

Streamgraphs & Gestalt Psychology & Line Arrangements

Course Update

- Rainbow Grades has been updated with
- Maksim's office hours are now Weds 1-3pm
- Grade inquiries before Exam 1
- **Exam 1:** Friday the 2nd
 - There will be no class period
 - You will have 2 hours* to complete the exam via Submittity once you have first clicked into the gradeable.
 - *Reach out if the school provides you w/ accommodations
 - The Exam must be completed on Friday
 - Closed book with a double sided study sheet
- **Break!** Relax, recharge, and think about your final project
- **Homework 6 (when we come back)**
 - Write up 2x project ideas
 - Post them on the forum
 - Form teams

Today

- **Accessibility**
- HW5: Experimenting with Color
- Linguistic Coloring
- Reading for Today:
 - “Stacked Graphs – Geometry & Aesthetics”
- Reading for Friday
- Research Example
 - Gestalt Psychology
 - Computational Geometry: Arrangements
 - User Studies

Accessibility

- What is it?
 - “When websites and web tools are properly designed and coded, people with disabilities can use them.” W3.org
- WebAIM: Web Accessibility in Mind
 - A major standard provider in web accessibility
- WCAG: Web Contrast Accessibility Guidelines
 - Specifically for visually impaired individuals
 - (But it makes it easier for everyone else to see too!)

WCAG

- Three levels
 - A, AA, and AAA
 - All websites should strive for AA
 - Government sites may require AAA
- What is a contrast ratio:
 - Ratio of the luminance (brightness) of the lightest shade to the darkest shade
- Small text and large text have different requirements

Tools to make it easier

- Lighthouse!
 - Automatic audits of your site to find accessibility problems
 - Also helpful if you want to deploy a Progressive Web App (PWA)
- WAVE
 - Cross browser automatic web accessibility testing
- Web inspector
 - Selecting web elements shows you their contrast
- Web Color Picker
 - Shows lines for AA and AAA


More reading

- The Science of Color Contrast
 - <https://medium.muz.li/the-science-of-color-contrast-an-expert-designers-guide-33e84c41d156>
- WebAIM
 - <https://webaim.org/articles/visual/>
- Submittity Accessibility Guidelines
 - https://submittity.org/developer/interface_design_style_guide/web_accessibility

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Homework Assignment 5: Experimenting with Color



Teams of 2
encouraged!

- Revisit an earlier assignment/data/toolkit
 - Make a non-color-related improvement to this visualization
- Prepare many versions of the same visualization experimenting with different color palettes, e.g.:
 - Shades of grey
 - Black & white
 - Cool vs. warm tones
 - Bold/saturated vs. pastel
 - Colorblind aware
 - Light vs dark background and/or color negation
 - Etc.
- Analyze the effectiveness of the color scheme for each visualization.
 - How well does it convey the message? Or mislead the viewer?
- Compare the visualizations to each other.

Today

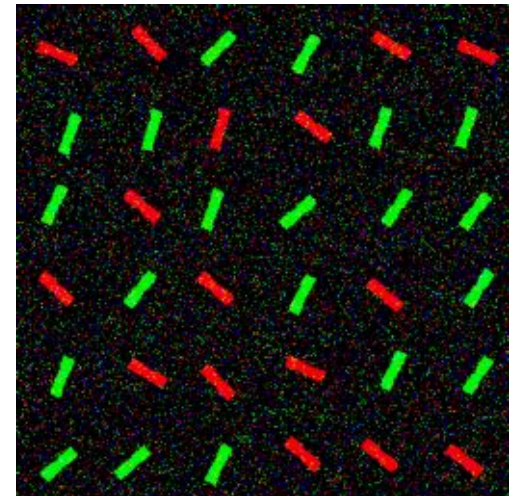
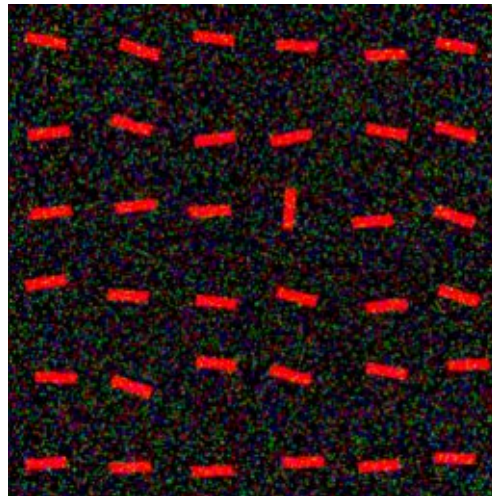
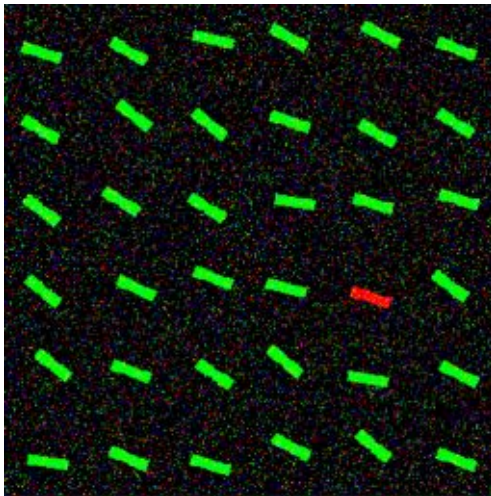
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Visual Salience

