
21	6	90	2648	15	70	1
10	8	215	4615	14	70	1
10	8	200	4376	15	70	1
11	8	210	4382	13.5	70	1
9	8	193	4732	18.5	70	1

- Data to Data Relation (which cars are similar? Cluster? Outliers?)

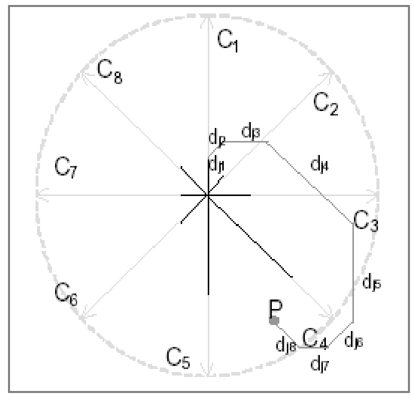


Contextual layouts

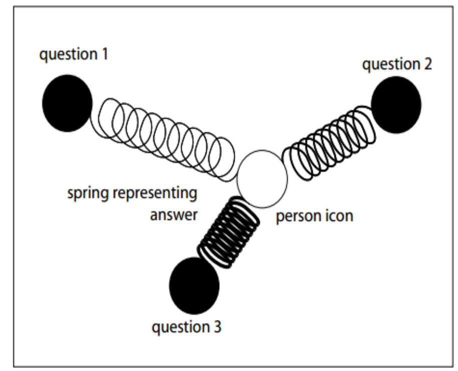
Radviz



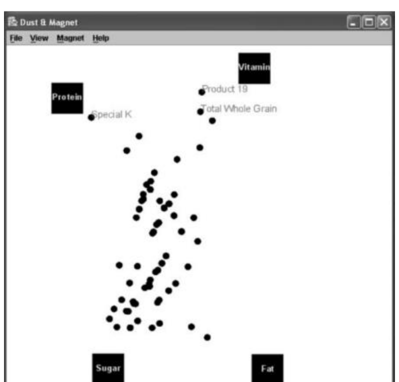
Star Coordinates



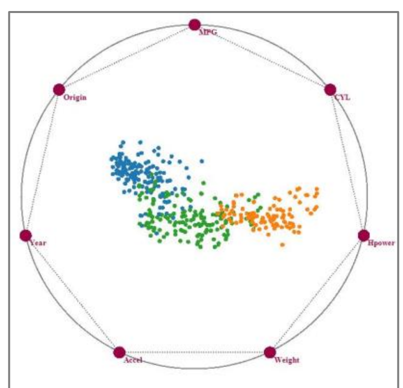
Gravi++



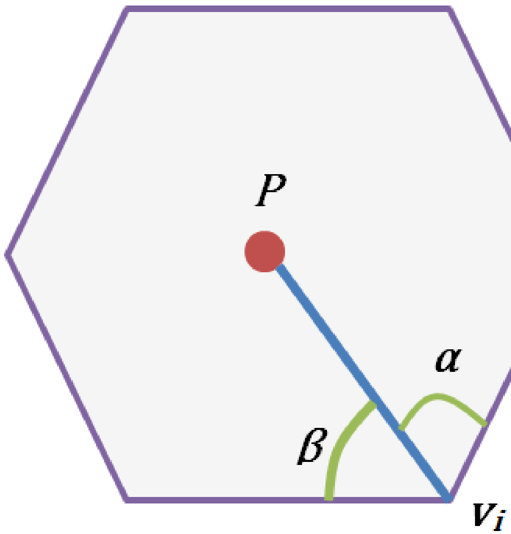
Dust & Magnet



Generalized Barycentric Coordinates



Generalized Barycentric Coordinates (GBC)



GBC interpolation

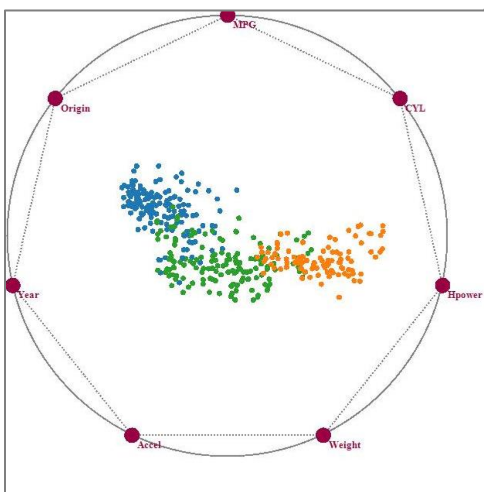
the interpolation weight w_i of vertex v_i for P is

$$w_i = \frac{\cot(\alpha)+\cot(\beta)}{\|P-v_i\|^2}$$

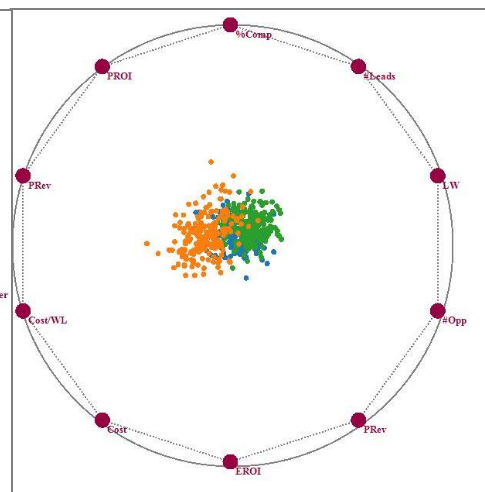
The interpolated value Pv at P is

$$Pv = \sum_{i=1}^{n} w_i v_i \text{ where } a_i = w_i / \sum_{k=1}^{n} w_k \text{ and } \sum_{i=1}^{n} a_i = 1$$

