High Dimensional Visualization

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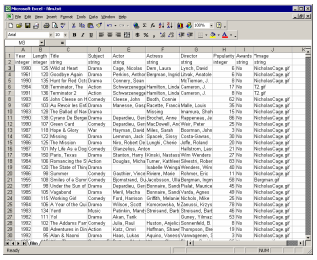
High Dimensional Data



High-D data:
- ungraspable to a human's mind

What does a 10-D space look like?

We need effective multi-D visualization techniques

Paper Reviewed

- Dimensional Anchors: a Graphic Primitive for Multidimensional Multivariate Information Visualizations, P. Hoffman, G. Grinstein, & D. Prinkney, Proc. Workshop on New Paradigms in Information Visualization and Manipulation, Nov. 1999, pp. 9-16.
- Visualizing Multi-dimensional Clusters, Trends, and Outliers using Star Coordinates, Eser Kandogan, Proc. KDD 2001
- StarClass: Interactive Visual Classification Using Star Coordinates , S. Teoh & K. Ma, Proc. SIAM 2003

Dataset

- Car
  - contains car specs (eg. mpg, cylinders, weight, acceleration, displacement, type(origin), horsepower, year, etc)
  - type: American, Japanese, & European

Dimensional Anchors (DA)

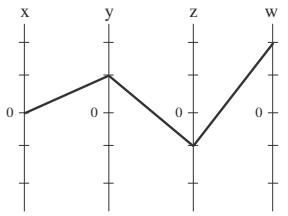
Dimensional Anchor:
- Attempt to unify many different multi-var visualizations
- Uses of 9 DA parameters

Base Visualizations

- Scatter Plot
- Parallel Coordinates
- Survey Plot
- Radviz spring visualization

Parallel Coordinates

- Point -> line
- (0,1,-1,2)=



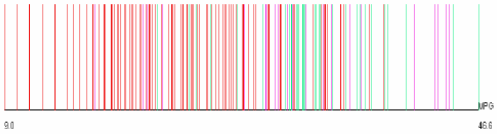
Base Visualizations

- Scatter Plot
- Parallel Coordinates
- Survey Plot
- Radviz spring visualization

Parameters ofDA

- Nine parameters are selected to describe the graphics properties of each DA:
  - p1: size of the scatter plot points
  - p2: length of the perpendicular lines extending from individual anchorpoints in a scatter plot
  - p3: length of the lines connecting scatter plot points that are associated with the same data point
  - p4: width of the rectangle in a survey plot
  - p5: length of the parallel coordinate lines
  - p6: blocking factor for the parallel coordinate lines
  - p7: size of the radviz plot point
  - p8: length of the "spring" lines extending from individual anchorpoints of a radviz plot
  - p9: the zoom factor for the "spring" constant K

Basic Single DA



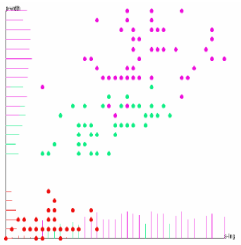
- •Dimension – miles per gallon
- •Data values are mapped to the axis
- • Mapped data points - *anchorpoints*, represent the coord values(points along a DA)
- •Lines extended from anchorpoints
- •Color – type of car (American – red, Japanese – green, and European – purple)

Two-DA scatter plot

DA scatter plot using two DAs

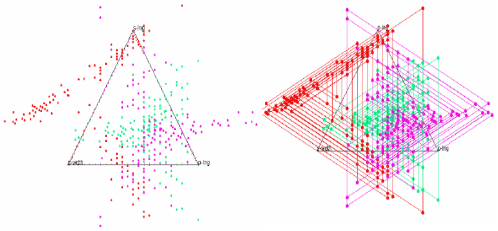
- Perpendicular lines extending outward from the anchor points
- If they meet, plot the point at the intersection

- p1: size of the scatter plot points
- p2: length of the perpendicular lines extending from individual anchor points in a scatter plot
- p3: length of the lines connecting scatter plot points that are associated with the same data point



