The Decision Boundary Map

An Interactive Visual Interface for Making Informed Decisions and Selections in the Presence of Tradeoffs

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Prologue

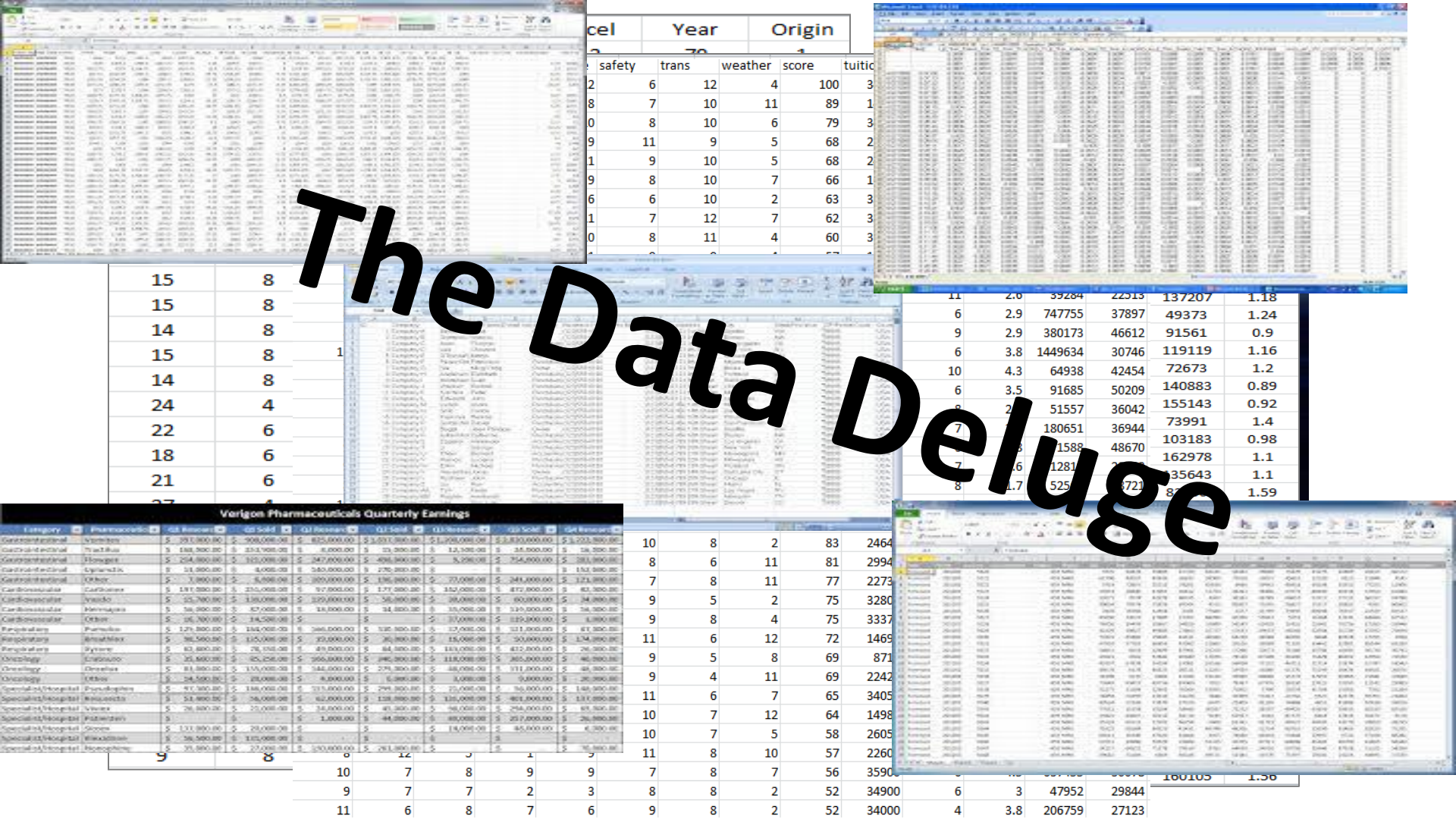
Decisions are often rendered in the presence of **tradeoffs**

- however, tradeoffs are often difficult to recognize and balance
- especially when there are many factors playing a role

Decisions are often rendered in the presence of **many factors**

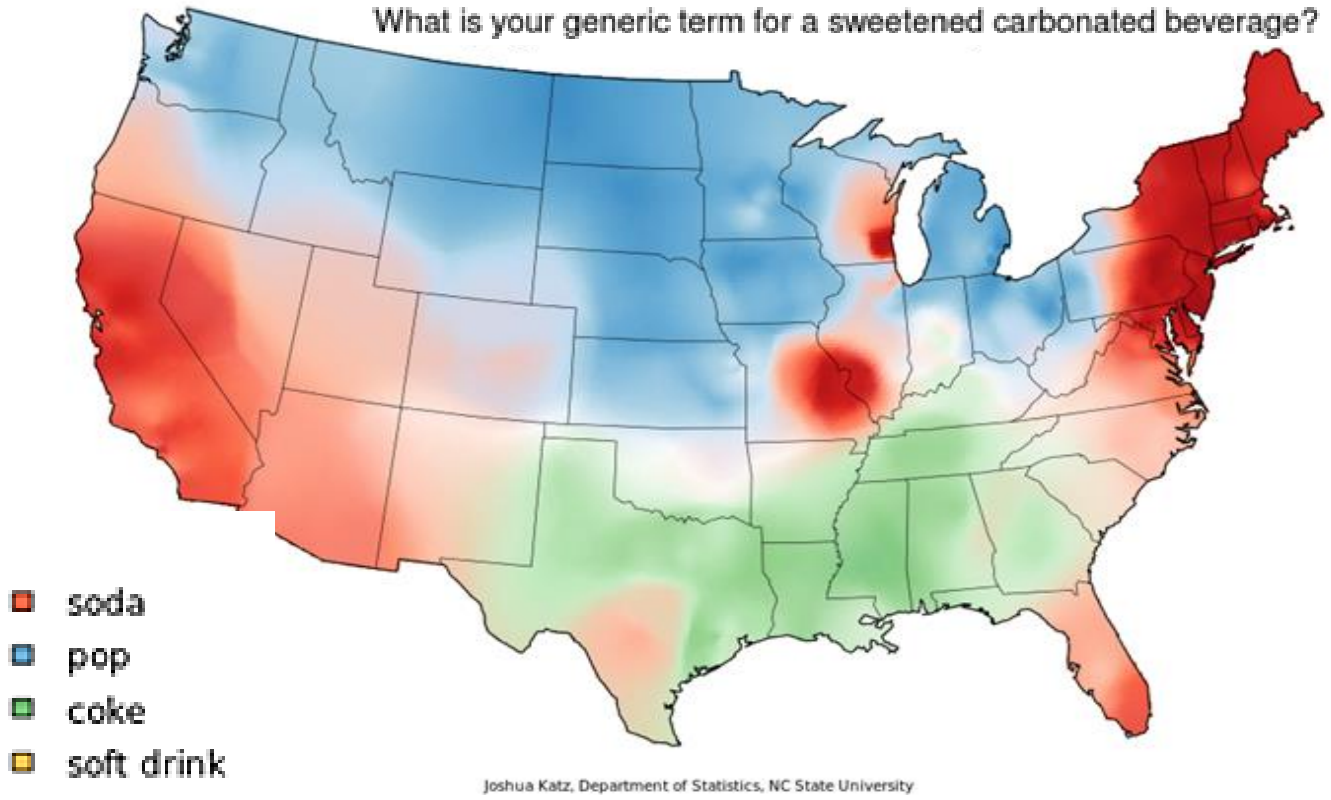
- there's high potential to overwhelm the human decision maker
- they might render decisions that they are not fully sure about
- only to recognize later that better choices could have been made