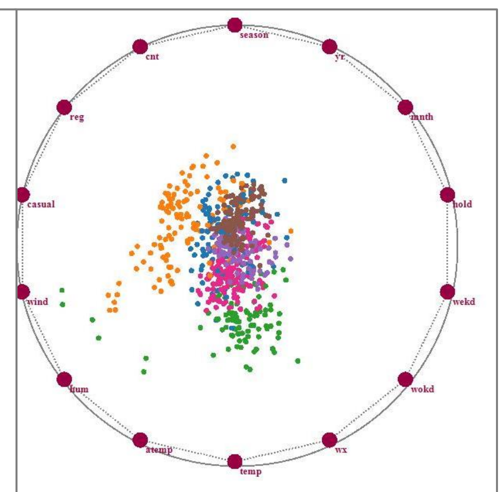
Car



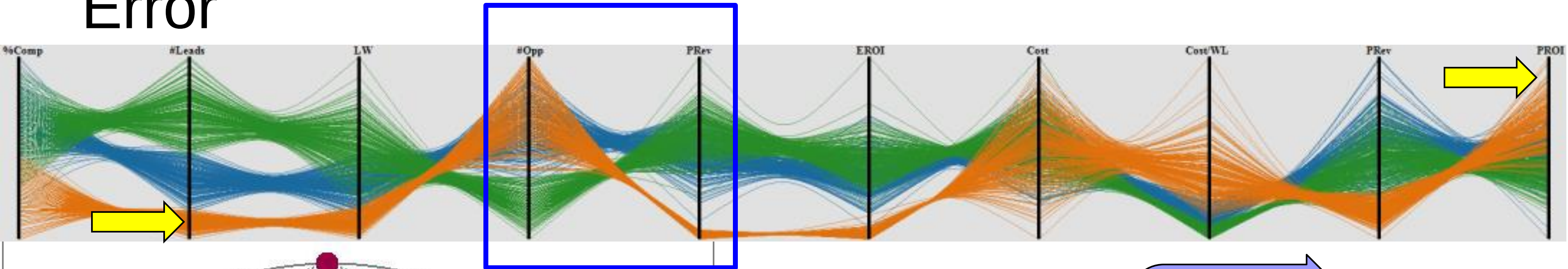
Sales Campaign

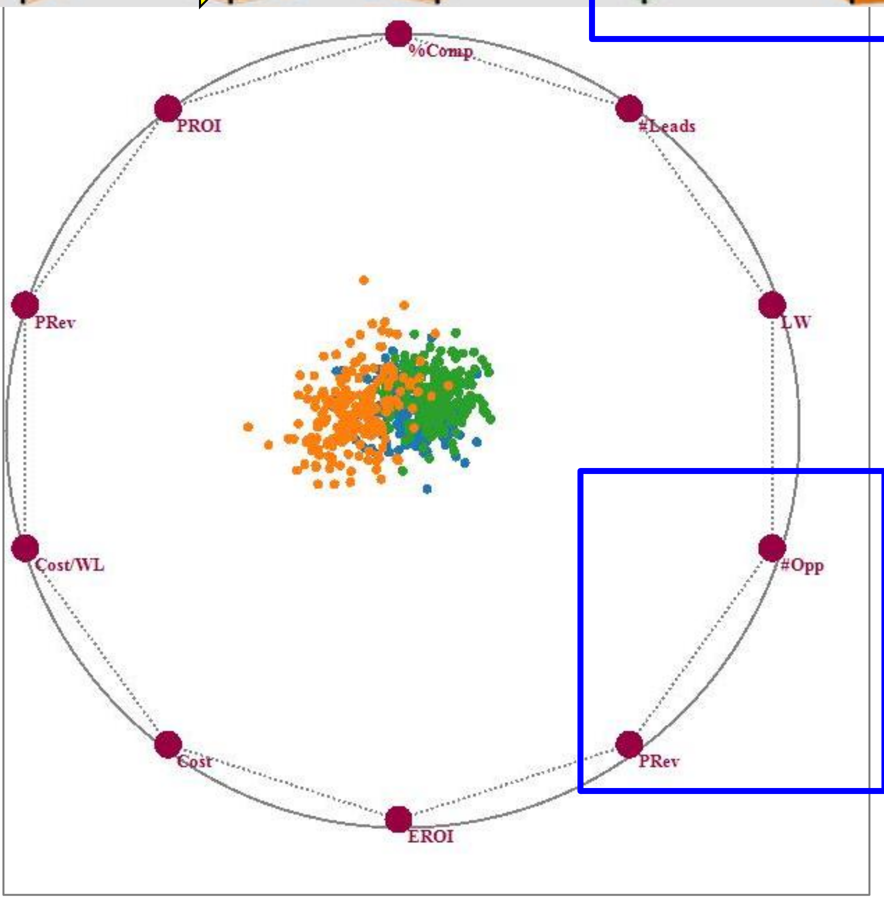


Bike



Error





Mapped

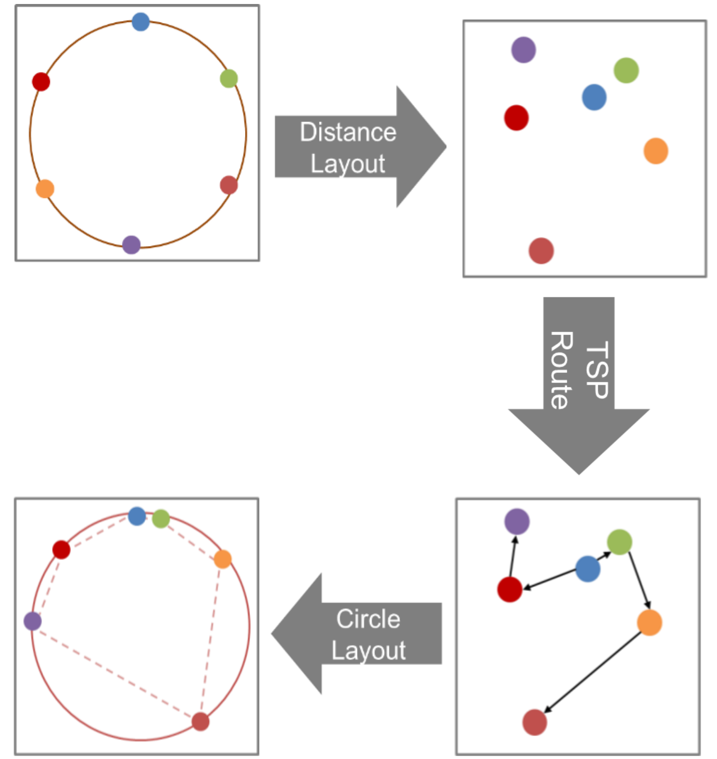
$$stress(L, C) = \sqrt{\frac{\sum_{ij}(L_{ij} - C_{ij})^2}{\sum_{ij} C_{ij}^2}}$$