Laurent Itti (2007), Scholarpedia, 2(9):3327.

http://www.scholarpedia.org/article/Visual_salience

- ... is the perceptual quality that makes some items in the world stand out from their neighbors and grab our attention

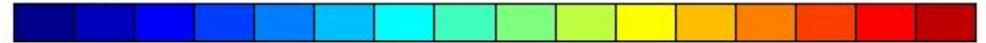


- Designers use saliency to create objects (such as this emergency triangle) that appear highly salient in a wide range of viewing conditions

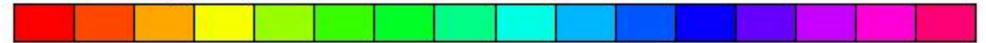


- “when using many colors of different hues, I get a blended hot mess of color that completely washes out and detail of the underlying 3D rendered model”
- The Matlab “jet” color scheme is the default (and it looks so pretty!), but it is misleading!

Bar of Colormap jet:



Bar of Colormap HSV:



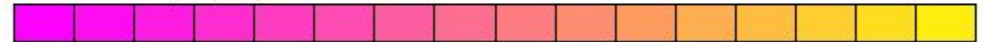
Bar of Colormap Hot:



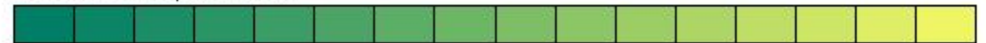
Bar of Colormap Cool:



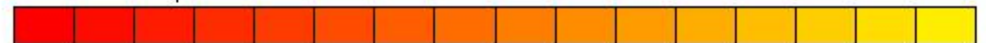
Bar of Colormap Spring:



Bar of Colormap Summer:



Bar of Colormap Autumn:



Bar of Colormap Winter:



Bar of Colormap Gray:



Bar of Colormap Bone:



Bar of Colormap Copper:



Bar of Colormap Pink:



Bar of Colormap Lines:



©sideway.hk

Semantic Coloring

“A Linguistic Approach to Categorical Color Assignment for Data Visualization”, Setlur and Stone, IEEE InfoVis 2015

