CSCI 4550/6550 Interactive Visualization

https://www.cs.rpi.edu/~cutler/classes/visualization/S24/

Lecture 10: Uncertainty in Bar Charts & User Studies

Today

- Homework 6 & Quiz 1
- From Last Lecture: User Study Design for Architectural Sketching
- Inspirational Case Study User Study: “Where do People Draw Lines”
- Reading for Today:
  - “Error Bars Considered Harmful: Exploring Alternate Encodings for Mean and Error”
  - “Visual Encodings of Temporal Uncertainty: A Comparative User Study”
- Readings for Tuesday
- Pop Worksheet: Temporal Uncertainty Design

Notes on Schedule…

- Friday Feb 16th = Quiz 1
  - *Sample problems are on the calendar*
- Thursday Feb 22nd = Homework 6 Due
  - Team of 2 assignment (work with someone new!)
  - *Teams must be formed on Submitty by Tuesday Feb 13th*

	Feb 13, Lecture 11: Uncertainty II: Node-Edge Graphs & Maps			Feb 16, Quiz 1 sample problems
Feb 19, *No classes*	Feb 20, *Monday schedule*		Feb 22, Homework 6: Stream Graphs due @ 11:59pm *Team Formation due on Tuesday February 13th!*	Feb 23, Lecture 12: Ethics & Privacy
Feb 26, Final Project	Feb 27, Lecture 13:		Feb 29, Homework 7:	Mar 1, Lecture 14:

Homework 6: Stream Graphs

Team of two – someone you haven't worked with yet on Homework!

- Choose an personal, categorized, dense time-based dataset. E.g.:
  - minutes spent in a week on sleep/class/homework/eat/sports/tv
  - lines of code written in different languages (python,c++,java,etc.)
  - money spent on tuition/apartment/food/travel/clothing/movies
  - …
- What are your categories? What is your time discretization?
- Data doesn't have to be 100% real.
  It's ok if you write a script to synthesize plausible data based.
- First, plot the data using a "boring" stacked bar graph over time
  (2 separate plots, 1 for each person, using the same design/colors)
- Then, create a streamgraph version of the same data
  (also 2 separate plots, 1 per person, using the same design/colors)

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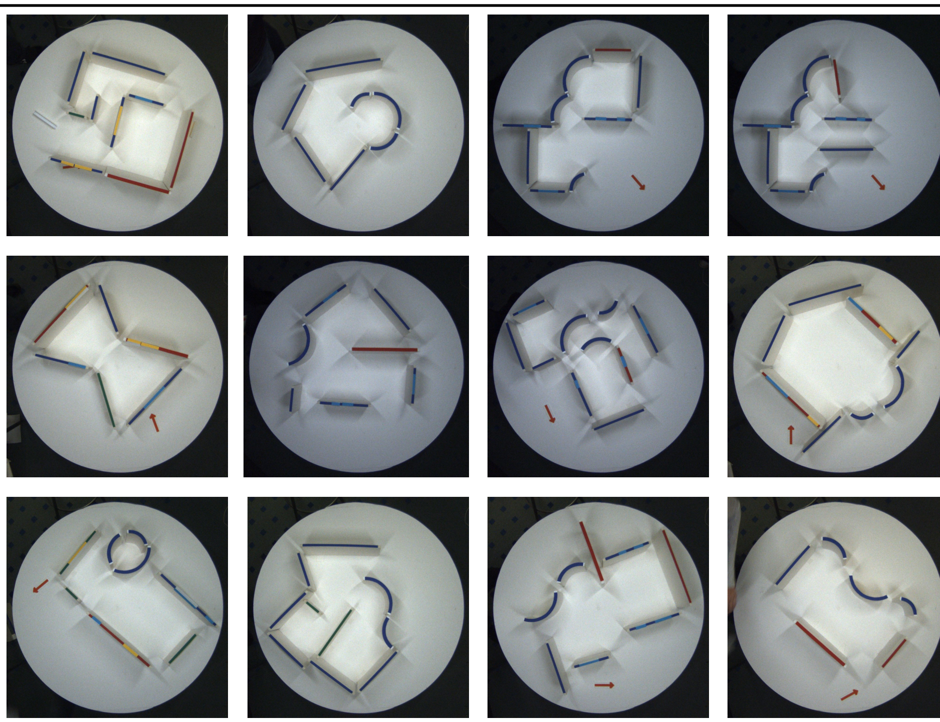


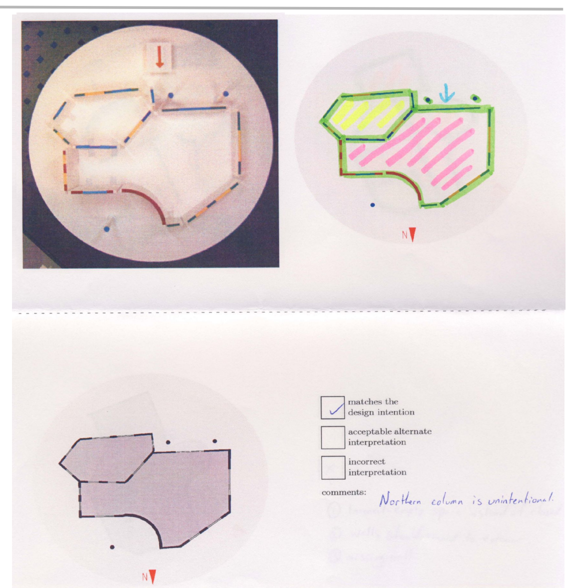
Our Goals in Conducting User Study Design

- Understand range of designs possible
- Improve physical sketching user interface
- Improve algorithm for sketch recognition of interior/exterior space
  - Learn common human interpretation “rules”
  - Quantify design ambiguity
- Measure effectiveness of *Virtual Heliodon* as an architectural daylighting design tool