Original

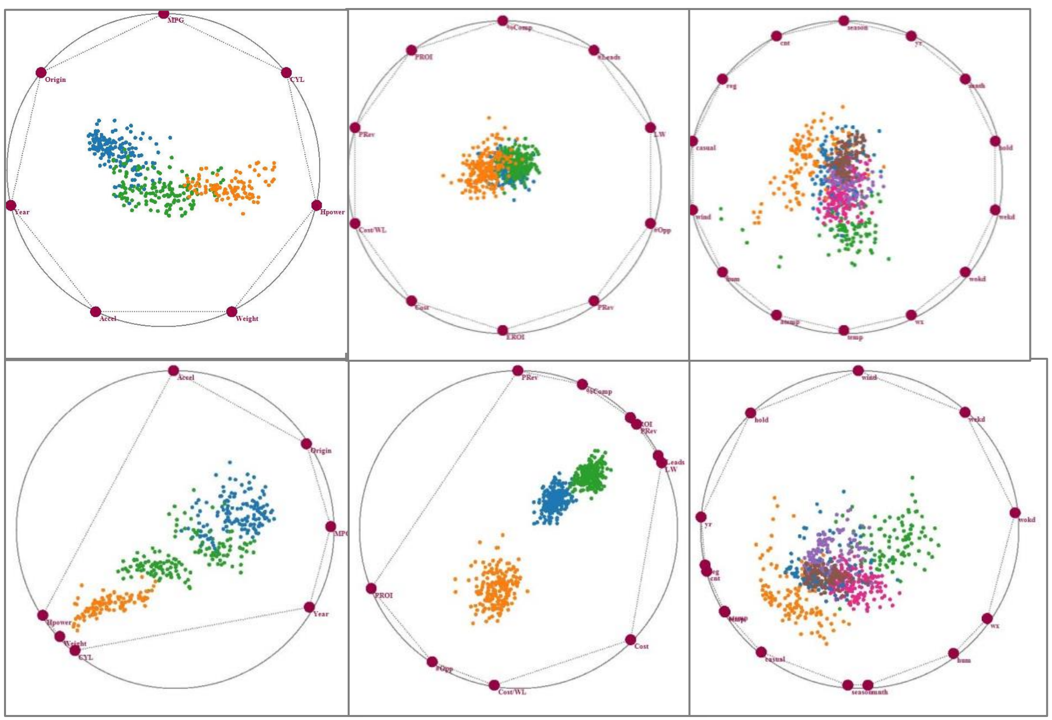
- Variables to Variables Error
- Data to Variables Error
- Data to Data Error

Variables to Variables Error - distance spaced layout

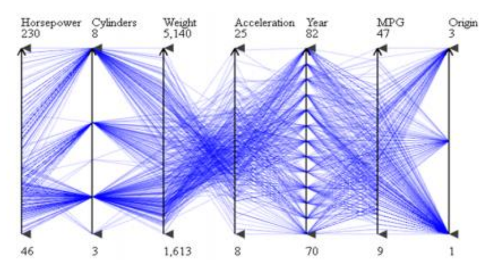
- Linear ordering of the vertices
  - Correlation matrix
  - Approximate Traveling Salesman Problem (TSP) for ordering
- Circle layout
  - Arrange on the circle, spaced with correlation