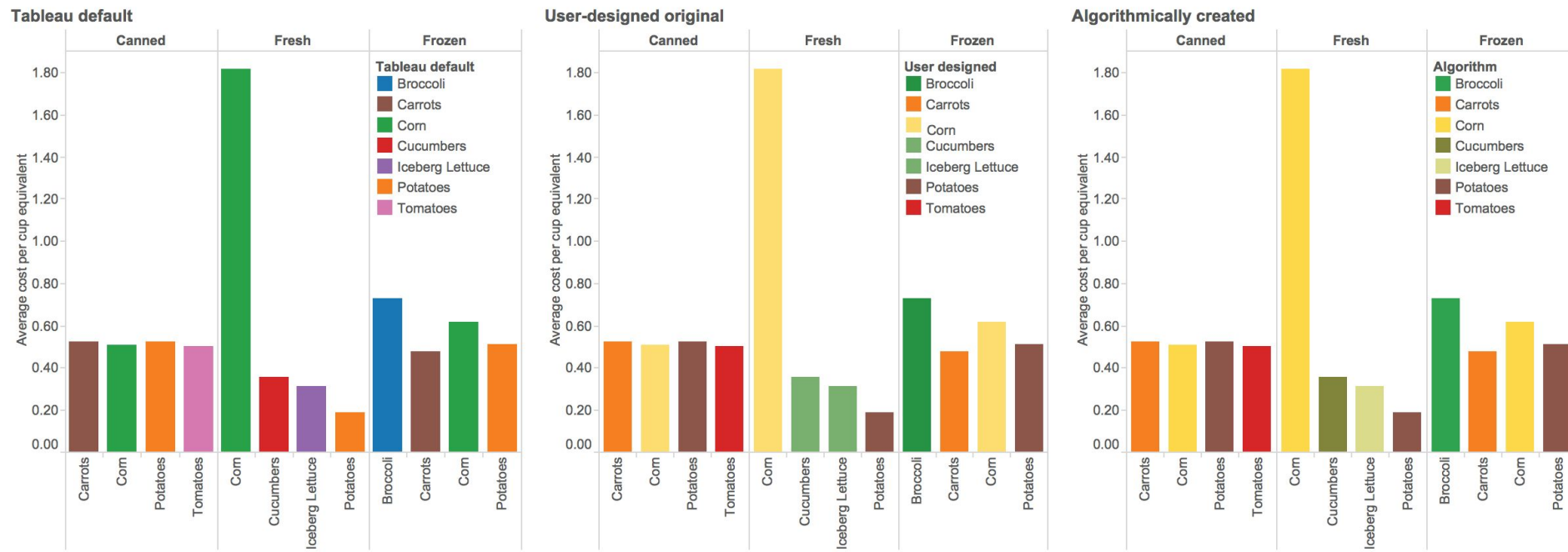
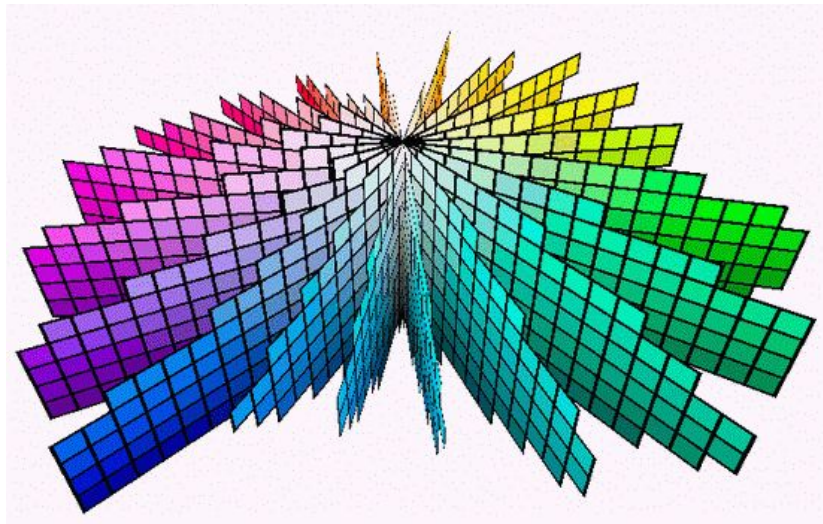


Fig. 1. This visualization was taken from a Tableau Public workbook [11] to illustrate the value of semantic color encoding. Left: The Tableau default colors are perceptually legible, but conflict with the data semantics (‘Tomatoes’ are pink, ‘Corn’ is green). Center: The Tableau author matched the colors to the data semantics (red for ‘Tomatoes’, yellow for ‘Corn’), which makes it easier to identify the different types of vegetables in the graph. Right: Our algorithm automatically created a similarly effective result.