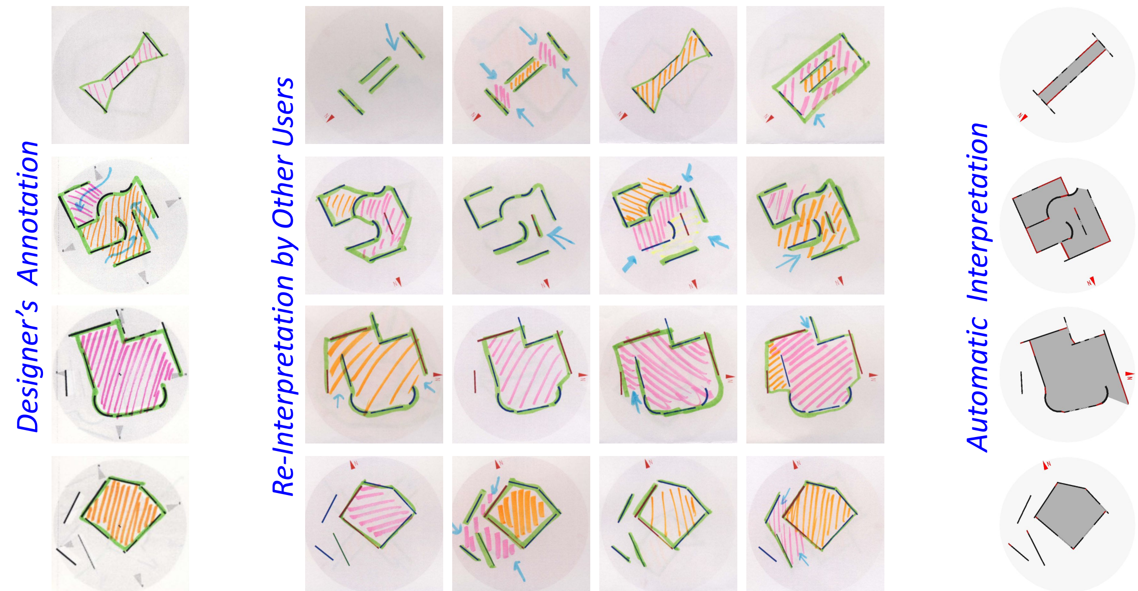
User Study 1: Open-Ended Design

- 30 participants (15 architects)
- 20 mins of sketching
- 329 unique designs (154 by architects)

- After design session:
- Designer annotates each design
- Then, we reveal our automatic interpretation

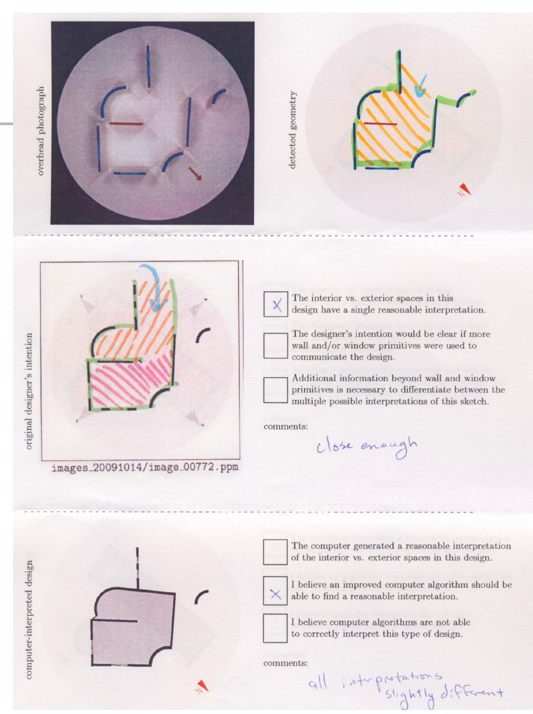


User Study: Identify/Quantify Ambiguous Designs



User Study 2: Re-Interpretation

- 114 designs from Study 1
  - All ambiguous designs included
  - Some clear designs (as controls)
- 15 participants
- Re-interpreted by another user
  - 3-6 new annotations for each
  - 346 total (124 by architects)
- Then compare to original designer's annotation
- And finally, to our automatic interpretation



Re-Interpretation Results

- No correlation found between background (architecture/arts/none) & interpretation accuracy
- We will continue to improve the robustness of our software

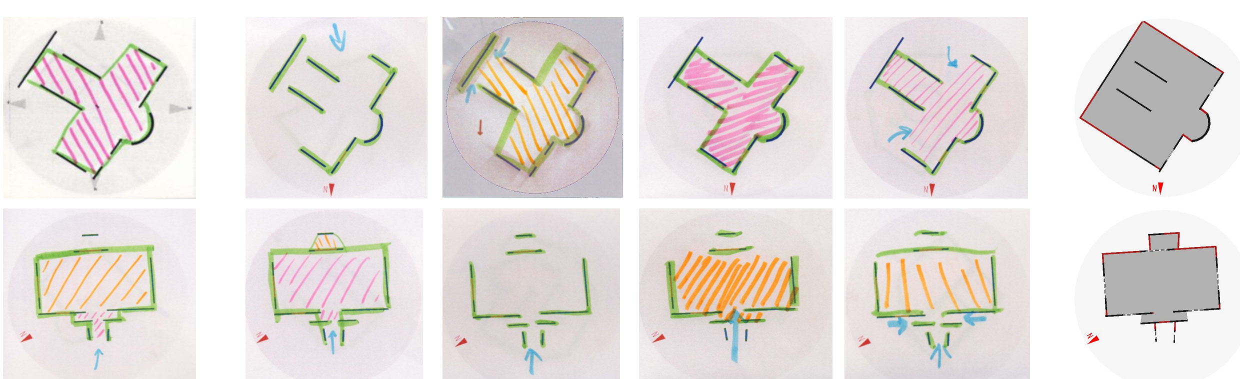
matches the original designer's intention

	correct		mostly correct		incorrect		total
clear	155	78%	17	9%	26	13%	198
ambiguous	74	56%	35	27%	22	17%	131
total	229	70%	52	15%	48	15%	329

multiple interpretations possible

Domain-Specific Knowledge Required

- Standard vocabulary of architectural forms (e.g., cruciform, portico, etc.)
- Maybe architectural data and modern AI/ML would help in these cases?



