Streamgraphs &
Gestalt Psychology &
Line Arrangements

Holton Rower
“Sometimes I Have to Look
in the Mirror to See if I’m
Still There”
2011

https://www.youtube.com/
watch?v=Gyktr2Ol4v4

http://seaburyschoolnavigators.
blogspot.com
What is the science behind this art? What physics/fluid would we need to accurately model to build a simulation?

- water/oil interaction (chemistry too)
- pen/stick/needle/stylus actions (water depth, speed through & speed in/out, angle, thickness, material, momentum)
- Momentum of water/color
- Surface tension
- Paper step looks hard
- Layered transparency blending? (not sure)
- Use this technique, paint on flat water, apply pattern to curved surface
- Fluid rigid body simulation
  - Surface tension
  - Viscosity
- Paint mixing vs displacement
- How to dye the oil? (not water-based)
Today

• Reminder: Quiz next week Friday
• Reading for Today:
  “Stacked Graphs – Geometry & Aesthetics”
• Readings for Tuesday Feb 27th
• Research Example
  – Gestalt Psychology
  – Computational Geometry: Arrangements
  – User Studies
Readings for Today

• “Stacked Graphs – Geometry & Aesthetics”
  Lee Byron & Martin Wattenberg, IEEE TVCG 2008

• Internet feedback was a large part of paper
  – Unnecessary?
  – started off as a story or documentary rather than an academic paper, strange
  – vulgar language ;(, seemed unprofessional (?)
  – Cannot measure “organic and emotionally pleasing”,
    proper analysis of comments beyond ‘some people liked it/
    some did not’ was not attempted/difficult/impossible

• Like other art… it is controversial, and that’s ok!
  – Eye magnets

• Layout
  – Tufté’s macro/micro: show both the sum and the individual values
  – Minimize “wiggle” of extremes & middle curves, thicker layers weighted more
    highly (but does not display data as accurately?)
  – Keep graph centered (don’t drift up or down)
  – Border/space between layers? If required by media
  – Labels are important
  – Interaction is good
  – Looks like mountains, foreground/background, perceived overlap implies some
    data is bigger than just the visible area
• Colors
  – Natural & pleasing, not too loud or distracting, (boring?)
  – For a particular dataset is it necessary to match disjoint regions by color?
  – Choose color from relevant 2D axes mapped to color & saturation
  – Don’t all need to be unique, aren’t limited by # of distinguishable colors
• Local contrast
  – Display data, e.g., time of onset, popularity,
  – Bias color selection to keep image balanced
• Order
  – Lack of prescribed ordering is unsettling
  – Sort by time of offset or “measure of volatility”
  – Generally alternating top & bottom seems to be best
  – Entrance position discussion interesting
• This is not a black box one-size-fits-all visualization technique. It requires thought to choose colors & tweak layout. It won’t work for all data. Could be done badly…
  – Difficult for newbies - no clear, straightforward solution/guidance for layout or color
  – Waviness of output appropriate for music data
  – Handles massive amount of data
  – This should be a graph option in Excel

• Legend mandatory to understand and interpret a particular streamgraph (no conventions)
  – The plots are so interesting you are motivated to figure it out
• Abstract was awkward talking about an image that wasn’t right there
• Insufficient comparison images within the paper (copyright thing? page limit? assumed to be “common knowledge”?)
• Didn’t explain improvements streamgraph vs. theme river
• Personalized visualizations are cool
• Purpose of this visual: to look cool & be engaging & draw interest or to scientifically measure & conclude things?
• Some sloppy figure callouts/captions/labels. Some captions too short. Why was this image included? Need to do more than just describe the source of the data
• Vertical vs horizontal: horizontal most appropriate for time data.
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Reading for Tuesday Feb 27th (pick one)

- "Error Bars Considered Harmful: Exploring Alternate Encodings for Mean and Error", Correll & Gleicher, TVCG 2014
Reading for Tuesday Feb 27th *pick one*


![Visual En codings of Temporal Uncertainty](image)

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.