Stroop Effect

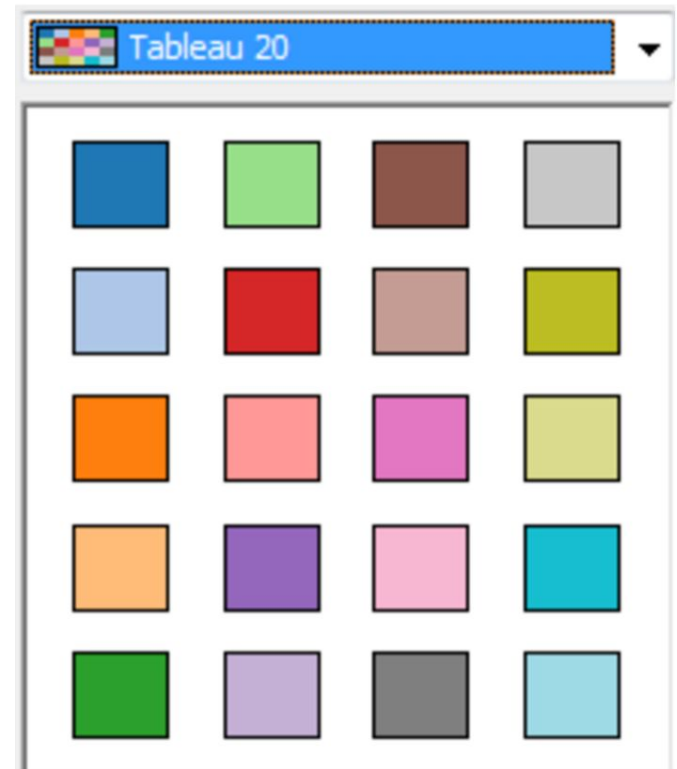
<http://faculty.washington.edu/chudler/words.html>



Munsell Color System (Hue, Chroma, Lightness)



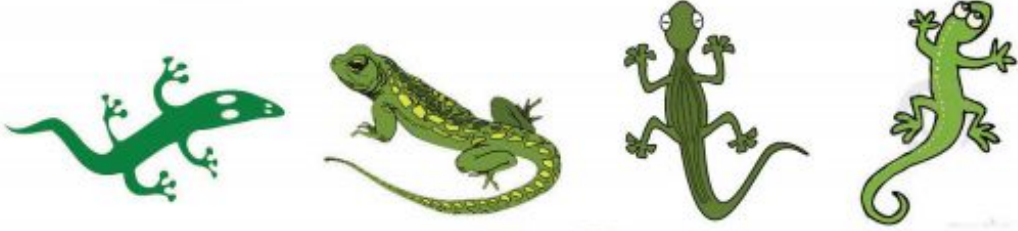



<http://www.codeproject.com/Articles/7751/Use-Direct-D-To-Fly-Through-the-Munsell-Color-So>

TableauColors



- Is a word colorable?
 - Use Google n-grams to find # of times it is associated with color (books only? *Would this be even better if they had a general human speech corpus?*)
 - Are there strong color associations for a word?
- What is the best color value?
 - google images (clipart or natural images?)
- Semantic context
 - apple the fruit or apple the company?
 - NLP (Natural Language Processing)
- K-means clustering to create set of distinct colors (flexibility of different colors for some items)
- *“The power of these names is not their accuracy, but their memorability and ease of use.”*

- Berlin & Kay's 11 basic color terms:
 - black, white, red, green, yellow, blue, brown, purple, pink, orange, gray
- Why clipart?

Input term	Top clustered images	Canonical color
taxi		
lizard		
saffron		

- Query expansion, Ontology, Concept tree

- Not surprised that it performs poorly for logos
- Even if the results are always perfect, this can be a huge timesaver!
And expand what colors we should consider.
 - Why limit choices to Tableau 20? Why not pantone? Or Munsell?
- Good scientific organization to paper
- Larger datasets & statistics always(?) better than surveys
 - Presented algorithms are entirely dependent on these datasets
- Impressive result for 2 different fields
(could alternatively be a paper in an NLP conference)
- Lots of detail in the paper (good for reproducibility)...
but also feels like lots of padding/redundancy in the paper?
(same example used multiple times)
- Discussion could be stronger/more complete
 - Competitor's results often (always?) seemed better...
- Xkcd is awesome
- Sentiment analysis (sorta creepy)
- Why include poem?