P = (0.8, .2, 0, 0, 0, 0, 0, 0, 0)

Three DAs



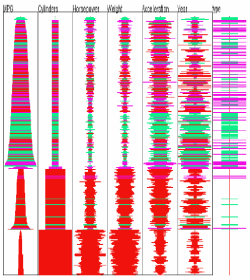
P = (0.6, 0, 0, 0, 0, 0, 0, 0, 0)

P = (.6, 0, 1.0, 0, 0, 0, 0, 0, 0)

P3: length of lines connecting all displayed points associated with one real data point(record)

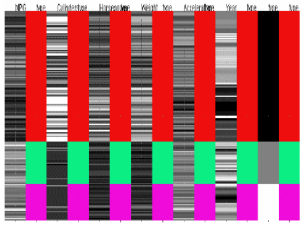
Seven DA Survey Plot

- 7 vertical DAs in a row
- Rectangle extending from an anchor point
  - size is based on the dimensional value
  - eg. Type- discrete value
    red < green < purple



CCCViz – Color Correlated Column

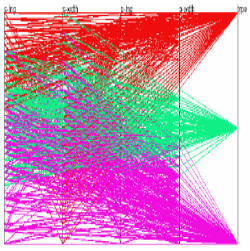
- Does a dimension (gray scales) correlate with a particular classification dimension(color scale) ?
- Correlation is seen in mpg, cylinders etc.
- p4: width of the rectangle in a survey plot



CCCViz DAs with P = (0, 0, 0, 1.0, 0, 0, 0, 0, 0)

DAs in PC configuration

- Line from one DA anchorpoint is drawn to another
  - length of these connecting lines is controlled by p5.
  - p5 = 1.0, fully connected, every anchorpoint connects to all the other (N-1) anchorpoints
- P6 controls how many DAs a p5 connecting line can cross
  - p6 = 0, traditional PC



P = (0, 0, 0, 0, 1.0, 1.0, 0, 0, 0)

DAs in Regular Polygon

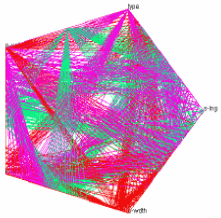
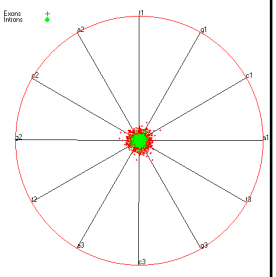


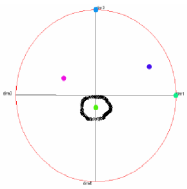
Figure 15 DAs in a regular polygon P = (0, 0, 0, 0, 1.0, 0, 0, 0, 0) Mesh Plot

Intro. to RadViz Spring Force

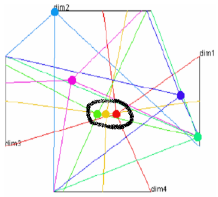
- a radial visualization
- One spring for each dimension.
- One end attached to perimeter point. The other end attached to a data point.
- Each data point is displayed where the sum of the spring forces equals 0.



DAs RadViz



Original Radviz – 3 overlapping points
Limitation: data points with different values can overlap



DAs spread polygon
P = (0, 0, 0, 0, 0, 0, .5, 1.0, .5)

DA layout

- ✓ Parameters – Done !
- Layout
  - DAs can be arranged with any arbitrary size, shape or position
  - Permits a large variety of visualization designs

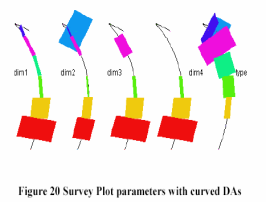
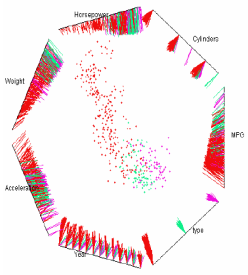