Designer's Annotation

Re-Interpretation by Other Participants

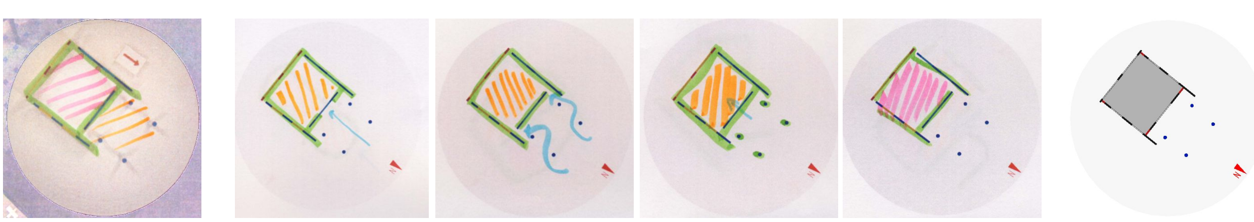
Automatic Interpretation

Future Work

- Improve/robustify interpretation algorithm
  - Detect symmetry & repetition
  - Multi-zone interiors & circulation paths
- Incorporate domain-specific knowledge
- Enhance user interface
  - Additional tokens, more complex element shapes
  - Alternative to sketching in plan:
    sketch (double height, multi-floor) vertical sections
- Apply to pen-based sketch interpretation

Thanks!

- Yu Sheng, Ted Yapo, & Andrew Dolce
- Our user study volunteer participants
- Funding from NSF & IBM



Designer's Annotation | *Re-Interpretation by Other Participants* | *Automatic Interpretation*

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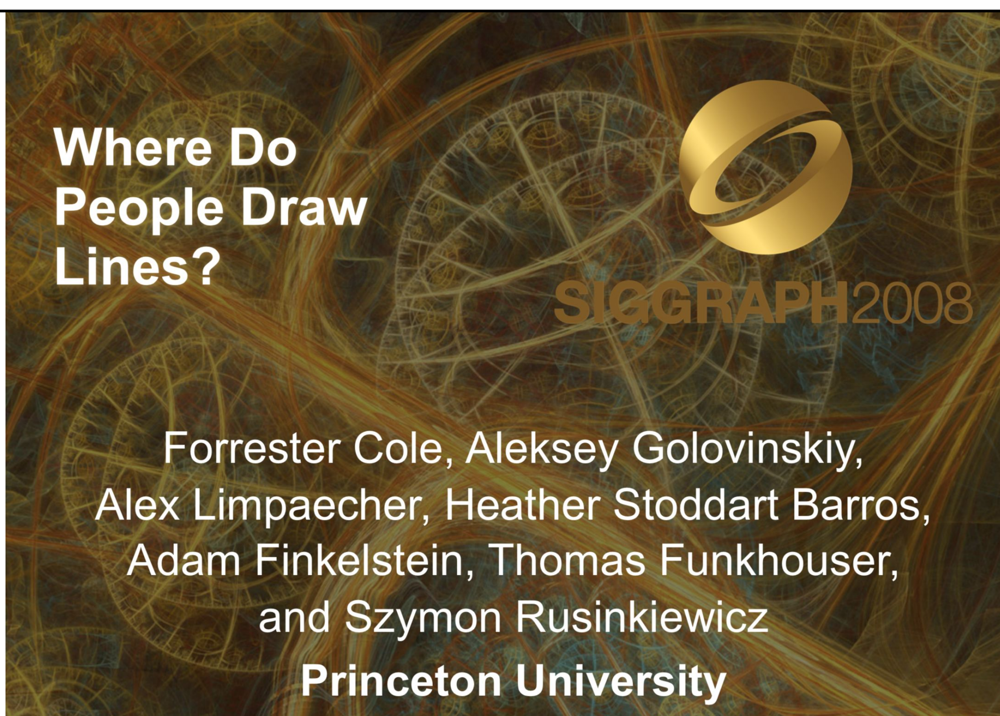
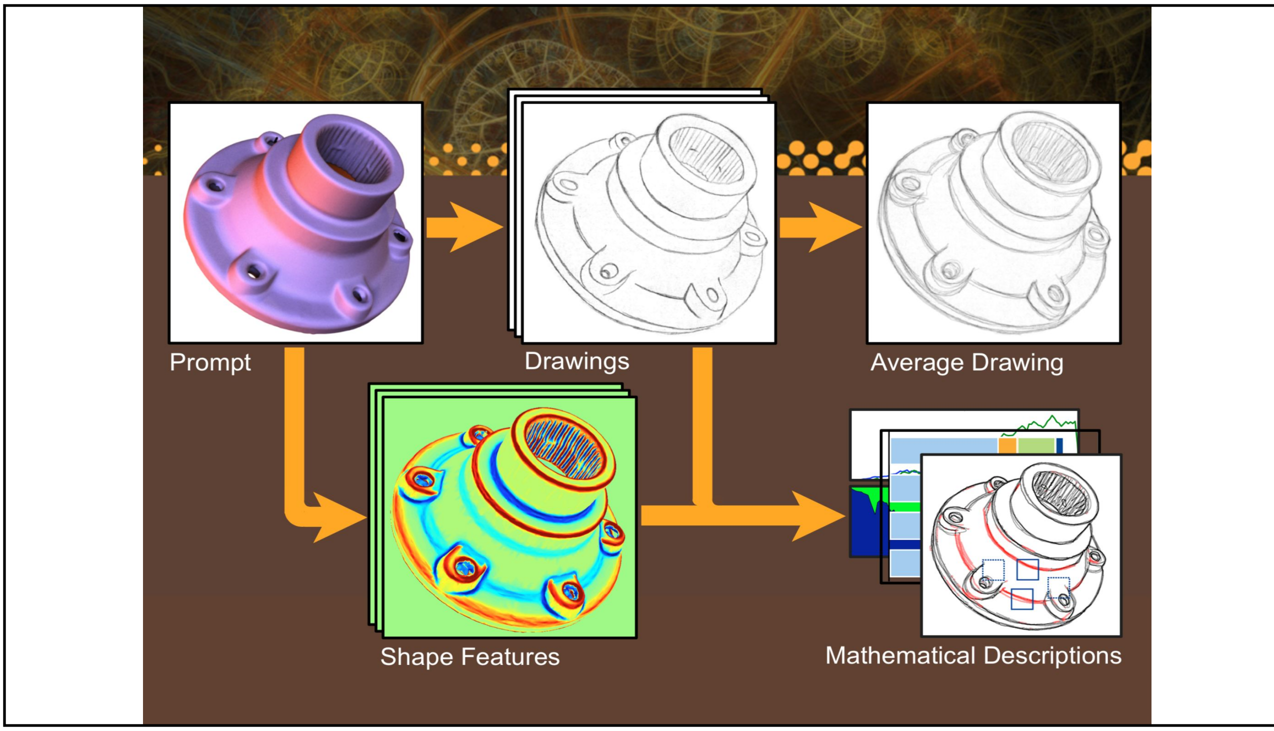