Car Sales Campaign Bike

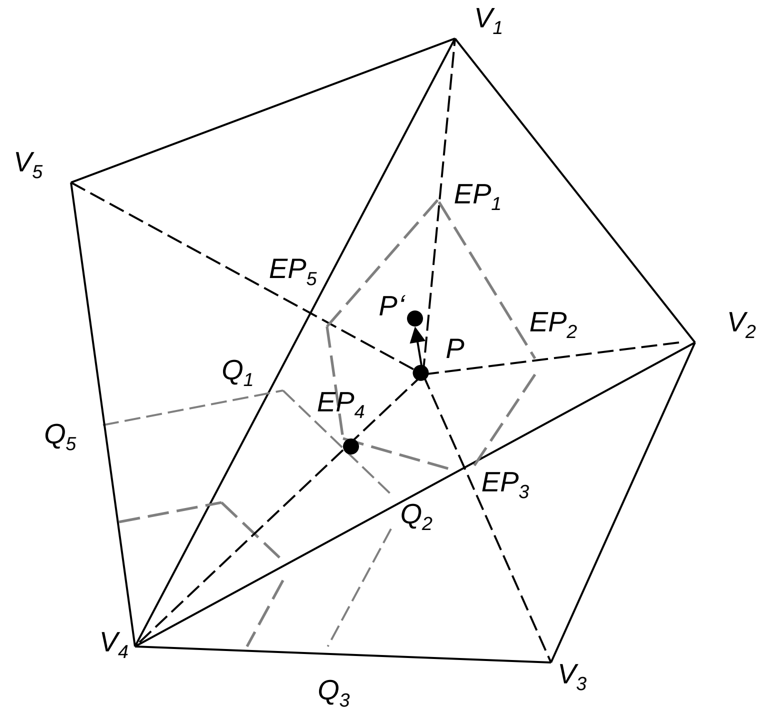


49% 85% 44%

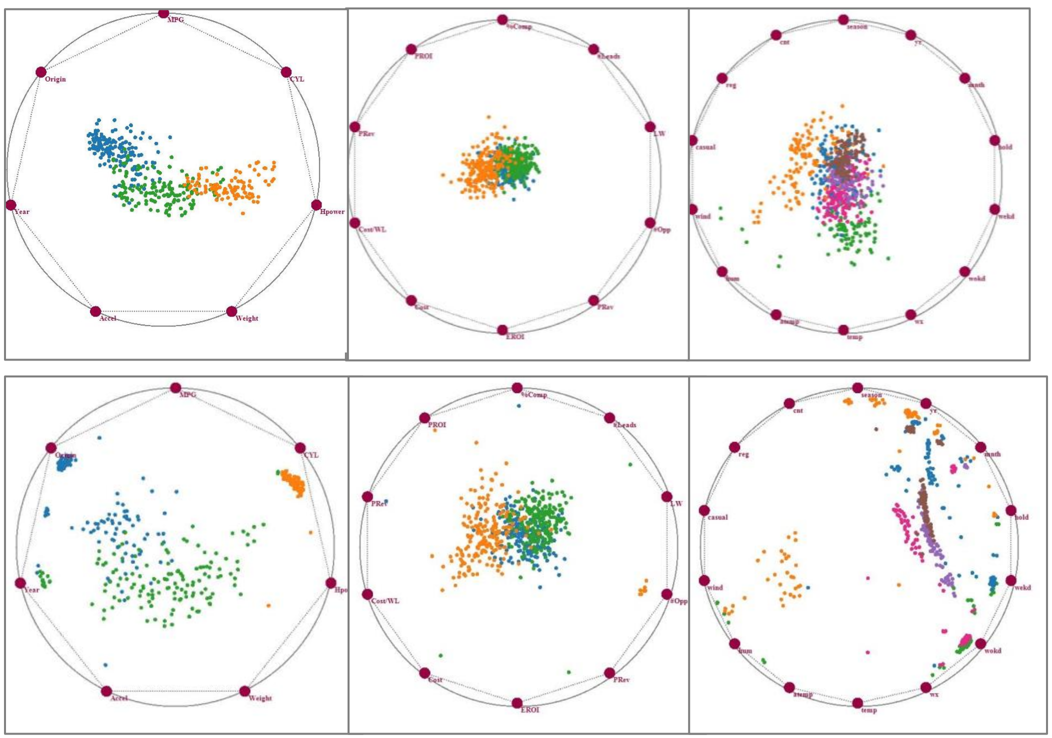


Data to Variables Error - iterative error reduction

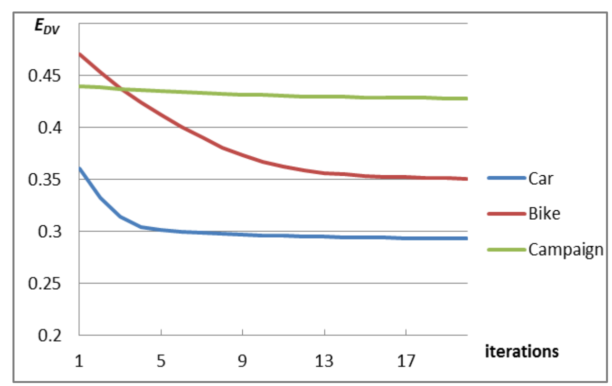
- Construct the iso-contours.
- Compute the error of each dimension
- Construct the error polygon
- Move to the center of polygon iteratively