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Interpreting Physical Sketches as Architectural Models

Barbara Cutler and Joshua Nasman
Department of Computer Science
Rensselaer Polytechnic Institute

“Virtual Heliodon” for Daylighting Analysis

camera to detect geometry
4 projectors to display solution
design sketched with foam-core walls
Tangible Interface for Architectural Design

Exterior & interior walls

Tokens for:
• Windows
• Wall/floor colors
• North arrow

Overhead camera  Projection geometry  Inferred design
Our Contributions

• Algorithm for automatic interpretation of interior space vs. exterior space
• Construction of a watertight 3D mesh
• User study collected >300 example designs
• Validation of algorithm
  – Compare to annotations by the original designer
• Quantify design ambiguity
  – Compare annotations of a design by other users

Related Work

• Tangible User Interfaces [e.g., Ben-Joseph et al. 2001]
• Sketch-based Modeling User Interfaces
  [Zeleznik et al. 1996; Igarashi et al. 1999; Dorsey et al. 2007]
• Pen-based Sketch Recognition [e.g., Wacom 2010]
• Automated Recognition of CAD Drawings
  [Aoki et al. 1996; Llados et al. 1997; Ah-Soon and Tombre 2001; Kulikov 2004; Lu et al. 2005]
• Human Vision, Perception, & Gestalt Psychology
  – Seek the simplest explanation for an incomplete diagram
  – Closure, proximity, symmetry, continuity, collinearity, & parallelism
Gestalt Principles: Reification

- Constructive or generative aspect of perception

Pragnanz: Gestalt Laws of Grouping

- Proximity
- Similarity
- Closure
- Symmetry
- Common fate
- Continuity
- “Good” gestalt (regular, simple & orderly, eliminate complexity & unfamiliarity)
- Past experience
Gestalt Principles

• Figure/Ground

Overview of Algorithm

• Image Processing (our earlier publications)
• Lack of precision in sketch: Should elements be parallel? collinear? perpendicular? tangent?
• Link tangent walls to form continuous chains that divide space into zones
• Determine interior vs. exterior
• Generate floor plan diagram & watertight mesh geometry (more details in our paper)
Tolerance Example: Collinearity

- Detected Geometry
- Designer’s Intention
- Favor Collinearity
- Favor Skew Lines

Other Users’ Interpretations

Connecting segments together

- End points near each other (what epsilon/tolerance?)
- Approximately parallel (what epsilon/tolerance?)

- Snap to perfect line? Or preserve original shape?
- What if we have multiple matches?
Linking Elements to Form Chains

• If $A \rightarrow B$ and $B \rightarrow A$ are best matches for tangent, then the walls are joined into a chain

Detected Geometry

Wall Chains, Extended to Infinity

Halfspace Zones & Enclosure

• Further subdivided using GraphCuts (if needed)

Halfspace Zones

Densely Sampled Enclosure (Visibility Test)
Complexity Analysis?

Input: $n$ physical walls or sketched pen strokes

Consider connecting into chains

- How many endpoint-endpoint connections?
- How to reduce # of comparisons?

After joining into $m$ “wall chains” ($m \leq n$)

- How many point intersections (between wall chains)?
  - What if the wall chains are perfect lines?
  - What if they wall chains are general curves?
- How many zones/cells/faces (assume lines)?
- How to uniquely label faces?

Labeling Interior vs. Exterior

- How many ways to label entire diagram interior vs. exterior?
  Assume $f$ faces, and each face should be labeled interior or exterior.

4 lines (wall chains) with this configuration, limited to this circle, we have 9 faces/zones
Interior/Exterior Enclosure Threshold

- Unfortunately, there is no universal threshold
- Varies design-to-design, and within-a-design

![Automatic Interior/Exterior Determination & Final Floorplan](image)

**Complexity Analysis?**

**Input:** $n$ physical walls or sketched pen strokes

Consider connecting into chains

- How many endpoint-endpoint connections? $\frac{2n \cdot 2(n-1)}{2} = O(n^2)$
- How to reduce # of comparisons? *Spatial data structure, like a quadtree*

After joining into $m$ “wall chains” ($m \leq n$)

- How many point intersections (between wall chains)?
  - What if the wall chains are perfect lines? $O(m^2)$
  - What if they wall chains are general curves? $O(\infty)$
- How many zones/cells/faces (assume lines)? $O(2^m)$
- How to uniquely label faces? *Binary code, each bit represents which “side” of each wall chain it lies on.*

**Labeling Interior vs. Exterior**

- How many ways to label entire diagram interior vs. exterior? $O(2^f) = O(2^{2m})$
  
  Assume $f$ faces, and each face should be labeled interior or exterior.
Interior/Exterior Optimization

- Analyze histogram of point-sampled enclosure values
- Maximize usage of lengths of real wall elements
- Minimize length of inferred (added) walls
- Minimize area assigned in opposition of simple threshold metric

Complex Boundaries & Varying Gaps

Open Courtyards & Multiple Buildings
Our Goals in Conducting User Studies

• 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
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

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<td>total</td>
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</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.)
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