Prompt
Drawings
Average Drawing
Shape Features
Mathematical Descriptions


Artistic Style
Prompt Image
Solid, Smooth Feature Lines
Disallow:
Hatching and Shading
Sketchy Lines

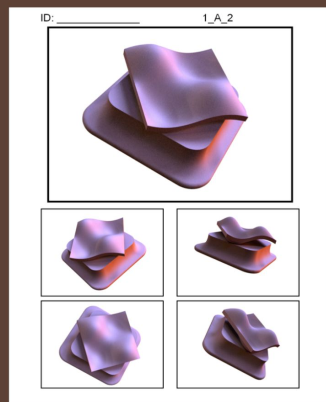

Study Protocol
Steps:
1. Fold
ID: 1_A_2
ID: 1_A_2
Prompt Page
Drawing Page
SIGGRAPH2008


Study Protocol
Steps:
1. Fold
2. Draw
ID: 1_A_2
ID: 1_A_2
Prompt Page
Drawing Page
SIGGRAPH2008

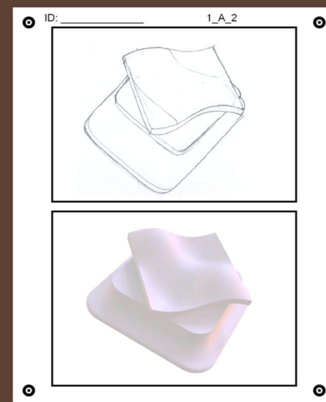
Study Protocol

Steps:

1. Fold
2. Draw
3. Unfold



Prompt Page

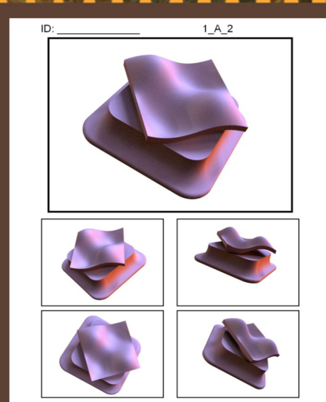


Drawing Page

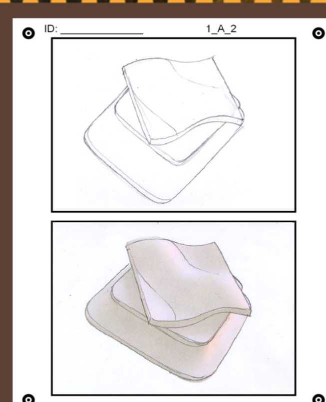
Study Protocol

Steps:

1. Fold
2. Draw
3. Unfold
4. Trace



Prompt Page



Drawing Page

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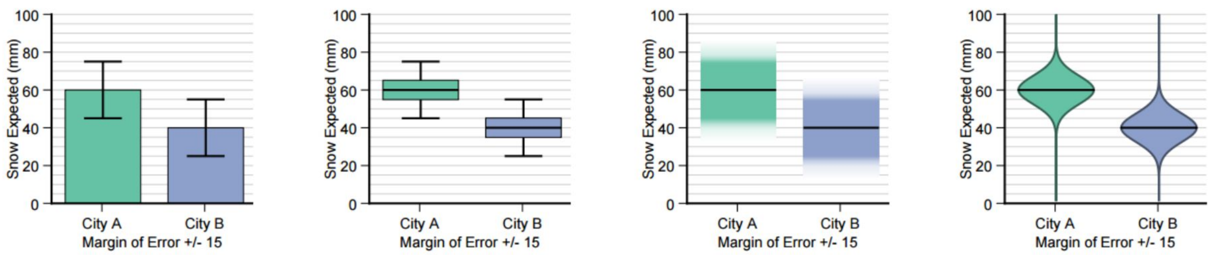
Reading for Today

"Error Bars Considered Harmful: Exploring Alternate Encodings for Mean and Error", Correll & Gleicher, TVCG 2014



(a) **Bar chart** with error bars: the height of the bars encodes the sample mean, and the whiskers encode a 95% t-confidence interval.

(b) **Modified box plot**: The whiskers are the 95% t-confidence interval, the box is a 50% t-confidence interval.

(c) **Gradient plot**: the transparency of the colored region corresponds to the cumulative density function of a t-distribution.

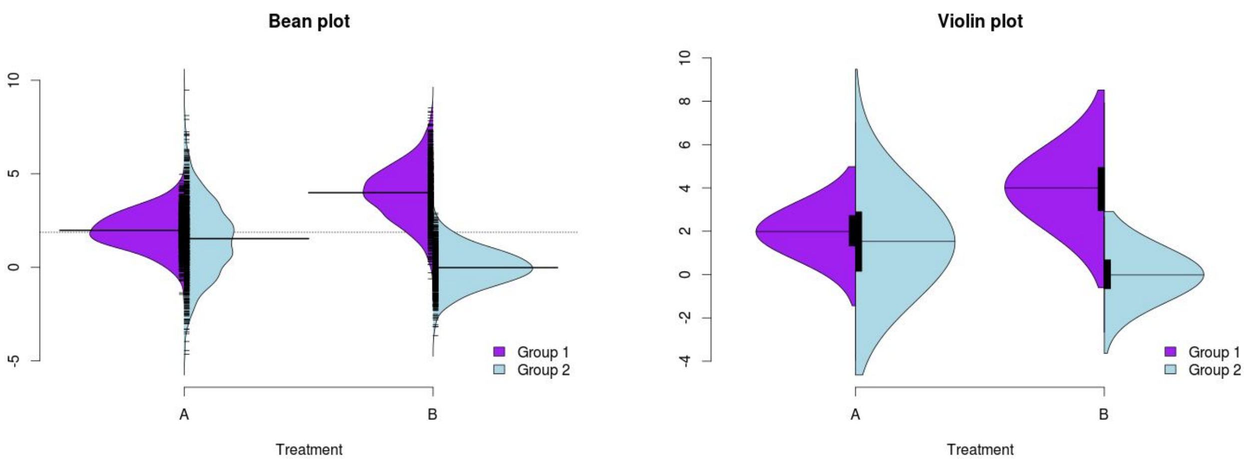
(d) **Violin plot**: the width of the colored region corresponds to the probability density function of a t-distribution.

