Lecture 8 高维数据 ①降维
②scatter-plot-matrix
③parallel coordinates
④Glyph-based methods | star plots 雷达图 | chernoff faces
⑤"small multiples"

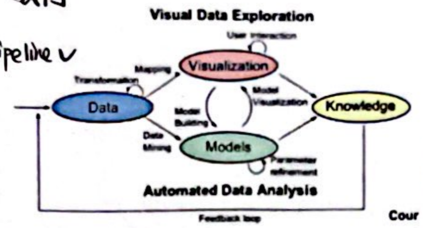
information $\xrightarrow{\text{encoding}}$ 显示 $\xrightarrow{\text{decoding}}$ 人的理解
=visualization = visual interpretation
data trans → mapping → Display → perception → cognition

What can 可视化做什么？

Lecture1 1.Represent information 2.Analyze data 3.Communicate data

可视化帮助我们 1. Helps us think 2. Uses perception to offload cognition 3. Serves as an external aid to augment working memory 4. Boosts our cognitive abilities 可视化流程

也是一种可视化pipeline ✓



可视化 pipeline

- **Data transformation:** converts raw data into a more suitable intermediate representation (e.g., resampling, interpolation, coordinate transformation)
- **Mapping:** converts intermediate data into a number of graphical entities called visualization icons (e.g., isosurfaces, vector arrows, LIC textures, streamlines)
- **Rendering:** Displays the graphical entities on screen
- **Visual perception:** recognition of visual attributes such as color, shape, length, contrast and texture
- **Cognition:** association of low and high level visual information with meaning (e.g., yellow means high temperature, vectors show the direction and speed of a water flow)

以用户为中心的可视化设计生命周期 ✓

什么时候不需要可视化：当 fully automatic solution 存在且被相信。

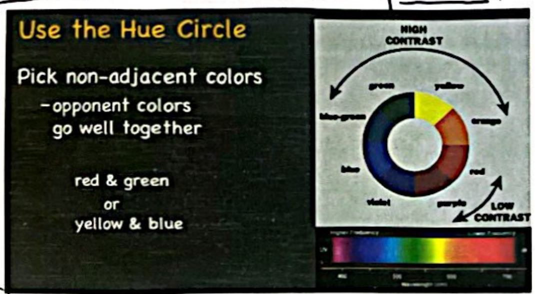
Lecture2 Definition of Visualization:Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively. Why Having Human-in-the-loop? 1. Visualization is suitable when there is a need to augment human capabilities rather than replace people with computational decision-making methods 2. Beyond human patience 3. Scale to large datasets 4. Support interactivity Benefits of Visualization for Humans 1. Long-term use for end users (e.g., exploratory analysis of scientific data) 2. Presentation of known results 3. Stepping stone to better understanding of requirements before developing models 4. Helps developers of automatic solution refine/debug, determine parameters 5. Helps end users of automatic solutions verify and build trust

例子：用户愿意使用去构建的系统性能 → 色彩心理学

不要同时使用饱和度过高的颜色 eg.红+蓝

perceptual system 是基于相对判断而并非绝对的判断。weber's law.

你看到的



Lecture3 Visual Perception: about the nature of the signals coming in; what you see. Perception is the organization, identification and interpretation of sensory information in order to represent and understand the environment. Cognition :about how you understand and interpret what you see. In science, cognition is a group of mental processes that includes attention, memory, producing and understanding language, solving problems, and making decisions. Gestalt Theory 1.Figure and Ground 2.Closure 3.Similarity 4.Continuity 5.Proximity

你所理解的。

记忆在cognition中很重要，而人记忆能力有限，可视化必须作为一种外部工具来增强工作记忆。

Box plot

Lecture4 Types of data visualization methods in EDA: 1.Plotting of raw data 2. Plotting of statistical values 3. Multiple coordinated views (Dashboard)

Exploratory data analysis 探索性数据分析

彩色 X，灰色 ✓
彩虹不是一个好的色彩方案，是光谱色彩方案
适合 quantitative ✓
ordinal：亮度+饱和度

Principles of Graphical Integrity

① pie chart
② bar chart
③ sparkline
④ scatter plot matrix
⑤ histogram
⑥ contour map
⑦ heatmap

- **Minimize the Lie Factor**
  - Tell the truth about the data - above all else show the data
- **Use Consistent Scale**
  - Show data variation, not design variation
  - Make large data sets coherent
- **Present Data in Context**
  - Reveal the data at several levels of detail from broad overview to the fine structure

encoding ☆
选择2D/3D
只用height ✓

$$\textit{Lie Factor} = \frac{\text{size of effect shown in graphic}}{\text{size of effect in data}}$$

Tufte's Rule

$$\textit{size of effect} = \frac{|\text{second value - first value}|}{\text{first value}}$$

更易 encoding
color / size / coordinate

How not to lie
① show entire scale
② show data in context
③ consistent, linear scale
④ up vs. down，暗示趋势方向
⑤ 避免 size encoding。
只用 H/W
X 不都用
避免 S, V encoding