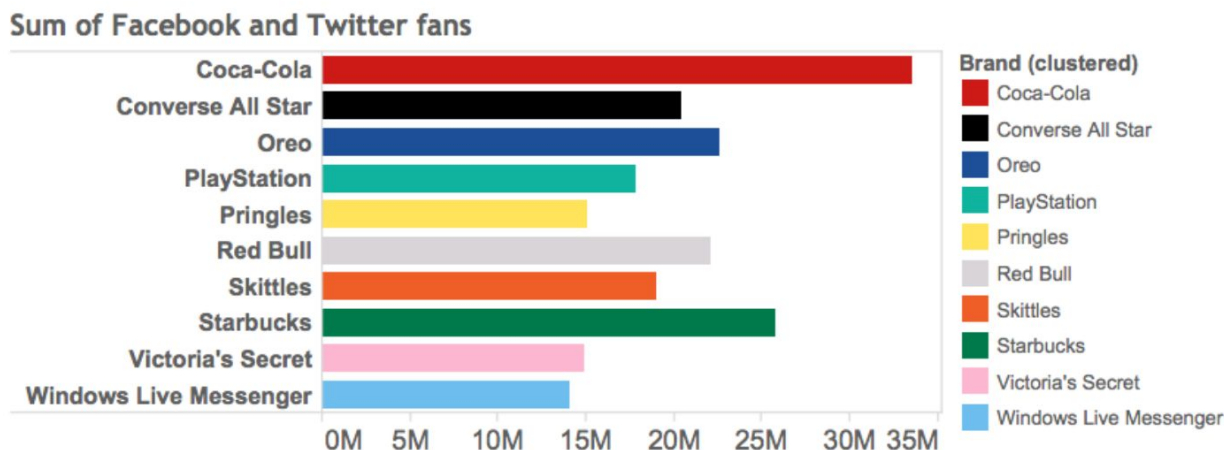
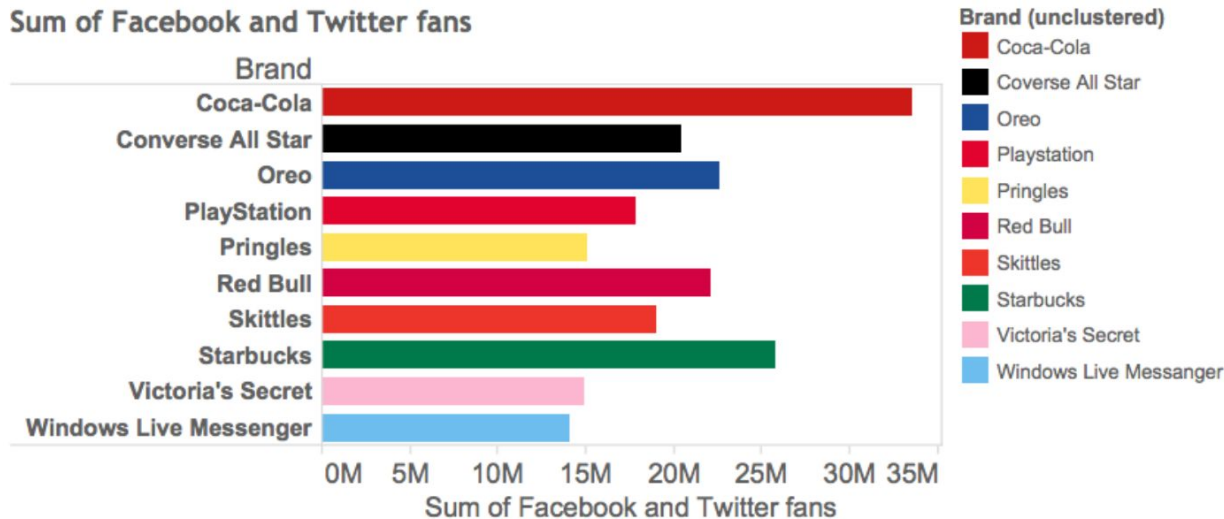