Car Sales Campaign Bike

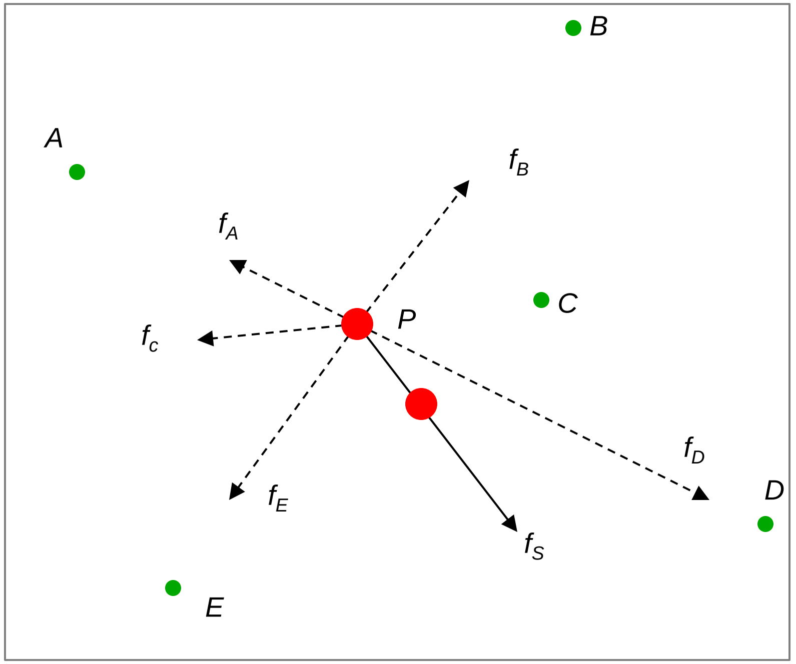


25% 2% 29%

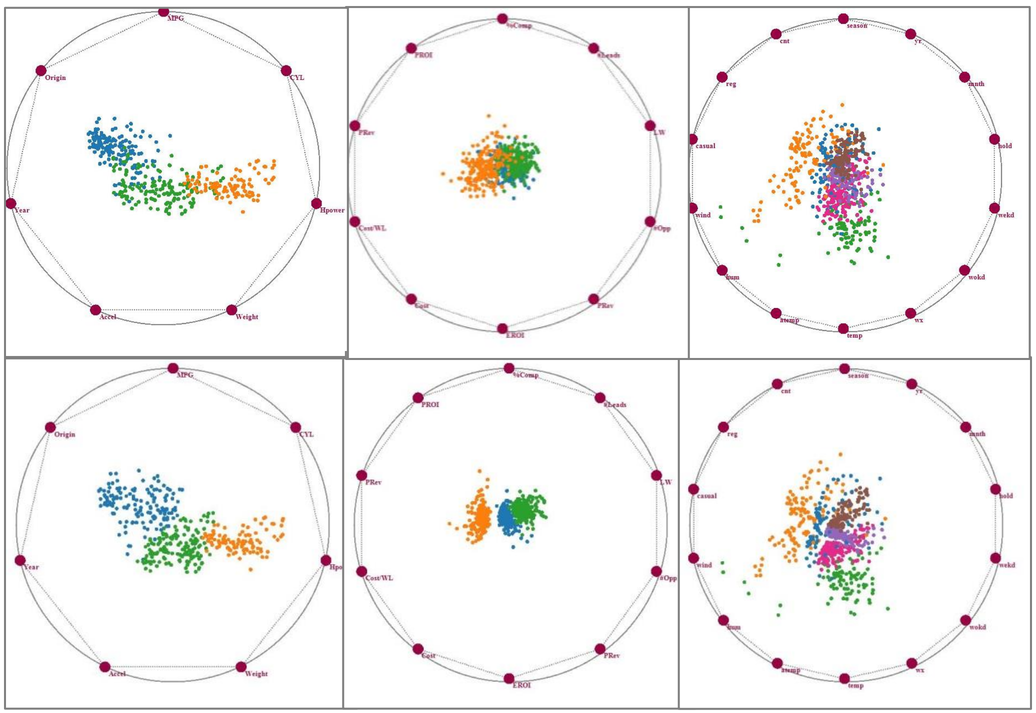


Data to Data Error - force directed adjustment

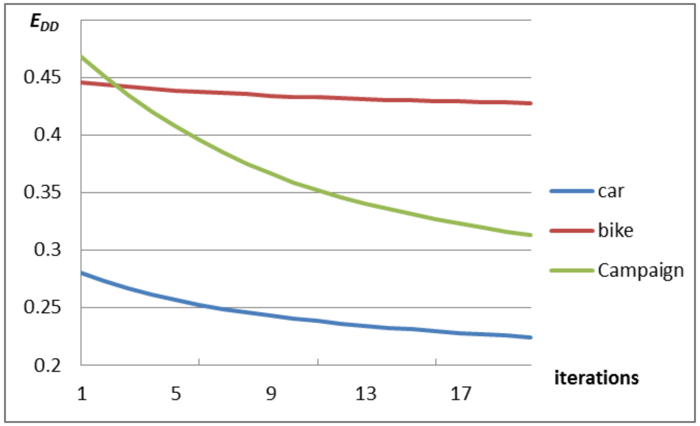
- Construct the Network
  vertices: data points
  edges: springs
  force: error *real distance – mapped distance*
- Drag or push the points in turn.