- What is “Inferential statistics”?
- What is “Null-hypothesis significance testing”?
- Others have suggested problems with error bar visualization, but no one (“to our knowledge”) has done a rigorous comparative study yet
- Outliers are more memorable, resulting in bias of our perception of the distribution/mean/stddev
    - Visualizing uncertainty will help correct this bias
- People use error bars in different ways (might not be labeled or labeled far away in caption or text)
    - Range, 95%, 80%, stderror, stddev, etc.
    - Depending on the use, different heuristics necessary for visual analysis/inference
    - Common practice: add glyph (*) to indicate something is statistically significant
- Graphically *salient* features of the different options have impact on interpretation
- Standards have developed, been defined in different disciplines
    - Examined all publications in recent conference, counting # that use different variants of error bars

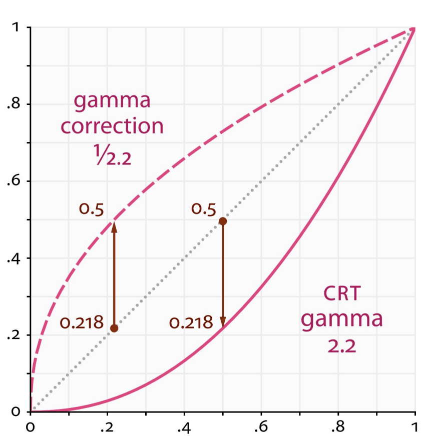
- Can potentially use any “visual channel” (transparency, width) to express uncertainty
  - Violin plots not widely used… good choice(?) chance to introduce a new standard
- Goals:
  - Visualize error without losing visualization of mean
  - Users should draw proper inferences from data
  - Continuous better than binary encoding (allows different uses)
  - Probably should be symmetric
- What is the best choice for limited display resolution? (how to handle lots of data on one plot?)
- Transparency: low saturation is associated with low confidence/uncertainty
  - Gamma problem?

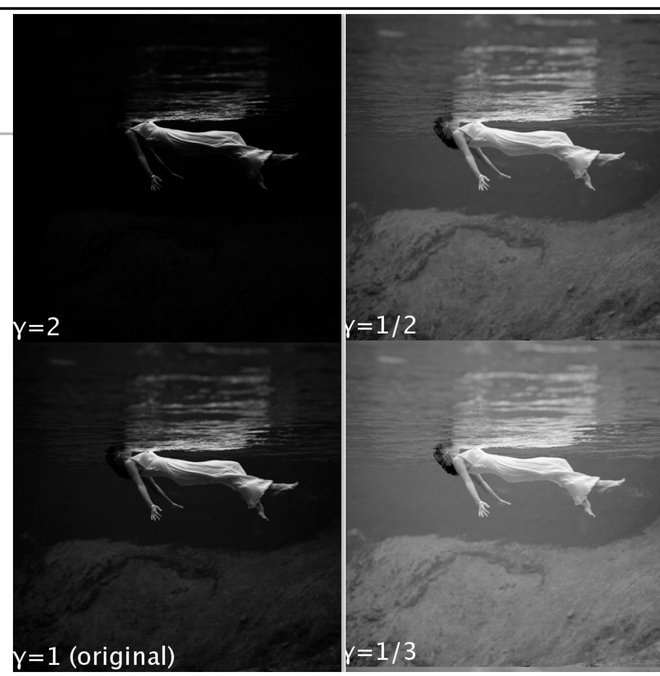
- One sample judgement (red dot in question)
- One sample + text judgement (question in caption)
- Two sample judgement (?)
- Mechanical Turk
- Impact of visualization choice for Prediction (this study) vs. Decision making (future work)
- What about Aesthetics? Preference?