Five Key Principles of Data Visualization

① 顶部文本不清晰
② 遮挡隐藏信息
② Perspective Distortion 透视失真
① occlusion hides information

- **Graphical Integrity:** Visual representations of data must tell the truth
- **Data-Ink Ratio:** Data Ink is the ink on a graph that represents data. Good graphical representations maximize data-ink and erase as much non-data-ink as possible 同时 优化 data-ink
- **Avoid Chart Junk:** Chart Junk is the excessive and unnecessary use of graphical effects in graphs
- **Data Density:** Proportion of total size of the graph that is dedicated to displaying data. Maximize data density and data matrix within reason
- **Small Multiples:** Series of the same small graph repeated in one visual. Small multiples are a great tool to visualize large quantities of data and with a high number of dimensions

"Least ink principle"
shape 纹理映射
X depth
① no unjustified 3D
② map ← 2D
③ eyes beat memory
④ resolution over immersion
⑤ function first, form next
⑥ responsiveness is required
⇒ 可视化咒语：mantra
overview first zoom, filter, details on demand

Lecture5 Transformation 1.Normalization 2.Smoothness 3.Sampling 4.Binning/Discretization 5.Dimensionality Reduction (1) Principal Components Analysis (PCA) (2) Multidimensional Scaling (MDS) (3) Self-Organizing Map (SOM) 6.Clustering

Evaluation Method:

magnitude channels：ordered 属性
pos在平齐轴
pos在非对齐轴
length (1D) size
Tilt/angle
Area (2D) size
Depth (3D pos)
color luminance
color saturation
curvature
volume (3D)
高 ↑ 选择 ↓ 低

Identity channel category 属性
spatial region
color hue
motion
shape

高效且易表达

(pos) ① 小区域用亮饱和度，大区域低且饱和 ② 使用少量color 作对比

- Inspection or Principled Rationale
  - Apply design heuristics, perceptual principles
  - Expert interviews
- Formal User Study
  - Controlled experiments
  - Interviews
  - Surveys
  - Usability study
- Field Deployment or Case Studies
  - Have people use visualization, observe and interview
  - Document effects on work practices
- Theoretical Analysis and Benchmarking
  - Time and space complexity
  - performance

Evaluation: when and what?

- Earlier stages:
  - Observe and interview target users (needs assessment)
  - Design data abstraction/operation (data types, transformation, operations)
  - Justify encoding/interaction design (design heuristics, perception research)
  - Informal analysis/qualitative analysis of prototypes (task-based)
  - Algorithm complexity analysis/evaluation
- Mid- and later stages:
  - Qualitative analysis of system (task-based)
  - Algorithm performance analysis
  - Lab or crowdsourced user study
  - Field study of the deployed system

NO 贯穿始终。

地理数据：用map.

Levels in Text Information

Based on understanding levels:
- Lexical Level: basic unit of text.
- Syntactic Level: structure information.
- Semantic Level: meaning of text contents.

original doc
↓
文字分析&&mining
↓
visualization
↓
interaction

Research Direction

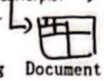
- Type of text:
  - Single document.
  - Document collection.
  - Temporal documents.
- Features of text:
  - Content.
  - Structure.
  - Multi-level information.

文本分析&&
Mining

- Preprocessing:
  - Text wrangling.
- Feature Extraction:
  - Keywords.
  - Word frequency.
  - Topics.
- Measurement:
  - Document similarity.
  - Clustering.

text.
Process: Visualization

- Visual Design:
  - Chernoff Face.
  - Flow metaphor. 河流的抽象模型
  - –
- Layout:
  - Force-directed.
  - Treemap 子之间存在层次性
  - Scatterplot 距离代表neigh
  - –



Process: Interaction

- Linking & Brushing:
  - Brushing: focusing.
  - Linking: highlighting.
- Zooming
- Focus + Content
- Filtering

text 可视化
①
② visualizing doc relation
③ multi-level doc 可视化

八 Text Analysis Methods : 1.Tokenization 2.Vector-space Model 3.Topic retrieving Visualizing Document Content : 1.Word cloud 根据词频 2.themeriver3.ConceptVector, Senten Tree 社会网络.

Visualizing Document Content

- Keyword-based Visualization
- Temporal Document Visualization
- Feature Distribution Visualization
- Opinion Analysis
- Query Visualization
- Software Visualization

+ Properties of Network 1.Complex relations(Directions, weights)2.Network centrality (Degree, Closeness, Betweenness , Eigenvector) Graph Representation 1.Node-link diagram (Sugiyama, Force-directed layout, MDS layout) 2.Adjacency matrix 3.Attribute-based representation

Nodes Position Computation*

- From random or initial configuration
- Loop:
  - Compute the repulsion and attraction force for every pair of nodes.
  - Accumulate the force (vector) for every node.
  - Update nodes position step by step according to their forces.
- Loop stops when the layout is "good enough"

Gmap Procedures 1.Layout the nodes on the graph 2. Clustering 3. Constructing voronoi diagram for every cluster 4. Coloring

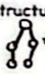
Visual Requirements:

- Key idea: to present the relationship among nodes clearly and efficiently.
  - Order of nodes follow their hierarchies.
  - Less edge crossing.
  - Shorten edge length.
  - Be aware of the aspect ratio.