Car Sales Campaign Bike



28% 62% 5%



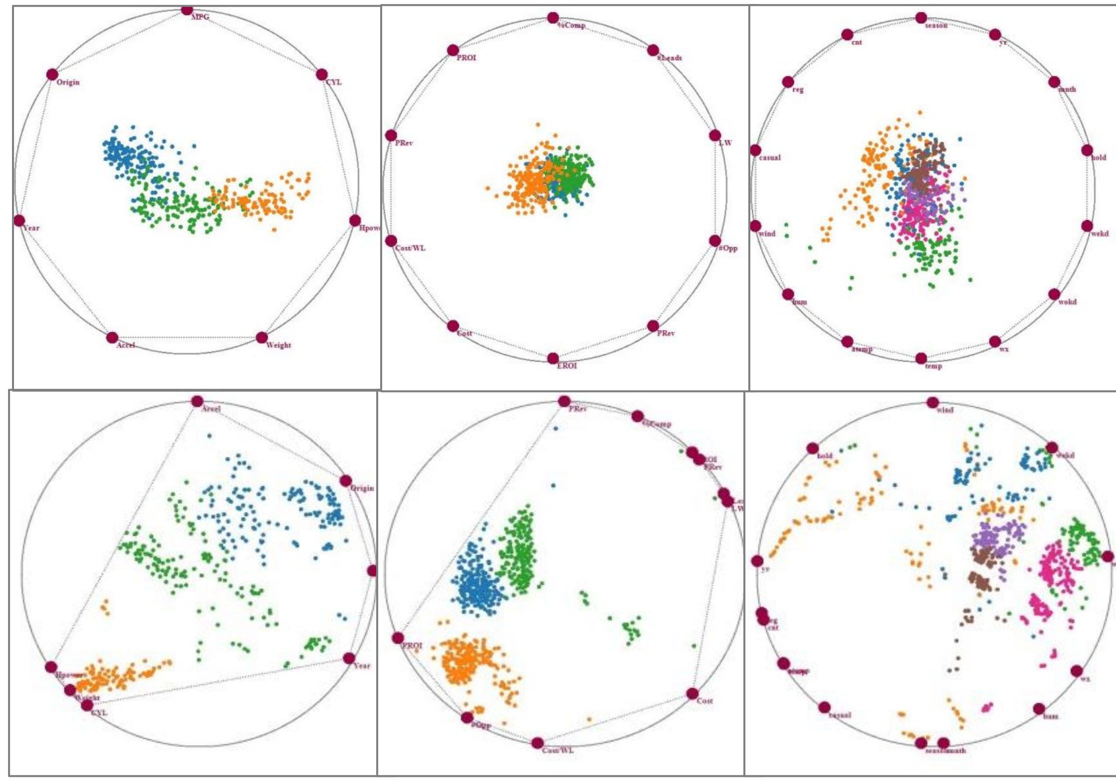
Finally – Combine together

Variables to Variables:
Distance spaced layout

Data to Variables:
Iterative error reduction

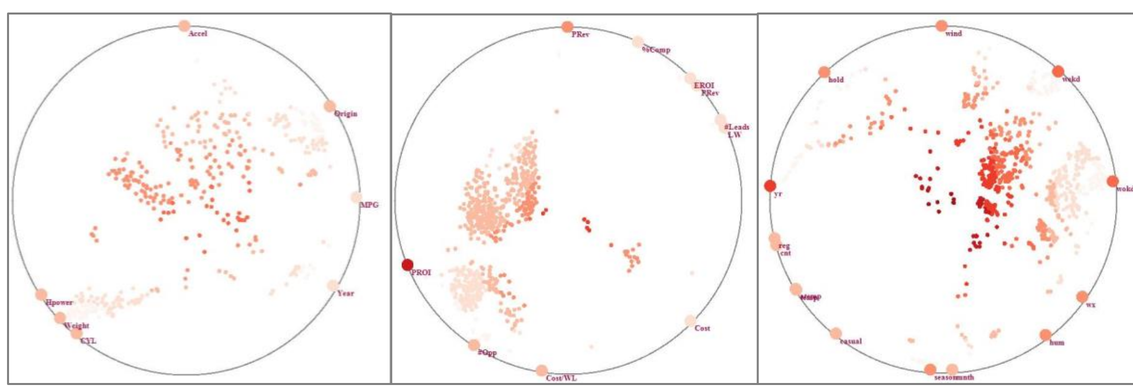
Data to Data:
Force directed adjustment

Car | Sales Campaign | Bike



44% | 78% | 41%

Error distribution

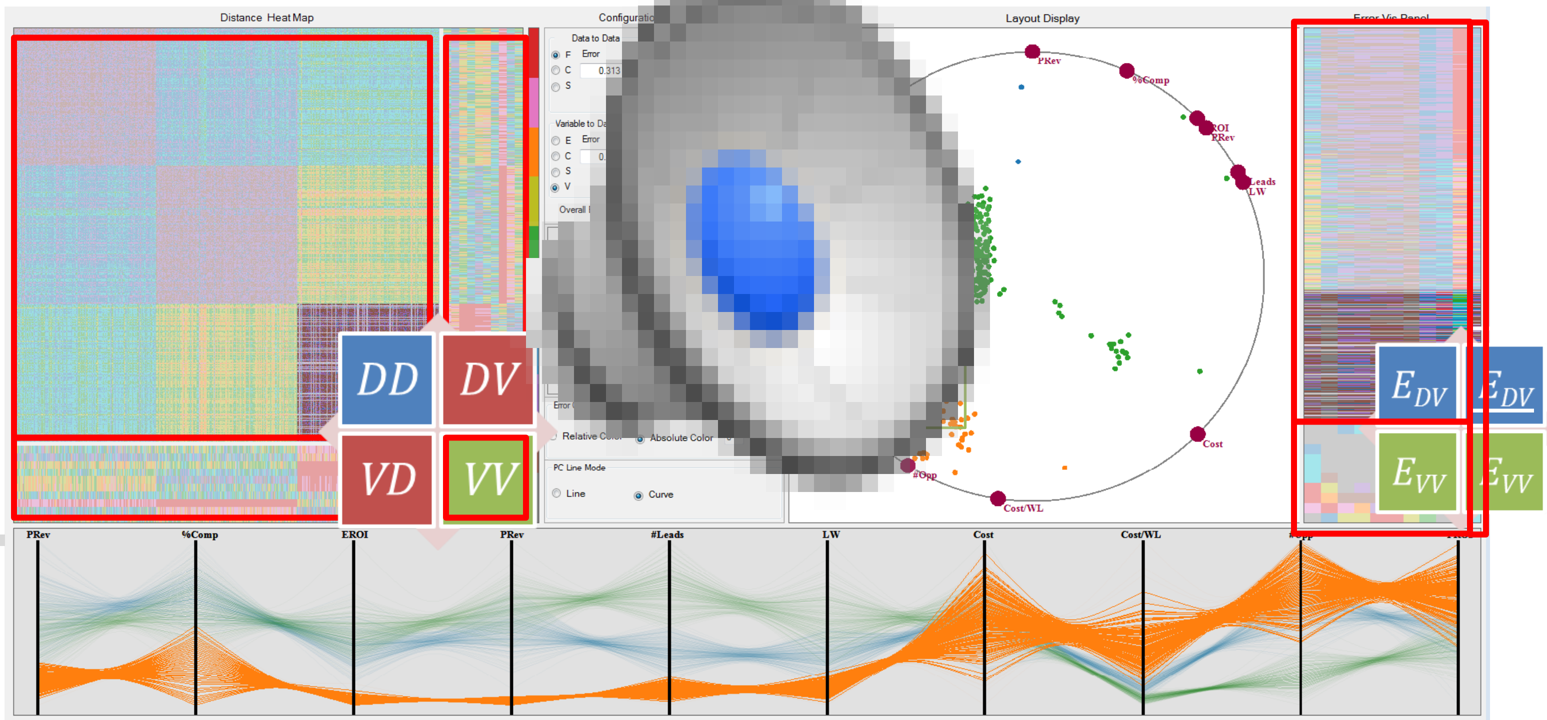


More Error ? – Data Overlap

[0.1, 0.2, 0.3],   [0.2, 0.4, 0.6] – same location ??

GBC Error Explorer - combining different visualization methods into a interface

Distance heatmap | Configuration Control Panel | Layout Display | Error Vis Panel



Parallel Coordinates Display

Conclusion and Future Work

Conclusion

- We unified the different contextual layouts.
- We proposed three algorithms – distance spaced layout, iterative error reduction and force directed adjustment – to reduce the error.
- We developed an interface by which users can explore the error by combining the different visualization schemes with interactions.

Future Work

- Attributes (variables) are arranged at the periphery of the data points. Better optimizations might be achievable by allowing the attribute points to mingle with the data points.

