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

Homework 6: Stream Graphs

- 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 \textit{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 \textit{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

- 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

User Study 2: Re-Interpretation
Re-Interpretation Results

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

<table>
<thead>
<tr>
<th></th>
<th>correct</th>
<th>mostly correct</th>
<th>incorrect</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>clear</td>
<td>155</td>
<td>17</td>
<td>26</td>
<td>198</td>
</tr>
<tr>
<td>ambiguous</td>
<td>74</td>
<td>35</td>
<td>22</td>
<td>131</td>
</tr>
<tr>
<td>total</td>
<td>229</td>
<td>52</td>
<td>48</td>
<td>329</td>
</tr>
</tbody>
</table>

matches the original designer’s intention

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?
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
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**Artistic Style**

- **Prompt Image** → **Solid, Smooth Feature Lines**
- **Disallow:**
  - Hatching and Shading
  - Sketchy Lines
Study Protocol

Steps:
1. Fold
2. Draw
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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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%, stderr, 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
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Reading for Today


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) ambiguity. 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)

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 trivial 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 than citation with author name.
• Surprised (both authors and us as readers) that violin plots didn’t perform as well as gradient plots
  - defined these seven visual variables for visual representations: location, size, color hue, color value, grain, orientation, and shape

**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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### Bertin’s Original Visual Variables

<table>
<thead>
<tr>
<th>Position</th>
<th>Changes in the x, y location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Change in length, area or repetition</td>
</tr>
<tr>
<td>Shape</td>
<td>Infinite number of shapes</td>
</tr>
<tr>
<td>Value</td>
<td>Changes from light to dark</td>
</tr>
<tr>
<td>Colour</td>
<td>Changes in hue at a given value</td>
</tr>
<tr>
<td>Orientation</td>
<td>Changes in alignment</td>
</tr>
<tr>
<td>Texture</td>
<td>Variation in ‘grain’</td>
</tr>
</tbody>
</table>

Table 1: These are Bertin’s visual variables

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Reading for Tuesday *pick one*

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

- “Visualizing Uncertain Information”,
  MacEachren, Cartographic Perspectives, 1992
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