9.层次数据,

ierarchical Data isualization

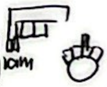
Node-link diagram (structure-clarity).
- Node-link tree.
- Hyperbolic tree.
- Cone tree.



相数结构

Space-filling methods (space-efficiency).
- Treemap.
- Voronoi treemap.

Icide diagram
Sunburst diagram



Hybrids.

11. Properties of Streaming Data 1.Unlimited in data volume 2.Uncontrollable with volume or order of the coming data 3.Online analytical processing (OLAP) is needed 4.There exists data error and data loss

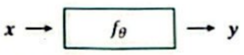
Types of Interactions

Dix and Ellis (AVI 1998)
- Highlighting and focus
- Accessing extra info – drill down and hyperlinks
- Overview and context – zooming and fisheyes
- Same representation, changing parameters
- Linking representations – temporal fusion

Daniel Keim (TVCG 2002)
- Projection
- Filtering
- Zooming
- Distortion
- Brushing & linking

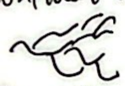
Yi et al. (TVCG 2007)
- Select
- Explore
- Reconfigure
- Encode
- Abstract/Elaborate
- Filter
- Connect

Classifiers that are commonly recognized as understandable, and hence need little effort to explain them



? 可视图合时间
纬度

confluent draw

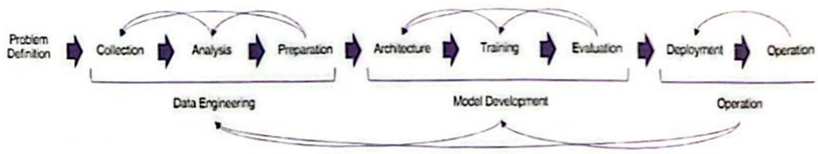


flow map.

Categories		Related Papers	Remarks
Interpretable Classifiers	Interpretable Architecture	Decision Trees [7],	rule-based
		Rule Lists [27, 59],	
		Rule Sets [60]	
		Linear Models [6]	linear
		kNNs [12, 22]	instance-based
	Learning Sparse Models	Decision Trees [43],	simplification
		Sparse SVMs [11],	
		Sparse CNNs [29]	
		Sparsity by Bayesian [56],	direct-sparsity
		Integer Models [55, 58]	

Not as explainable as they seemed to be!

The Life Cycle of a Classifier:



1.data collection
2.data characteristic
①时空移动轨迹
②几何形状:长度,持续时间,速度,方向.
3.Data 预处理
①采样/插值
4.Data calibration
轨迹校准

AI4VIS research primarily focuses on 7 problems: 1.Transformation converts visualizations from one format to another 2. Assessment measures the absolute or relative quality of a visualization in terms of scores or ranking 3.Comparison estimates the similarity or other metrics between two visualizations 4.Querying finds the target visualization relevant with a user query within visualization collections 5.Reasoning challenges AI to interpret visualizations to derive high-level information like insights and summaries 6.Recommendation automates the creation of visualizations by suggesting data and/or visual encodings 7.Mining discovers insights from visualization databases

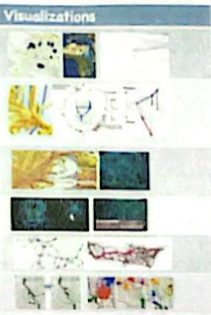
Good visualizations are accumulating rapidly
- Diverse, creative, and professional
- Clear patterns: alignment, color, font, etc.

Understand and reuse existing designs
- Design ideas: How to present information effectively
- Design details: How to present information aesthetically

Challenges
- Understand: Extract semantic models from examples
- Reuse: Find appropriate examples to reuse

- Basic Insights:
  - Read a value
  - Identify extrema
  - Characterize distribution
  - Describe correlation

十 五 Visual Analysis of Trajectories 1.motivation:Wireless Exploration 2.Challenges:Uncertainty, Noise, Scalability 3.Applications:Disaster Forecasting, Traffic Analysis and Management, Analysis of Movements of People, Location-based Service

	Techniques	Visualizations	Features
Spatial	Points Curves Proximately		1. Simple 2. Visual clutter
Temporal	Animation Color Shape 3D		1. Clear overview 2. Instant display vs durative display
Other	Color Height + Illumination		Clear visual patterns
User Interaction	Focus + Overview Brushing		User involved in the loop
Clutter Reduction	Force-directed Model Edge Bundling		1. Obscured semantics 2. Loss of information
Visual Analysis System	Interactive Progressive		Visual comparison and refinement

- Nested Qualitative Methods
  - Experimenter observations
  - Think-aloud protocol
  - Collecting participant opinions
- Inspection evaluation methods
  - Usability Heuristics
  - Collaboration Heuristics
- Information Visualization Heuristic
  - In situ observational studies
  - Participatory observation
  - Laboratory observational studi
  - Contextual interviews