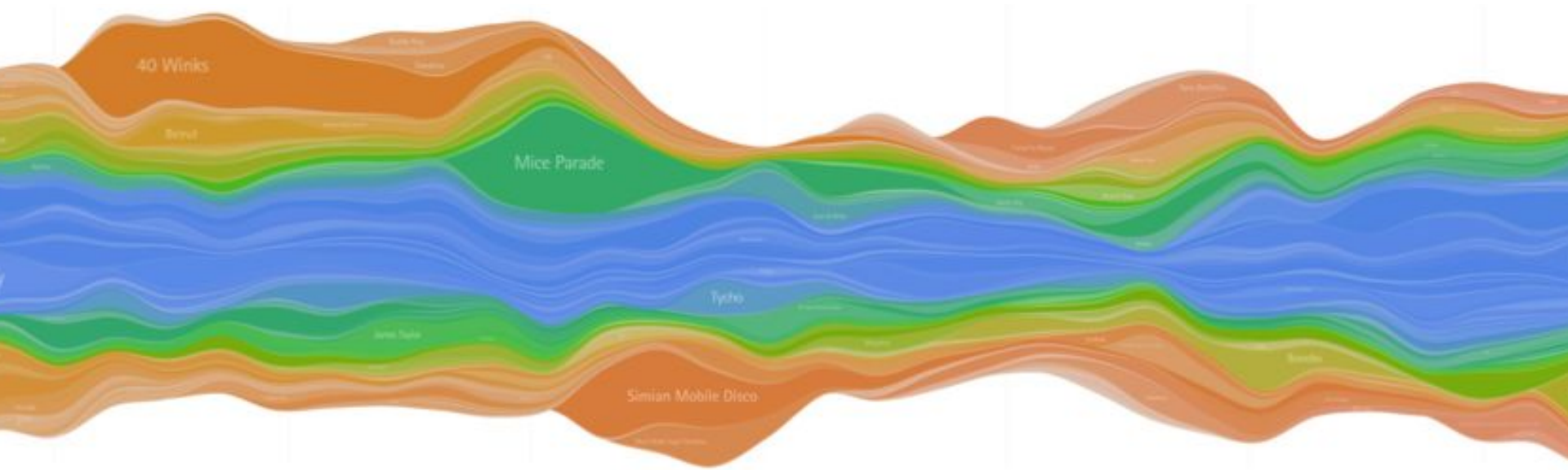
Fig. 12. Top row: A Tableau Public visualization [11] semantically color encoded with our algorithm before clustering is applied. One can observe several brands colored with shades of red. Bottom row: Once clustering is applied to the set of colors, some of the reds are replaced by alternate canonical colors obtained from the corresponding logo images.

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Reading 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
 - Tufte’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.
- Helpful reference:
<http://www.visualisingdata.com/index.php/2010/08/making-sense-of-streamgraphs/>



Holton Rower

“Sometimes I Have to Look
in the Mirror to See if I'm
Still There”

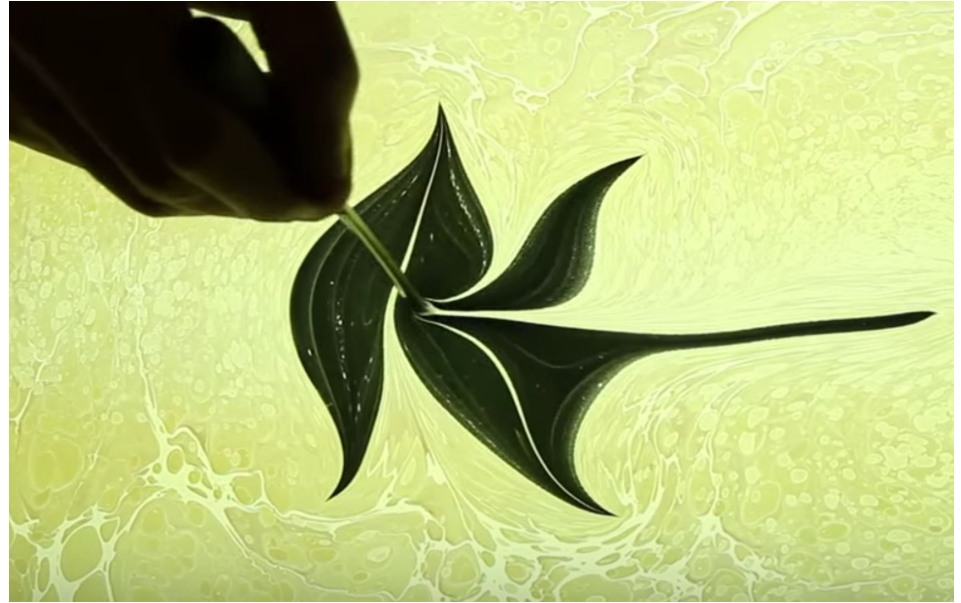
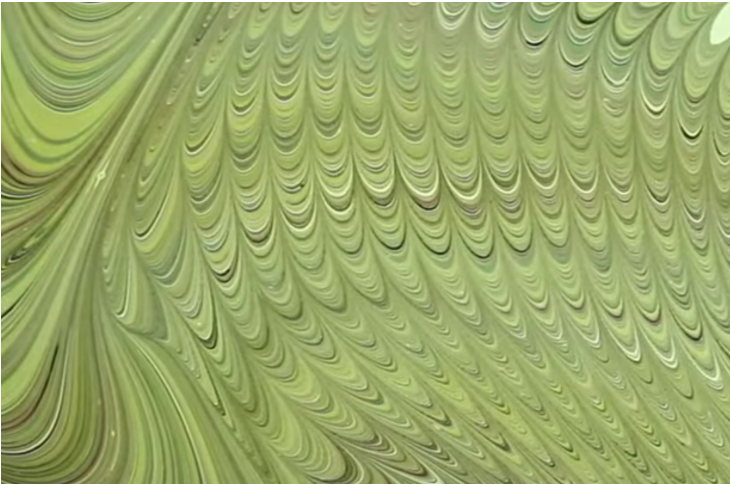
2011