We propose a **visual interface** to ease this pain


The Data Deluge
Verigon Pharmaceuticals Quarterly Earnings

We Need Something Intuitive

How About Something Like A Map?

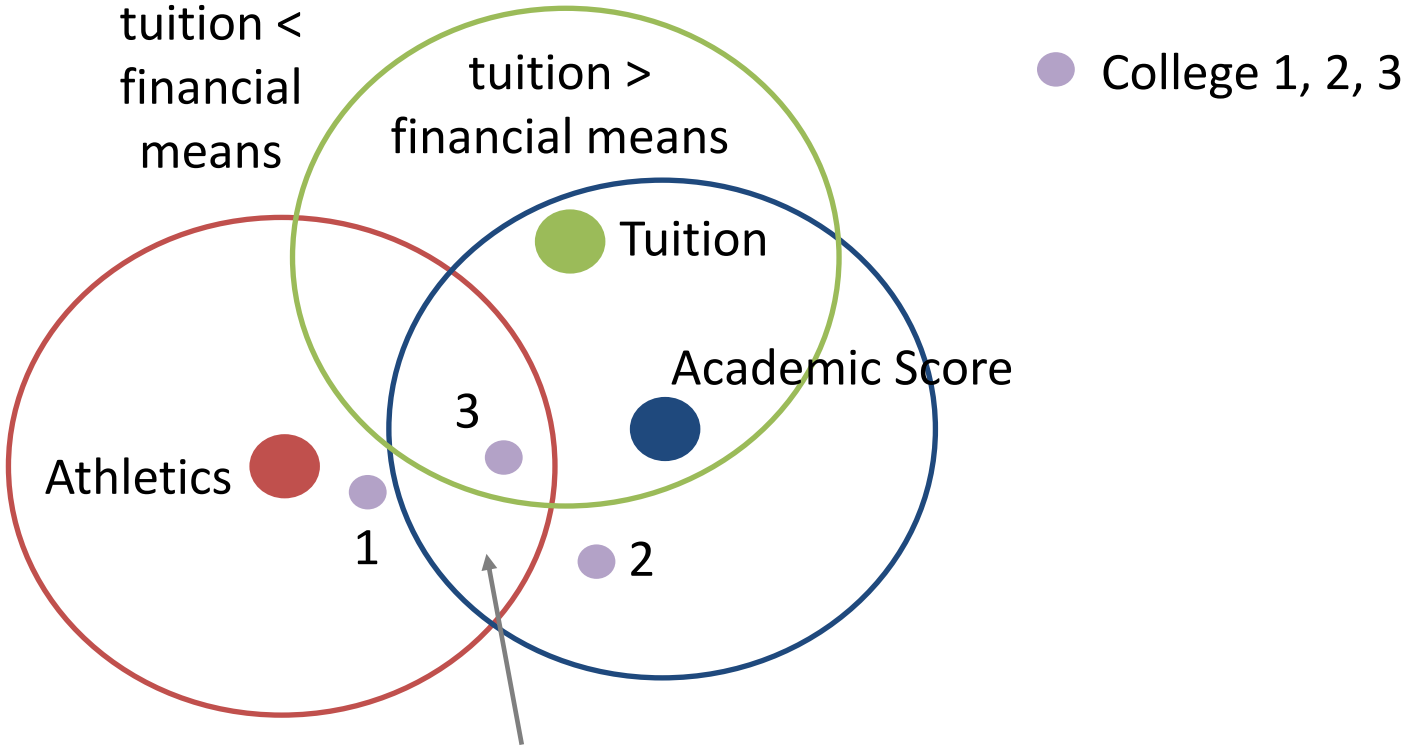


Example: Decide on a College

Many factors (and possible tradeoffs):

- athletics
- academics
- students per faculty
- social life
- tuition
- safety
- weather
- size
- and many more…

Concept: Visualize Using Decision Circles



no dream school here: good athletics, low tuition, high academic score

Interlude: The Data Matrix

Each college is an N-dimensional vector of attributes

- the data matrix has M rows of colleges each with N attributes
- the M colleges reside in an N-dimensional space of attributes

Goal is to flatten this N-D space into a 2D map with colleges

- this is called *embedding*
- embedding is essentially an optimization problem
- preserve the N-dimensional distance relations in the 2D layout