Reference

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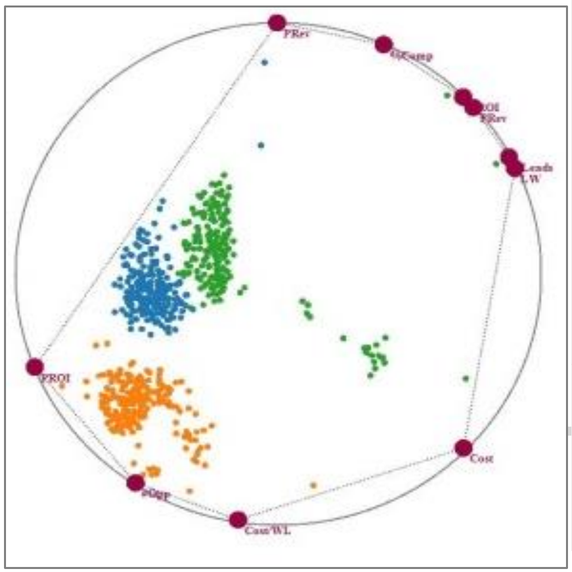
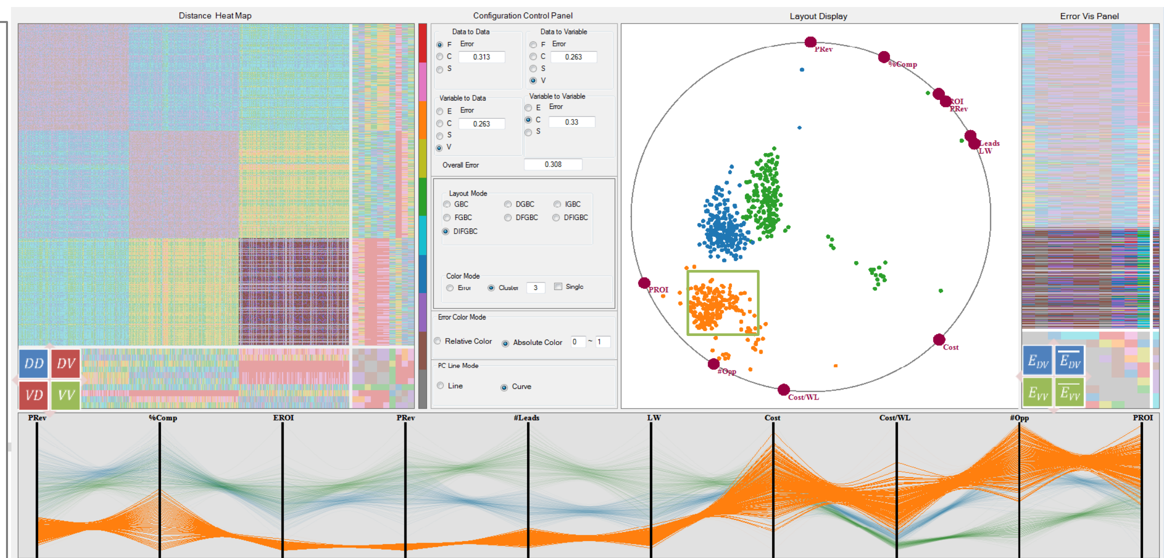
Questions ?

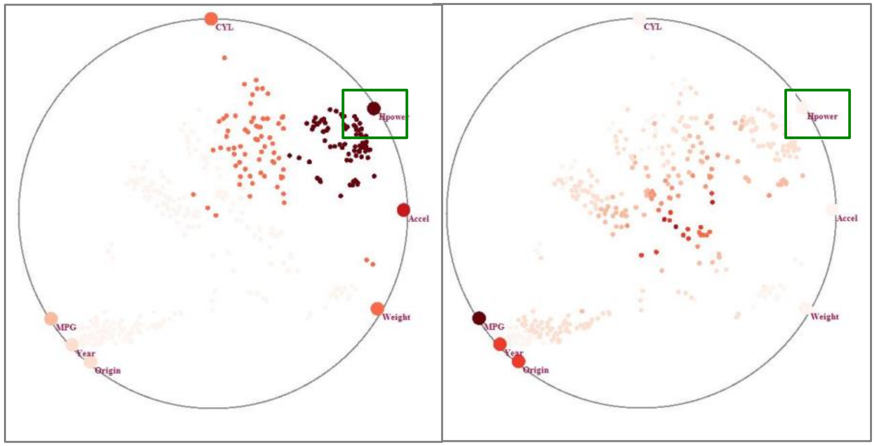
This research was partially supported by NSF grant IIS 1117132 and the MSIP, Korea, under the "IT Consilience Creative Program (ITCCP)" (NIPA-2013-H0203-13-1001) supervised by NIPA.

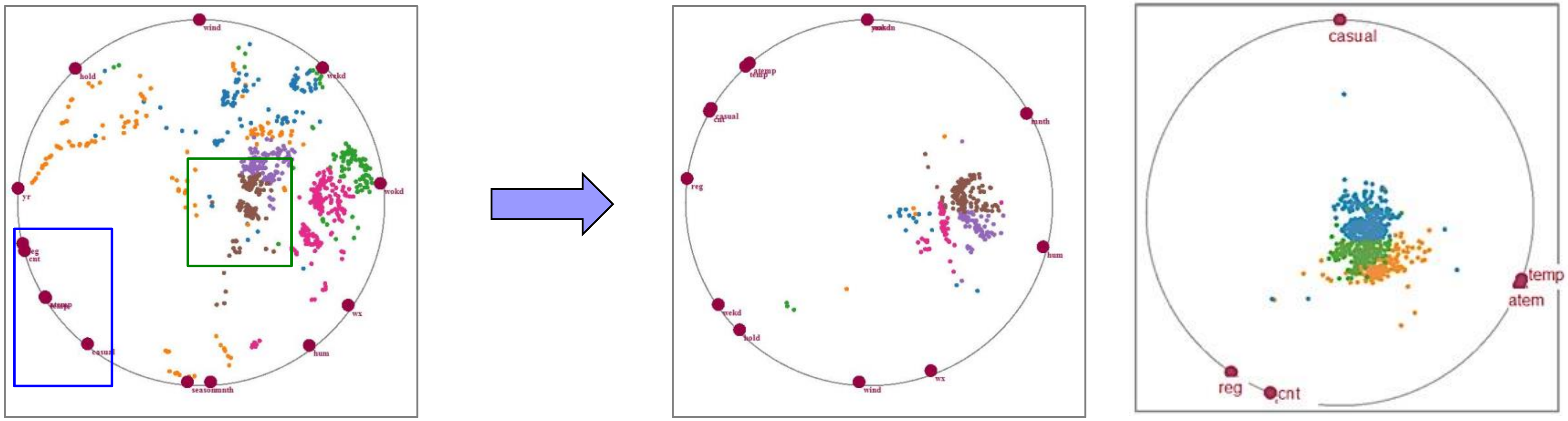




Interactions

- Verification coloring:
  Distance color and Error color
- Linked displays
- Local layout refinement
  Data-centric refinement and
  Variable-centric refinement

