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?)

• 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

$$Pv = \sum_{i=1}^{n} w_i v_i$$

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

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

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

- 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

<table>
<thead>
<tr>
<th>Car</th>
<th>Sales Campaign</th>
<th>Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td>49%</td>
<td>85%</td>
<td>44%</td>
</tr>
</tbody>
</table>
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 \textit{real distance} – \textit{mapped distance}

- Drag or push the points in turn.

Car  | Sales Campaign  | Bike

\begin{tabular}{ccc}
\text{28\%} & \text{62\%} & \text{5\%} \\
\end{tabular}
Finally – Combine together

Variables to Variables: Distance spaced layout
Data to Variables: Iterative error reduction
Data to Data: Force directed adjustment

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

• 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


Questions?

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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**

<table>
<thead>
<tr>
<th>Method</th>
<th>VF</th>
<th>MF ([p_i])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radviz</td>
<td>[v_i = \left(r \cdot \cos \frac{i}{2\pi}, r \cdot \sin \frac{i}{2\pi}\right)]</td>
<td>[\sum_{j=1}^{n} \frac{x_{ij}}{\sum_{k=1}^{n} x_{ik}} \cdot v_j]</td>
</tr>
<tr>
<td>Star Coordinates</td>
<td>[v_i = \left(r \cdot \cos \frac{\theta_i}{2\pi}, r \cdot \sin \frac{\theta_i}{2\pi}\right)]</td>
<td>[\sum_{j=1}^{n} x_{yj} v_j]</td>
</tr>
<tr>
<td></td>
<td>Or other</td>
<td></td>
</tr>
<tr>
<td>Gravi++</td>
<td>[v_i = \left(r \cdot \cos \frac{\theta_i}{2\pi}, r \cdot \sin \frac{\theta_i}{2\pi}\right)]</td>
<td>[\sum_{j=1}^{n} \sum_{k=1}^{n} s_{ij} x_{ik} \cdot v_j]</td>
</tr>
<tr>
<td></td>
<td>Or other free layout</td>
<td></td>
</tr>
<tr>
<td>Dust &amp; Magnet</td>
<td>[v_i = \left(r \cdot \cos \frac{\theta_i}{2\pi}, r \cdot \sin \frac{\theta_i}{2\pi}\right)]</td>
<td>[\sum_{j=1}^{n} a_{ij} x_{ij} \cdot v_j]</td>
</tr>
<tr>
<td></td>
<td>Or other free layout</td>
<td></td>
</tr>
<tr>
<td>GBC</td>
<td>[v_i = \left(r \cdot \cos \frac{\theta_i}{2\pi}, r \cdot \sin \frac{\theta_i}{2\pi}\right)]</td>
<td>[\sum_{j=1}^{n} \frac{x_{ij}}{\sum_{k=1}^{n} x_{ik}} \cdot v_j]</td>
</tr>
<tr>
<td>Remarks</td>
<td>[\theta_1 + \sum_{j=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.</td>
<td></td>
</tr>
</tbody>
</table>