Interlude: Space Embedding

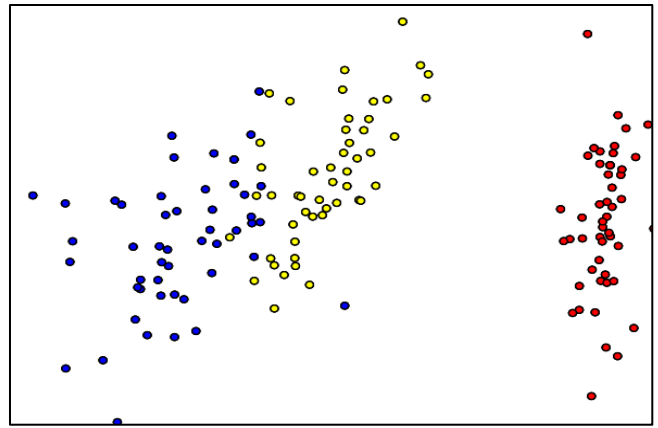
General idea:

- preserve N-D space distances δ_{ij} in 2-D space d_{ij}
- minimize

$$stress = \sqrt{\frac{\sum_{ij}(d_{ij} - \delta_{ij})^2}{\sum_{ij}\delta_{ij}^2}}$$

- Multi-Dimensional Scaling (MDS)
- similar data map to similar places

→ Similarity Map



But…

…are these schools so different?

Space Embedding: Shortcomings

Embedding the colleges is only half the information

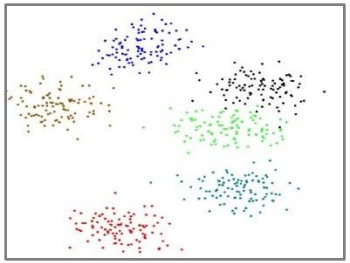
- we need to embed the attributes as well
- then we can tell what makes the colleges different
- it gives the decision context
- this requires an extension/augmentation to the data matrix

Introducing: the joint data-attribute matrix

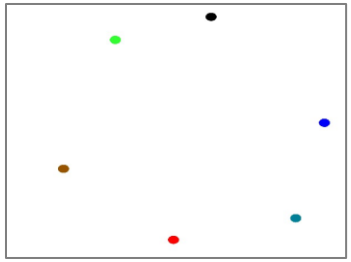
The Joint Data-Attribute Matrix

Best of both worlds

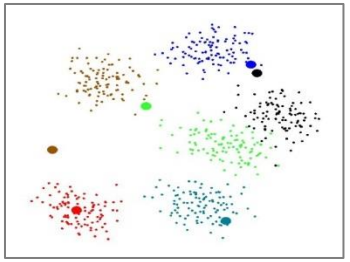
- similarity map of the data is based on vector similarity
- similarity map of the attributes is based on pairwise correlation