Bean Plot vs Violin Plot

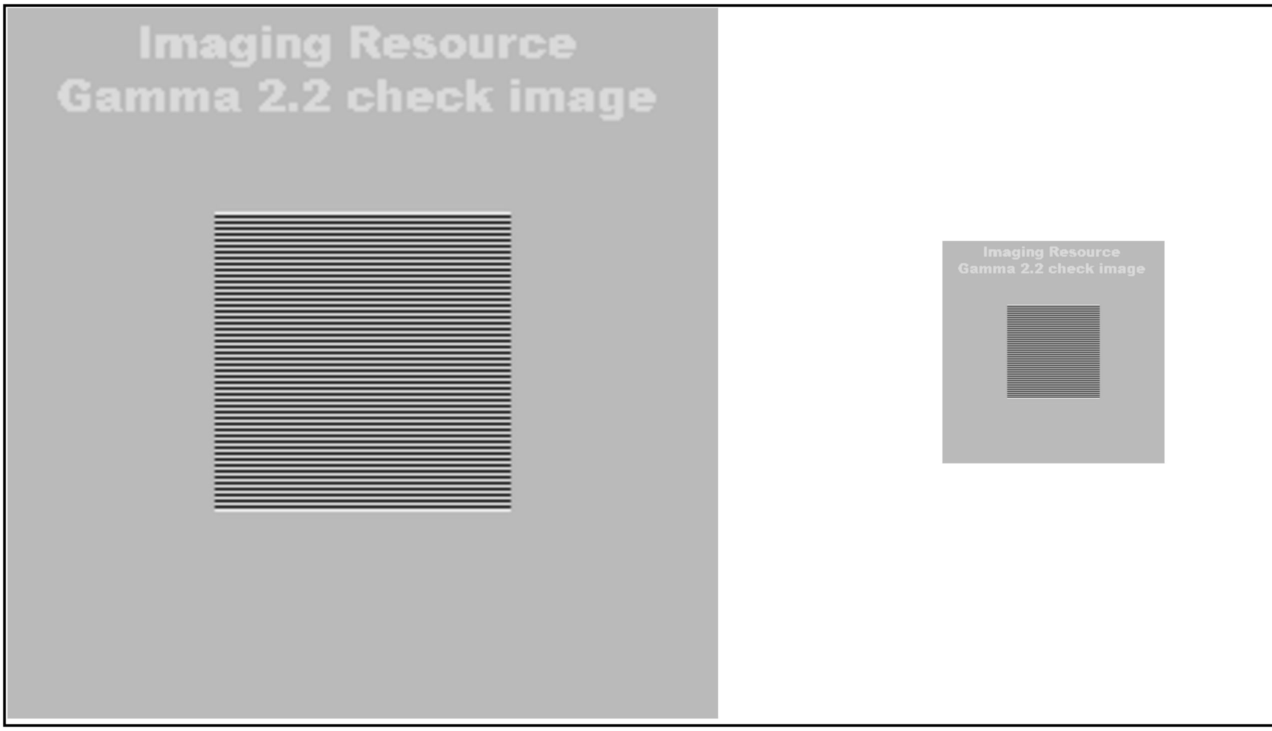


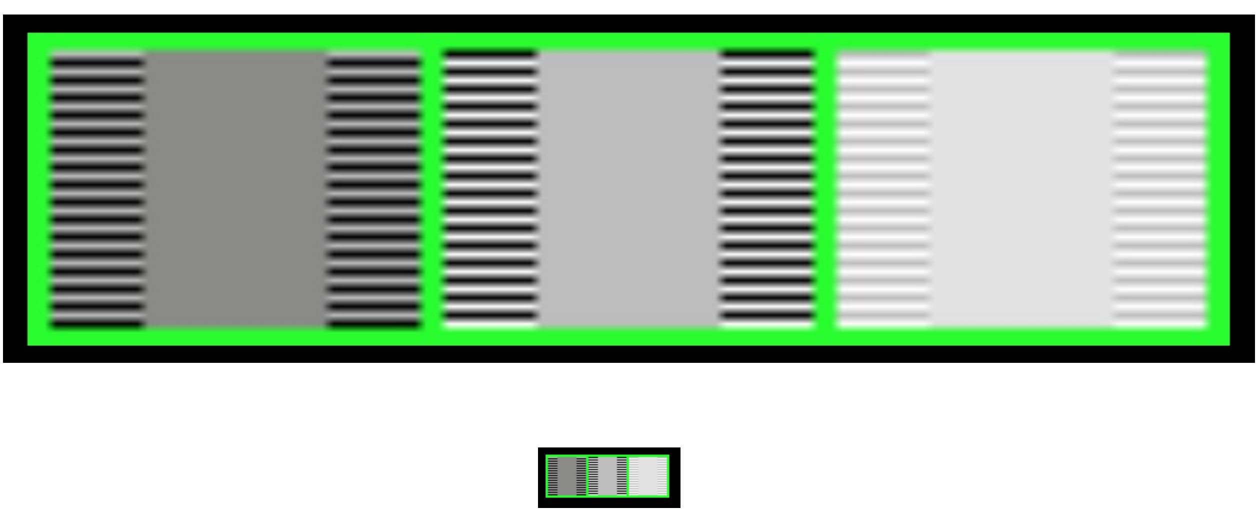
Gamma Correction





http://xahlee.info/img/what_is_gamma_correction.html


Imaging Resource
Gamma 2.2 check image
Imaging Resource
Gamma 2.2 check image



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Reading for Today

"Visual Encodings of Temporal Uncertainty: A Comparative User Study", Gschwandtner, Bogl, Federico, & Miksch, TVCG 2016

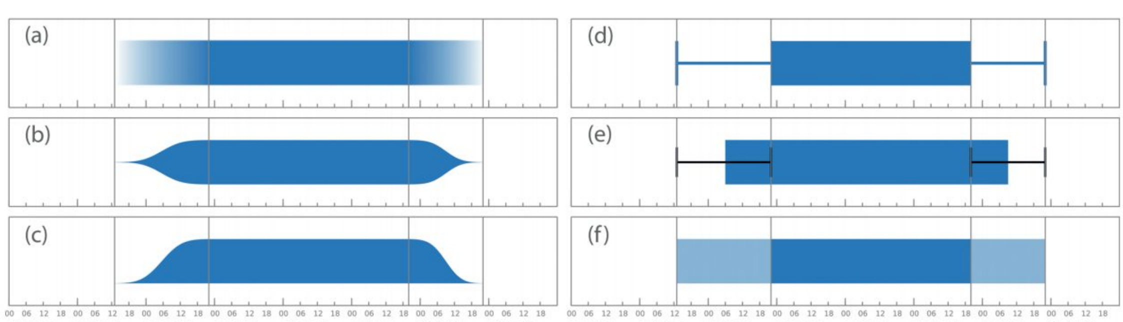
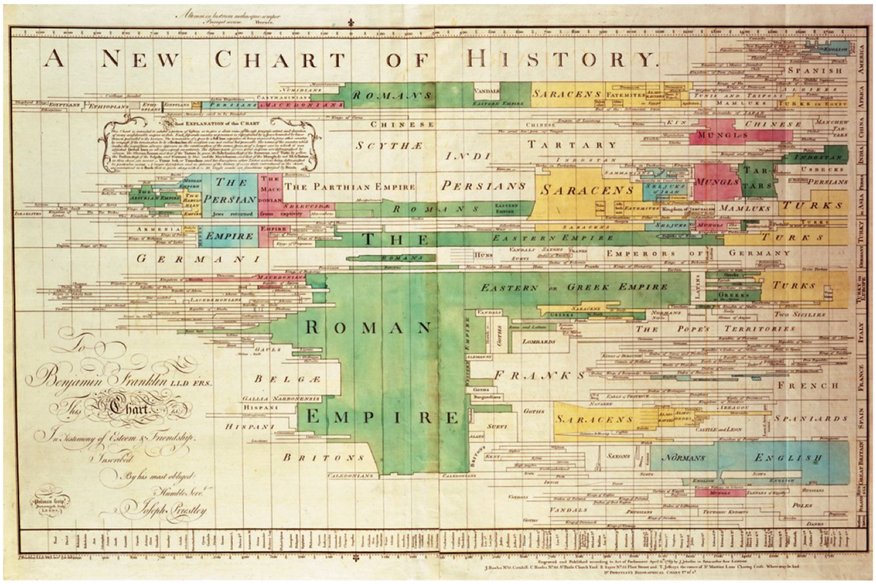
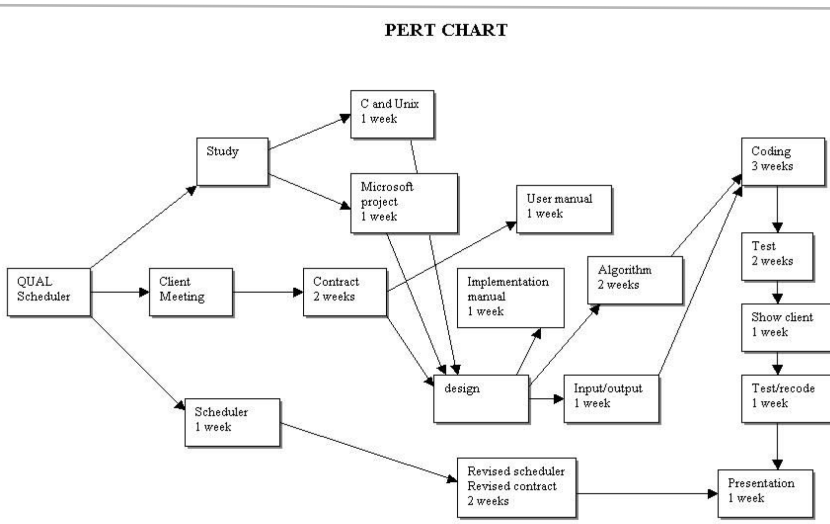