Figure 20 Survey Plot parameters with curved DAs

Combinations of Visualizations

- Can we combine features of two (or more) visualizations?
  - Combination of Parallel Coordinates and Radviz



Visualization Space

- Nine parameters define the size of our visualization space as R^9
- Include the geometry of the DAs, assuming 3 parameters are used to define the geometry
- The size of our visualization space is R^{12}
- "Grand Tour" through visualization space is possible
- New visualizations can be created during a tour

Evaluation

Strong Points

- ☺ Idea
- ☺ Many examples of visualizations with real data

Weak Points

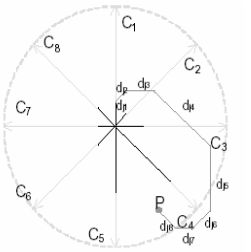
- ☹ Not accessible
- ☹ Short explanation of examples
- ☹ Lack of examples for some statement
- ☹ No implementation details

Where are we

- ✓ Dimensional Anchors
- ➢ Star Coordinates
  - a new interactive multidimensional technique
  - helpful in visualizing multi-dimensional clusters, trends, and outliers
- ❑ StarClass – Interactive Visual Classification Using Star Coordinates

Star Coordinates

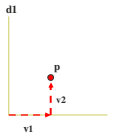
- Each dimension shown as an axis
- Data value in each dimension is represented as a vector.
- Data points are scaled to the length of the axis
  - min mapping to origin
  - max mapping to the end



Star Coordinates Contd

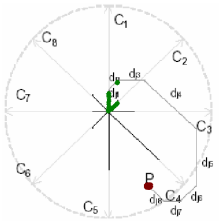
Cartesian

P=(v1, v2)



Star Coordinates

P=(v1,v2,v3,v4,v5,v6,v7,v8)



Mapping:
- Items → dots
- Σ attribute vectors → position

Interaction Features

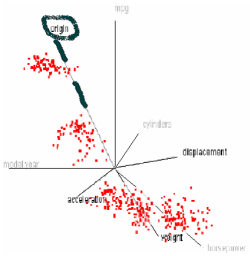
- Scaling
  - allows user to change the length of an axis
  - increases or decrease the contribution of a data column
- Rotation
  - changes the direction of the unit vector of an axis
  - makes a particular data column more or less correlated with the other columns
- Marking
  - selects individual points or all points within a rectangular area and paints them in color
  - makes points easy to follow in the subsequent transformations

Interaction Features

- Range Selection
  - select value ranges on one or more axes, mark and paint them
  - allows users to understand the distribution of particular data value ranges in current layout
- Histogram
  - provides data distribution for each dimension
- Footprints
  - leave marks of data points on the trail for recent transformations

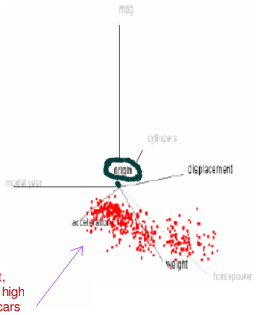
Applications – Cluster Analysis

- Playing with the "cars" dataset
  - scaling, rotating, & turning off some coordinates
- Four major clusters in the data discovered



Applications – Cluster Analysis

- Scaling the "origin" coordinate moves only the top two clusters
  - (JP & Euro)
- Down-scaling the origin
  - these two clusters join one of the other clusters(American-made cars of similar specs)
- Result: two clusters



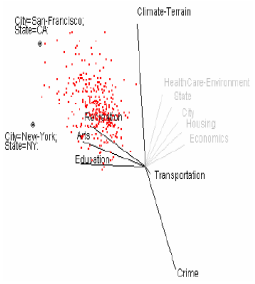
Low weight, displacement, high acceleration cars

SC – useful in visualizing clusters

- Within few minutes users can identify how the data is clustered
- Gain an understanding of the basic characteristics of these clusters