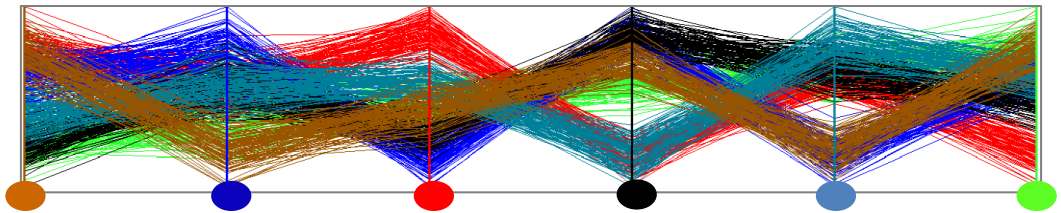
data



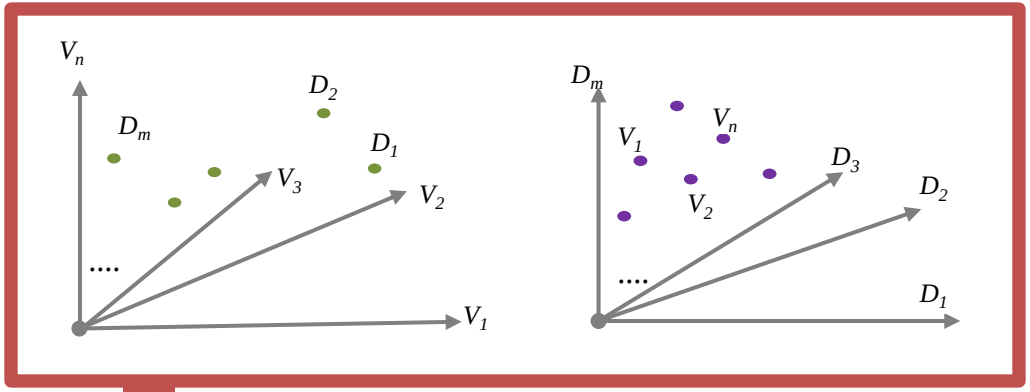
attributes

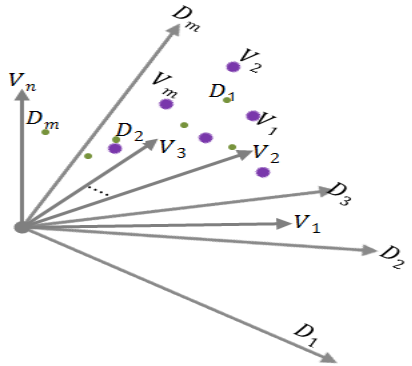


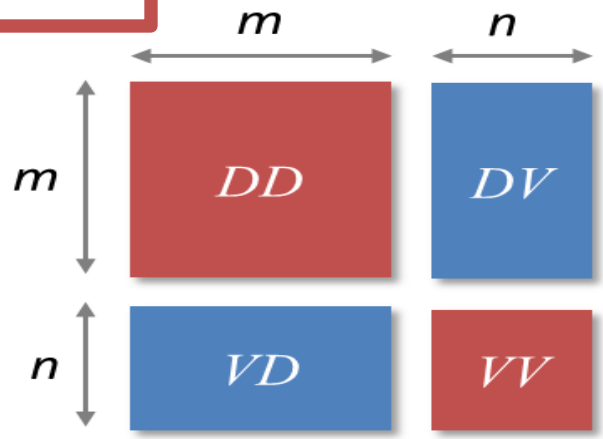
data + attributes



Achieved by Joint Matrix Optimization



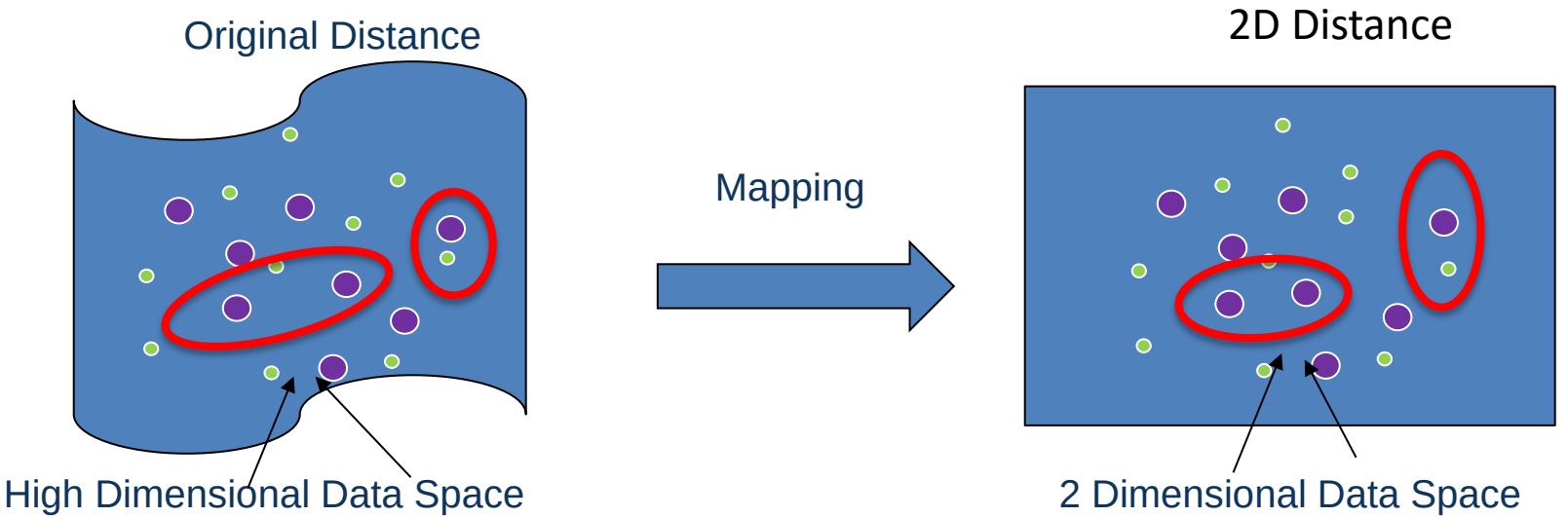




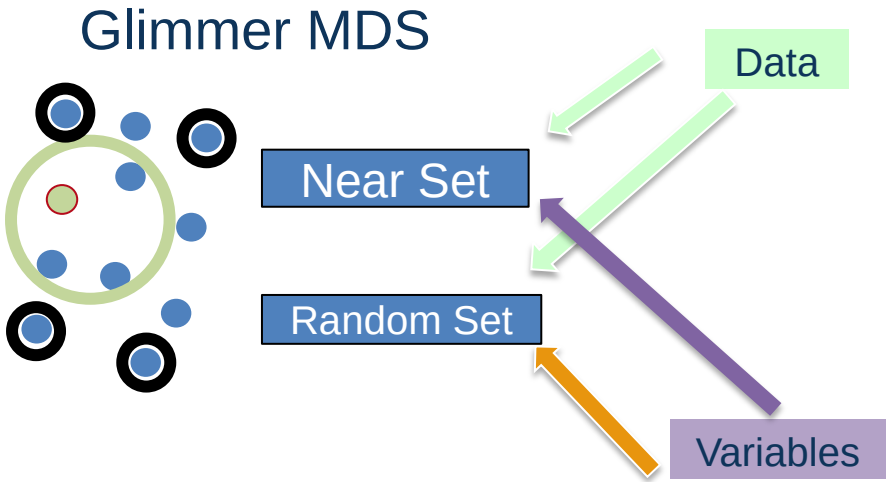
Flexible MDS Layout Schedules

Optimization schedules for data and attribute layout can vary

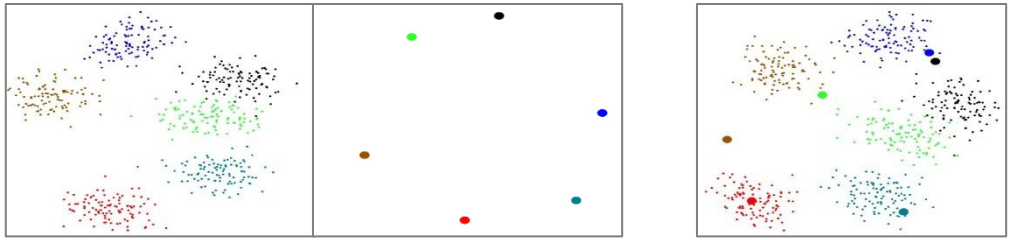
- allows us to steer accuracy of the layout to preserve data relationships of attribute relationships or achieve a balance



MDS Layout Schedules

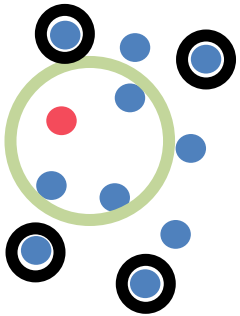


Data Variables



MDS Layout Schedules

Glimmer MDS



Near Set

Random Set

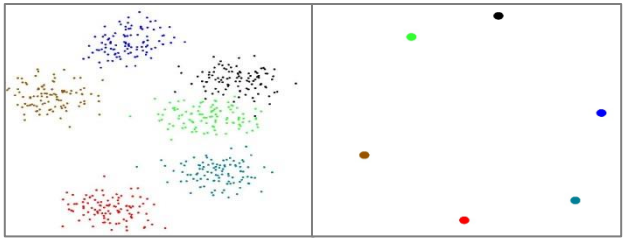
Data

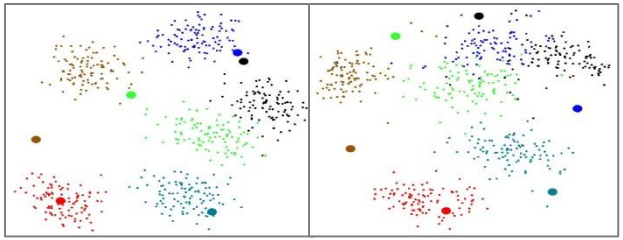
Variables

Data Variables

Variables

Data Variables





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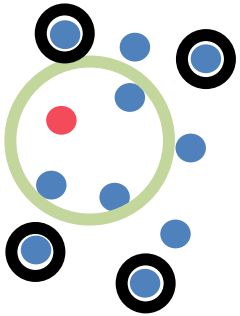