Fig. 1: Six different visual encodings of start/end uncertainty of temporal intervals used in the user study: (a) gradient plot, (b) violin plot, (c) accumulated probability plot, (d) error bars, (e) centered error bars, and (f) ambiguation. We designed encodings (a)–(c) to encode statistical uncertainty and encodings (d)–(f) to encode bounded uncertainty. All encodings were used to estimate earliest start, latest start, earliest end, and latest end, as well as minimum, maximum, and average interval duration. Moreover, encodings (a)–(c) were used to estimate the probability that the interval has already started/ended at a marked position in time.

Joseph Priestly Visualization (1765)

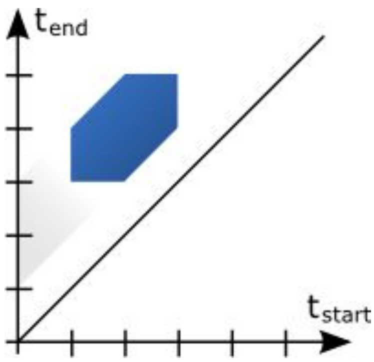


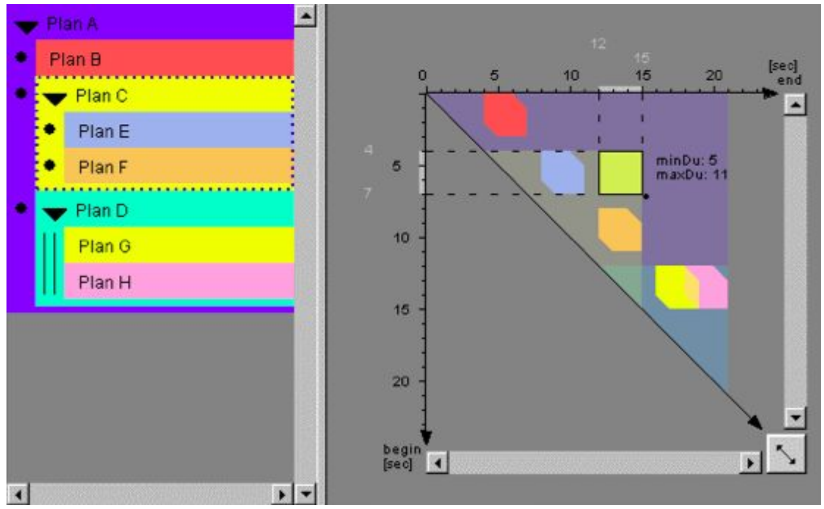
Pert Chart (US Navy 1950)



http://www.vistage.com/resource/how-to-keep-it-projects-on-schedule-part-2-pert-charts/

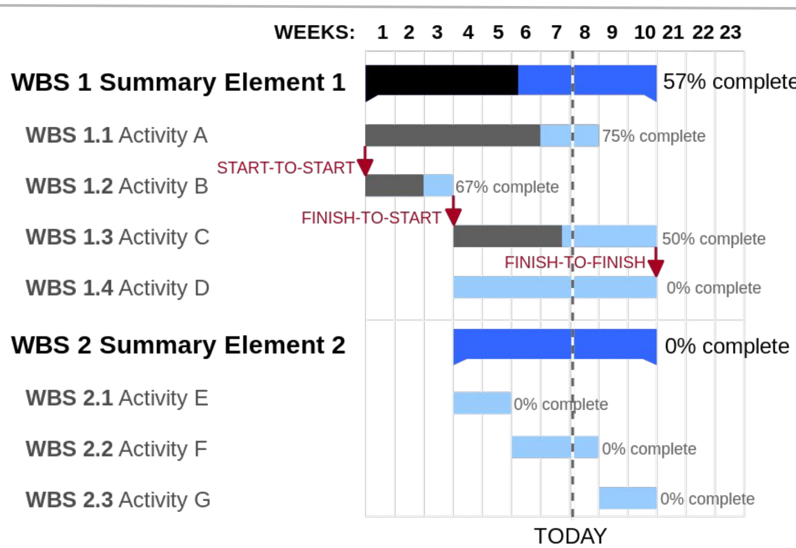
Sopo Diagram





https://eagereyes.org/techniques/sets-of-possible-occurrences

Gantt Chart



https://en.wikipedia.org/wiki/Gantt_chart#/media/File:GanttChartAnatomy.svg

- How to model time instants, intervals, spans
- Written examples of uncertainty for each are not completely clear(?)
- User study
    - Types of questions seem pretty complicated (compared to other user studies)
    - All users were students in a visualization class (trained in visual observation, researcher biases?)
    - Some users got confused and made trival mistakes (start vs. end earliest vs. latest)
    - Researchers admit some questions were badly phrased