Multi-factor Analysis

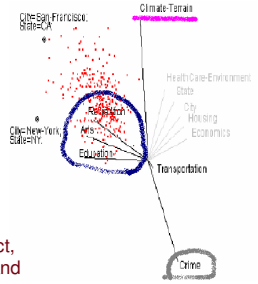
- Dataset – "Places"
  - ratings wrt climate, transportation, housing, education, arts, recreation, crime, health-care, and economics
- Important desirable factors pulled together in one direction and neg. undesirable factors in the opposite



Mutli-factor Analysis con't

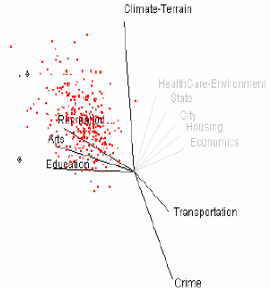
- Desirable factors:
  - recreation, art, & education
  - climate (most)
- Undesirable factor:
  - crime

What can you conclude about NY and SF?
- NY – outlier
- SF – comparable arts, ect, but better climate and lower crime



Multi-factor Analysis contd

- Scale up transportation
  - other cities beat SF in the combined measure



Evaluation of SC in Multi-factor Analysis

☹ Exact individual contributions of these factors are not immediately clear

☺ The visualization provides users with an overview of how a number of factors affect the overall decision making

Evaluation

Strong Points
- ☺ idea
- ☺ many concrete examples with full explanations

Weak points
- ☹ ugly figures (undistinguishable)

Where we are

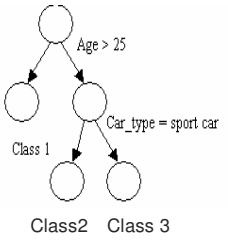
- ✓ Dimensional Anchors
- ✓ Star Coordinates
  - a new interactive multi-D visualization tech.
- ➢ StarClass – Interactive Visual Classification Using Star Coordinates

Classification

- Each object in a dataset belongs to exactly one class among a set of classes.
- Training set data : labeled (class known)
- Build model based on training set
- Classification: use the model to assign a class to each object in the testing set.

Classification Method

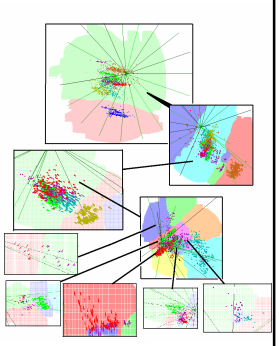
- Decision trees



Visual-base DT Construction

- Visual Classification
  - projecting
  - painting
  - region can be re-projected
  - recursively define a decision tree.
  - each project correspond to a node in decision tree
  - Majority class at leaf node determines class assignment

  (the class with the most number of objects mapping to a terminal region is the "expected class")



Evaluation of the system

Good

- ☺ Makes use of human judgment and guides the classification process
- ☺ Good accuracy
- ☺ Increase in user's understanding of the data

Bad

- ☹ expertise required?

Evaluation of the Paper

Good

- ☺ Ideas
- ☺ Accessible
- ☺ Concrete examples

Bad

- ☹ No implementation discussed

Summary

- Dimensional Anchor
  - unify visualization techniques
- Star Coordinate
  - new interactive visualization techniques
  - Visualizing clusters and outliers
- StarClass
  - interactive classification using star coordinate

Reference

- Dimensional Anchors: a Graphic Primitive for Multidimensional Multivariate Information Visualizations, P. Hoffman, G. Grinstein, & D. Prinkney, Proc. Workshop on New Paradigms in Information Visualization and Manipulation, Nov. 1999, pp. 9-16.
- Visualizing Multi-dimensional Clusters, Trends, and Outliers using Star Coordinates, Eser Kandogan, Proc. KDD 2001
- StarClass: Interactive Visual Classification Using Star Coordinates , S. Teoh & K. Ma, Proc. SIAM 2003
- http://graphics.cs.ucdavis.edu/~steoh/research/classification/SDM03.ppt