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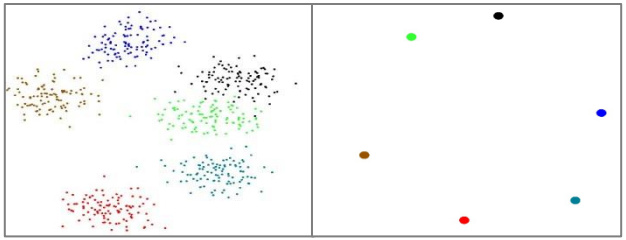
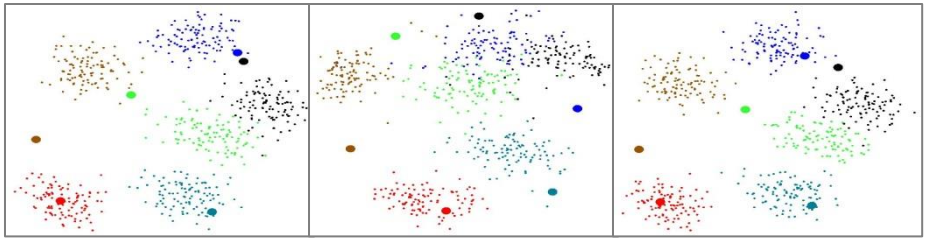
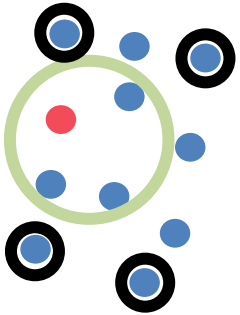




MDS Layout Schedules

Glimmer MDS



Near Set

Random Set

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Variables

Data Variables

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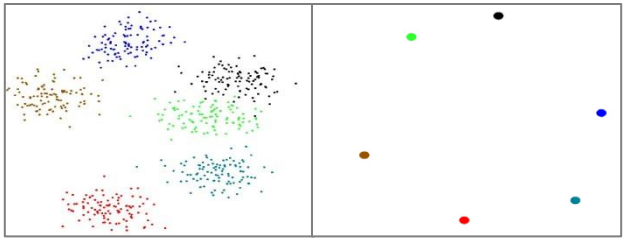
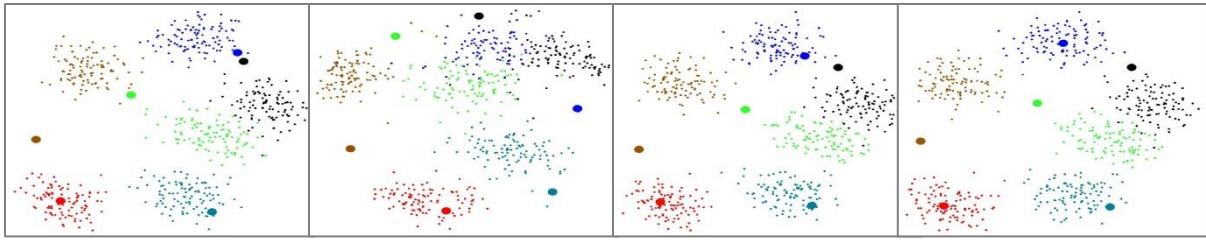
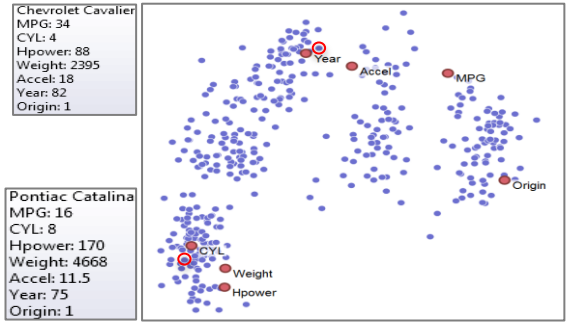
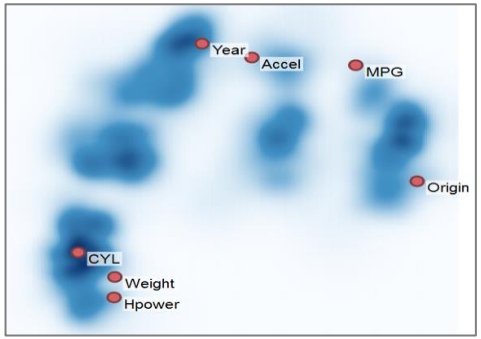




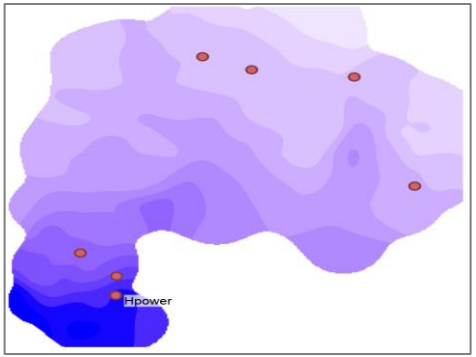
Constructing The Map



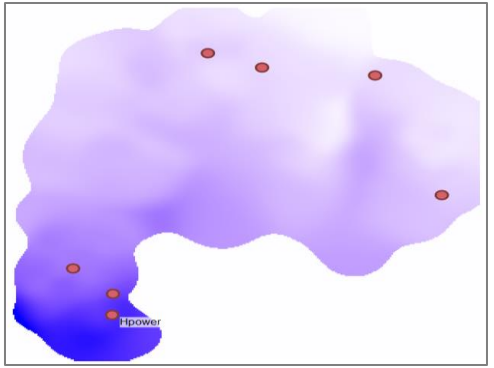
Adaptive Kernel Density Estimation



Nadaraya-Watson kernel regression



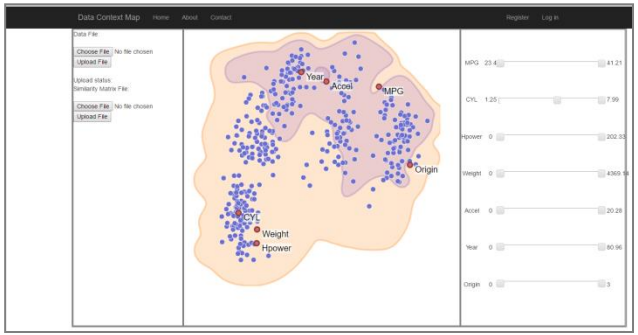
Contour boundary



Online Deployment

Our application runs interactively in modern web browsers

- data processing on back-end server, interactive graphics on client
- can be accessed anywhere and anytime, free of charge (for now)
- users can simply upload a spreadsheet with the data matrix
- application for a domain name .net and .com is in process
- a rudimentary version is already online and will have been fully developed at the time of the workshop