- Paper was detailed & reproducible
- Good size for user study (73)
- Citation using number only is harder to read that citation with author name.
- Surprised (both authors and us as readers) that violin plots didn't perform as well as gradient plots

- J. Bertin. Semiology of graphics: diagrams, networks, maps (translated by William J. Berg). University of Wisconsin Press, 1967/1983.
  - defined these seven visual variables for visual representations: location, size, color hue, color value, grain, orientation, and shape
- J. L. Morrison. A theoretical framework for cartographic generalization with the emphasis on the process of symbolization. International Yearbook of Cartography, 14:115–127, 1974.
- A. M. MacEachren. Visualizing uncertain information. Cartographic Perspectives, (13):10–19, 1992.
- A. M. MacEachren. How maps work: representation, visualization, and design. Guilford Press, 1995.

Statistical Significance?

- Is 92 people enough?
- *A test result is called statistically significant if it is deemed unlikely to have occurred by chance.*
  - The more people you have, the smaller the difference needs to be in order to be deemed statistically significant.
- Which Statistics Test to use?
  - Student's T-test
  - ANOVA - Analysis of Variance
  - (lots more)...
- *Unfortunately statistics are easy to mis-use / abuse*

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Jacques Bertin, “Semiologie Graphique”, 1967

Bertin’s Original Visual Variables	
Position changes in the x, y location	
Size change in length, area or repetition	
Shape infinite number of shapes	
Value changes from light to dark	
Colour changes in hue at a given value	
Orientation changes in alignment	
Texture variation in ‘grain’	

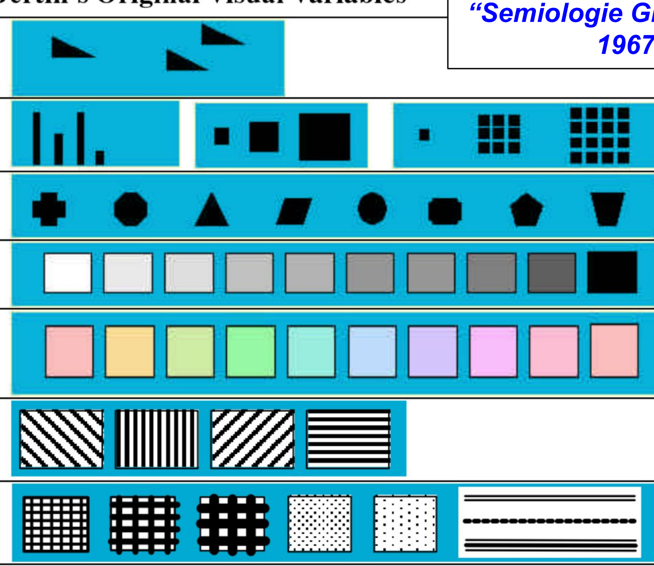
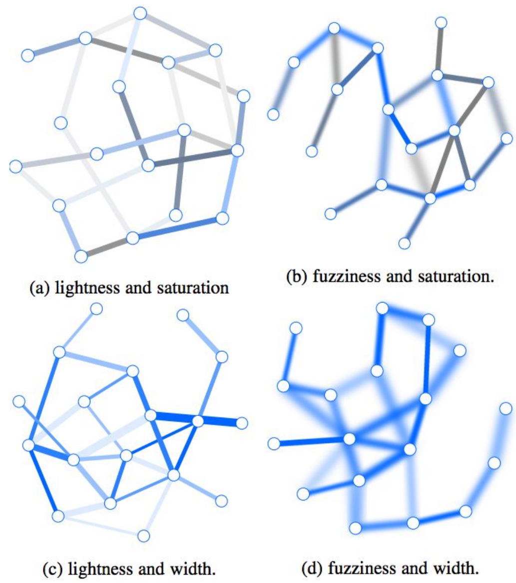


Table 1: These are Bertin's visual variables

https://innovis.cpsc.ucalgary.ca/innovis/uploads/Publications/Publications/Carpendale-VisualVariablesInformationVisualization.2003.pdf

Reading for Tuesday *pick one*

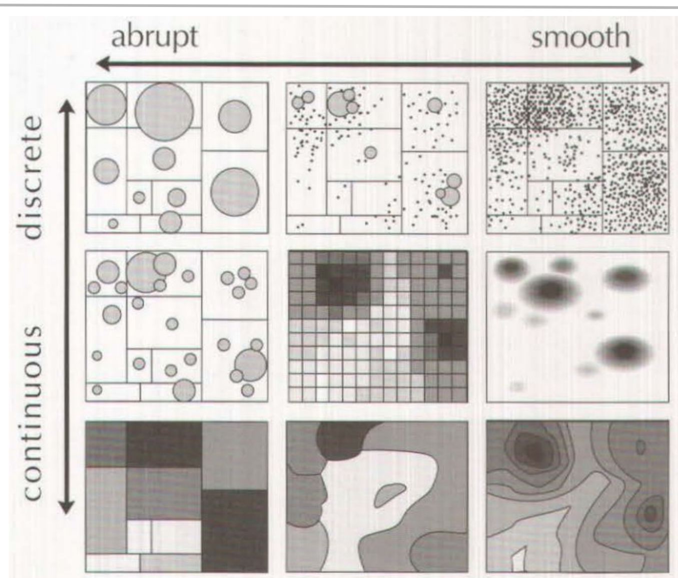
- "Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables" Guo, Huang, and Laidlaw, IEEE TCVG 2015



(a) lightness and saturation (b) fuzziness and saturation. (c) lightness and width. (d) fuzziness and width.

Reading for Tuesday *pick one*

- "Visualizing Uncertain Information", MacEachren, Cartographic Perspectives, 1992



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