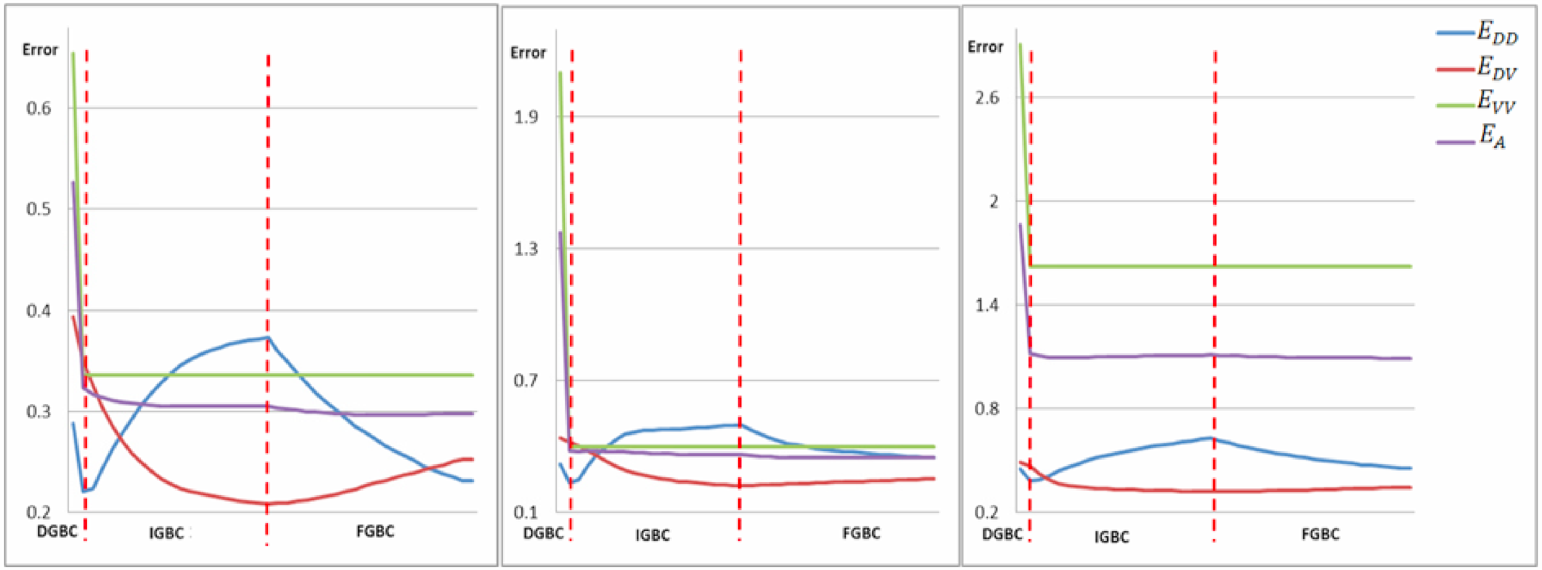




Unified Definition

Table 1. The features of different layout methods

Method	VF	MF (p_i)
Radviz	$v_i = \left(r \cdot \cos\frac{i}{2\pi}, r \cdot \sin\frac{i}{2\pi}\right)$	$\sum_{j=1}^{n} \frac{x_{ij}}{\sum_{k=1}^{n} x_{ik}} \cdot v_j$
Star Coordinates	$v_i = \left(r \cdot \cos\frac{\theta_i}{2\pi}, r \cdot \sin\frac{\theta_i}{2\pi}\right)$ Or other	$\sum_{j=1}^{n} x_{ij} v_j$
Gravi++	$v_i = \left(r \cdot \cos\frac{\theta_i}{2\pi}, r \cdot \sin\frac{\theta_i}{2\pi}\right)$ Or other free layout	$\sum_{j=1}^{n} \frac{s_j x_{ij}}{\sum_{k=1}^{n} s_k x_{ik}} \cdot v_j$
Dust & Magnet	$v_i = \left(r \cdot \cos\frac{\theta_i}{2\pi}, r \cdot \sin\frac{\theta_i}{2\pi}\right)$ Or other free layout	$\sum_{j=1}^{n} a_{ij} x_{ij} \cdot v_j$
GBC	$v_i = \left(r \cdot \cos\frac{\theta_i}{2\pi}, r \cdot \sin\frac{\theta_i}{2\pi}\right)$ Or other convex polygon	$\sum_{j=1}^{n} \frac{x_{ij}}{\sum_{k=1}^{n} x_{ik}} \cdot v_j$
Remarks	$\theta_1 + \sum_{i=2}^{n}(\theta_j - \theta_{j-1}) = 2\pi$. s_j stands for the strength multiplicator of v_j. a_{ij} is the attraction between dust *i* and magnet j. r is the circle radius.	



Error
0.6
0.5
0.4
0.3
0.2
DGBC
IGBC
FGBC
Error
1.9
1.3
0.7
0.1
DGBC
IGBC
FGBC
Error
2.6
2
1.4
0.8
0.2
DGBC
IGBC
FGBC
E_{DD}
E_{DV}
E_{VV}
E_A