Use Cases

General public (based on data we have already visualized):

- potential car buyers selecting cars fitting their preferences
- college-age kids and parents selecting the best-fitting college
- wine shoppers navigating the confusing landscape of wines
- investors picking stocks in light of specific investment profiles

Researchers (based on inquiries we have received):

- consulting firms for foundations and nonprofits to inform clients
- disease researchers to gain insight into the interaction of traits

Use Case: Deciding on the Best College

Data are a fusion of two datasets:

- College rankings from US News and World Report
- College Prowler website

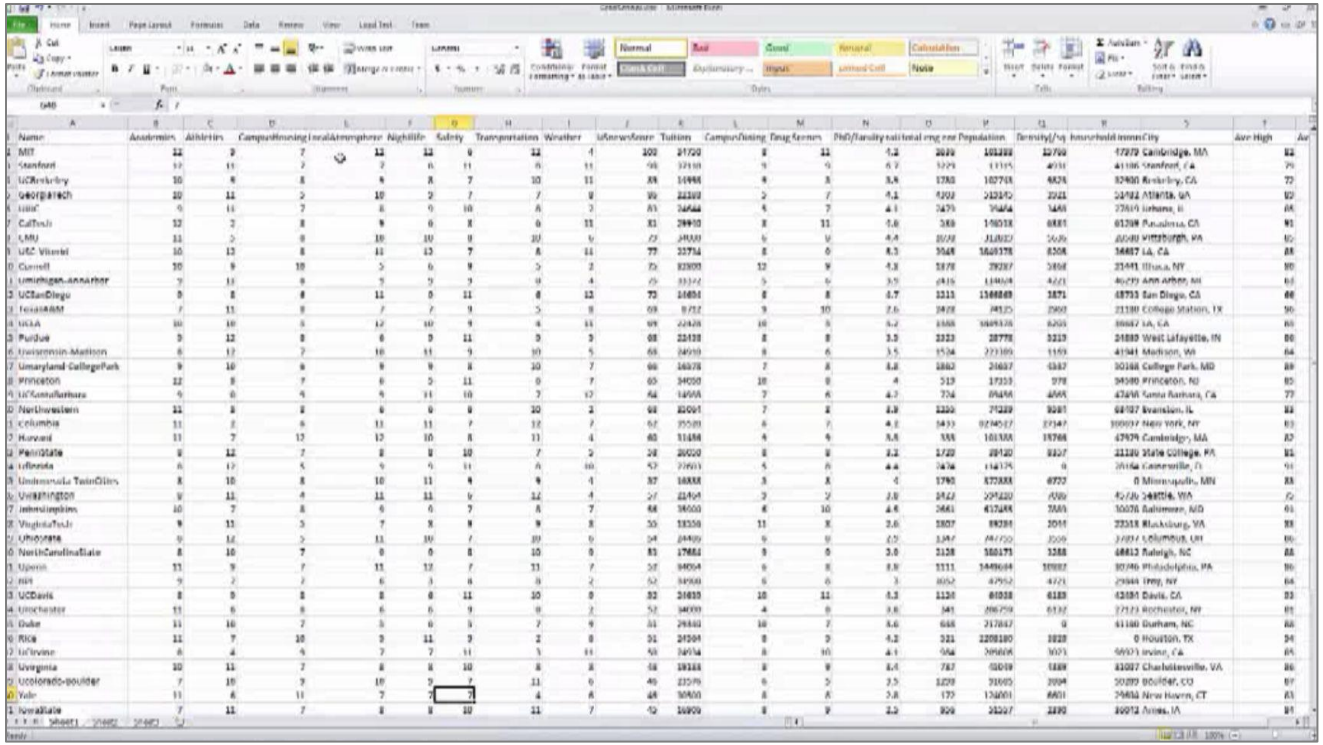
A video is online here

- some annotated stills are presented in the following

The Following Slides are Stills of the Video

Spreadsheet of University Data

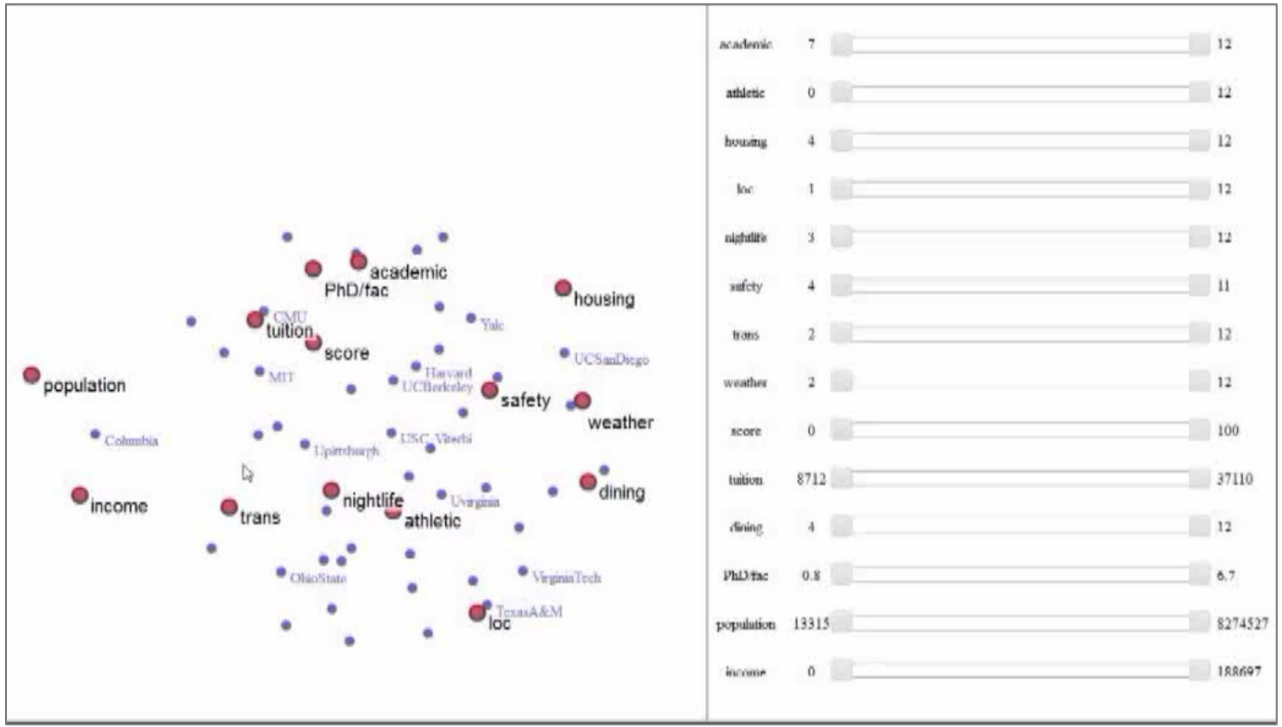
Overwhelming and difficult to rank and weigh tradeoffs



spreadsheet with colleges as rows and attributes as columns

The Colleges Shown in Attribute Context

Red nodes: attributes (decision factors); blue nodes: colleges

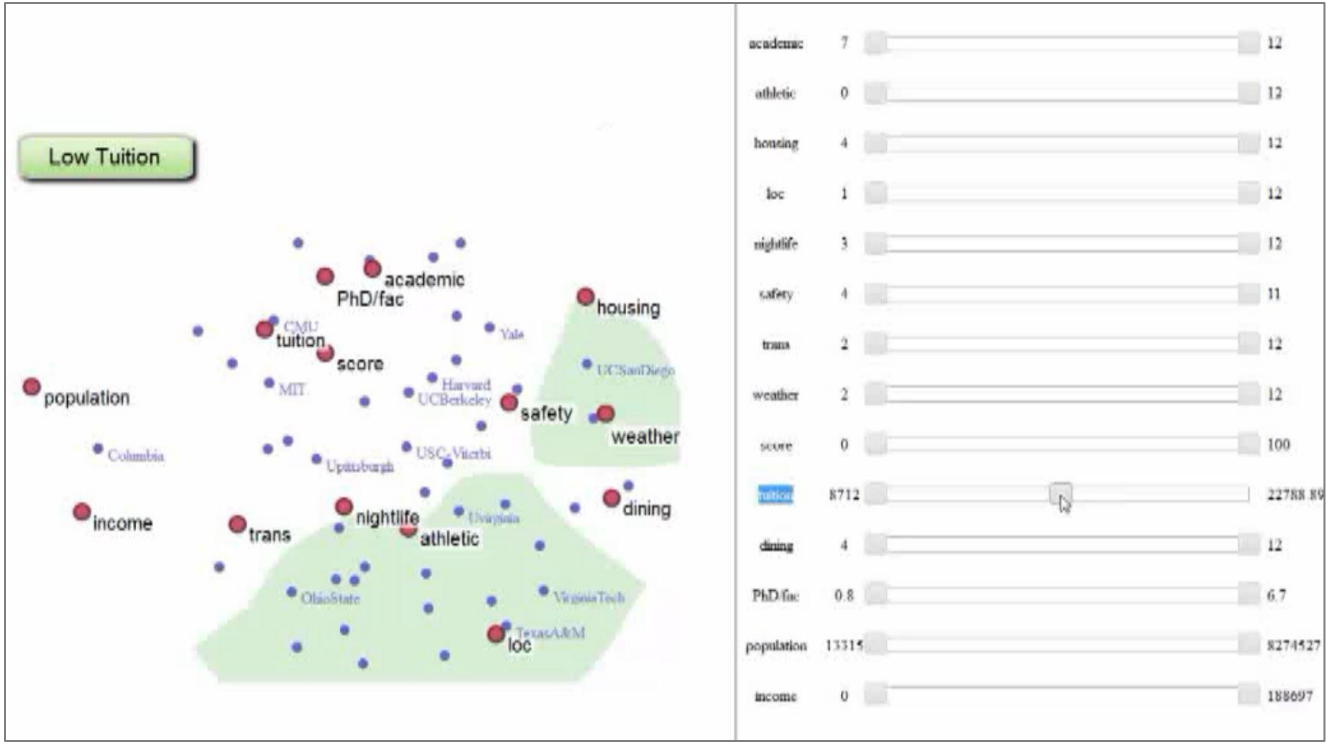


similar colleges / attributes map closely

colleges with higher attribute values map close to that attribute node

Decision Region for Tuition < $27,000

The green regions contain all colleges that fit that condition



tuition slider controls range and shape of the green tuition region (fully accurate)

Add Decision Region for Academic Score > 8.3

The purple region contain all colleges that fit that condition

academics slider controls the shape of the academics region

some colleges fall into both decision regions, tuition and academics : these are the perfect colleges

some colleges are close by: these are the trade-off colleges

Add Decision Region for Athletics Score > 9

The purple region contain all colleges that fit that condition

athletics slider controls the shape of the athletics region

only one college falls into all three decision regions: this is the perfect college for that user (U Virginia)

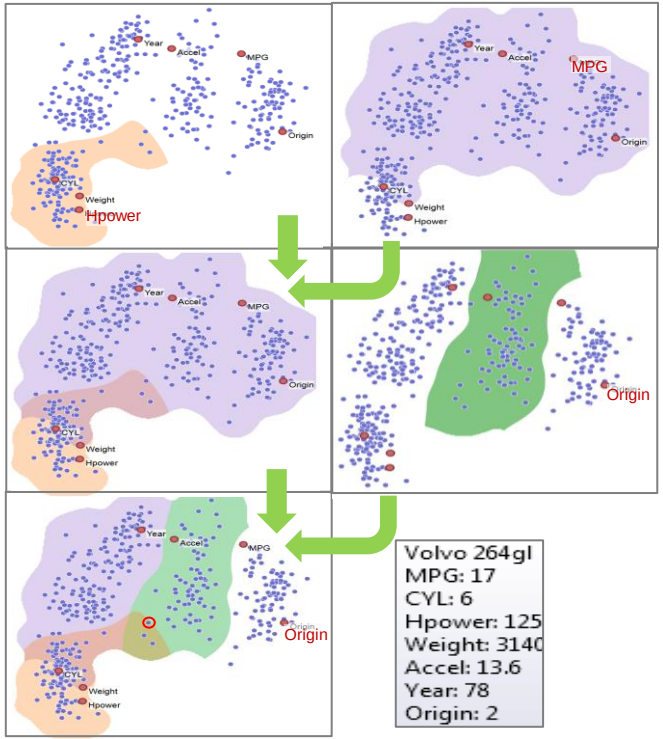
some colleges are close by: these are the trade-off colleges

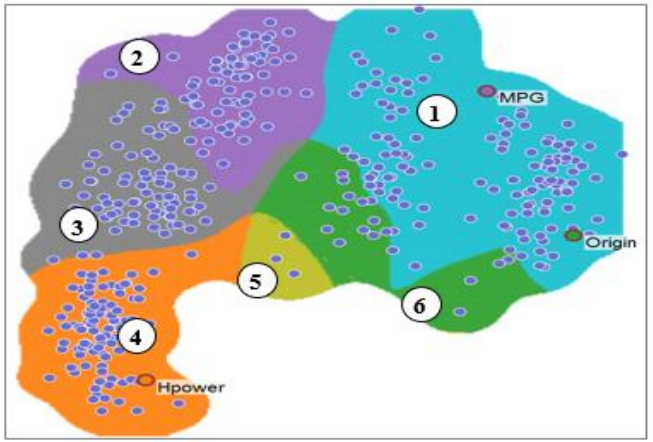
Use Case: Overviewing Types of Cars

Horsepower: 116~192

MPG: 16~30

European Car





Euro-Japanese efficient compact cars

US efficient compact cars

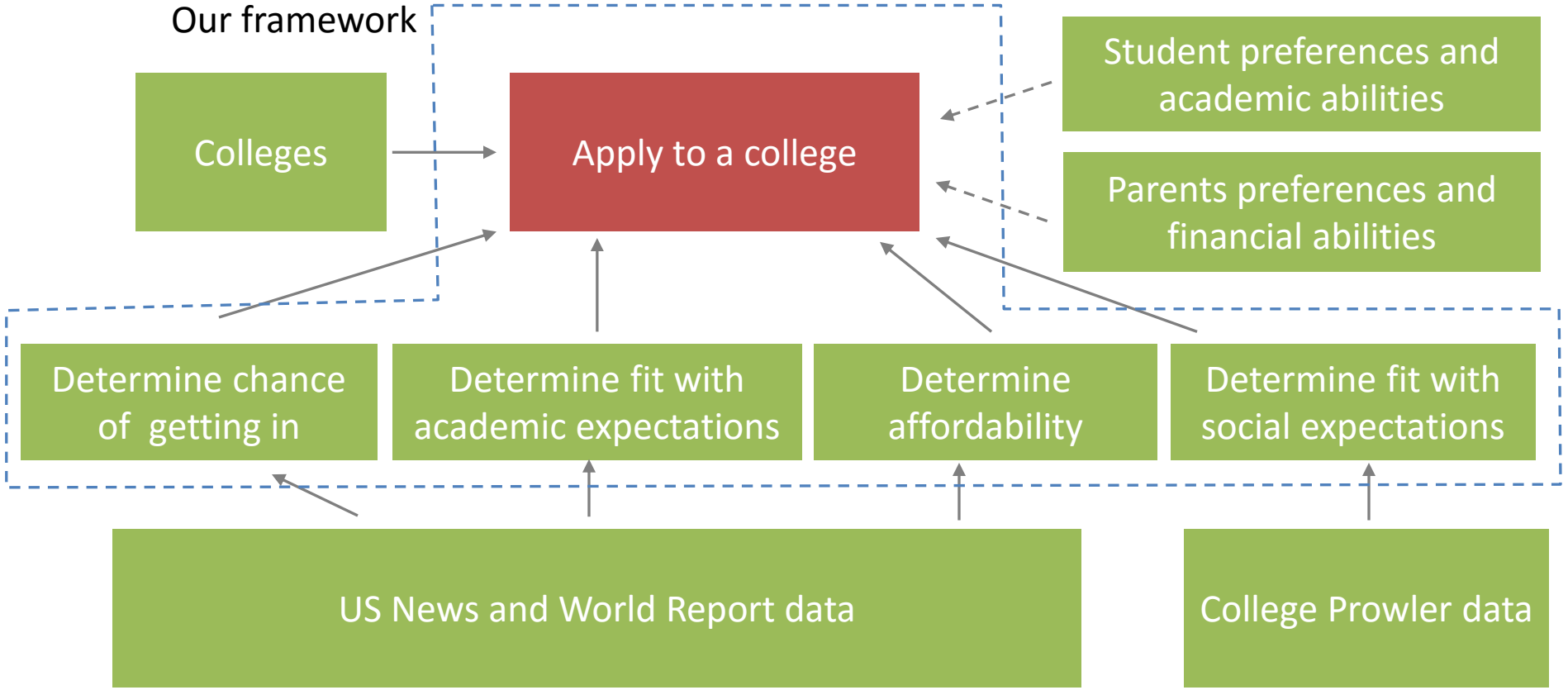
US semi-efficient medium-power cars

US big block gas guzzlers

Euro-Japanese gas guzzlers

Euro-Japanese semi-efficient medium-power cars

DMN for College Selection Decision



Conclusions and Future Work

User studies suggest that the framework is an intuitive environment to make decisions in selection tasks with many attributes (factors)

Some current work focuses on reducing the number of sliders

- give users options on the attributes they wish to control
- determine a set of good attributes automatically


ANY
QUESTIONS?