[https://www.youtube.com/
watch?v=Gyktr2OI4v4](https://www.youtube.com/watch?v=Gyktr2OI4v4)



[http://seaburyschoolnavigators.
Blogspot.com](http://seaburyschoolnavigators.Blogspot.com)

Ebru Art @ American Islamic College



<https://www.youtube.com/watch?v=llLIFcq3K3U>

What is the science behind this art?

What physics/fluid would we need to accurately model to build a simulation?



What is the science behind this art?

What physics/fluid would we need to accurately model to build a simulation?

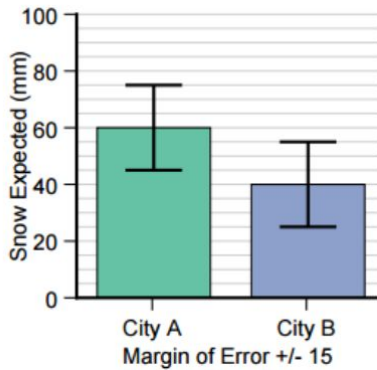
- water/oil interaction (chemistry too)
- pen/stick/needle/stylus actions (water depth, speed through & speed in/out, angle, thickness, material, momentum)
- Momentum of water/color
- Surface tension
- Paper step looks hard
- Layered transparency blending? (not sure)
- Use this technique, paint on flat 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

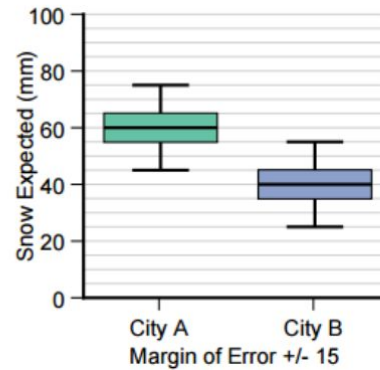
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Reading for Next Time

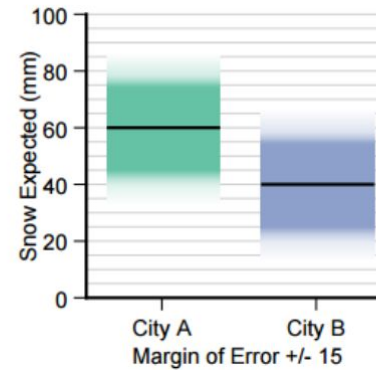
- "Error Bars Considered Harmful: Exploring Alternate Encodings for Mean and Error", Correll & Gleicher, TVCG 2014



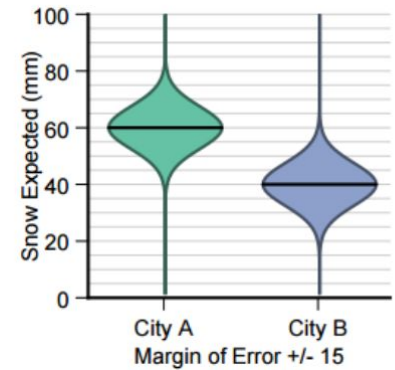
(a) **Bar chart** with error bars: the height of the bars encodes the sample mean, and the whiskers encode a 95% t-confidence interval.



(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.

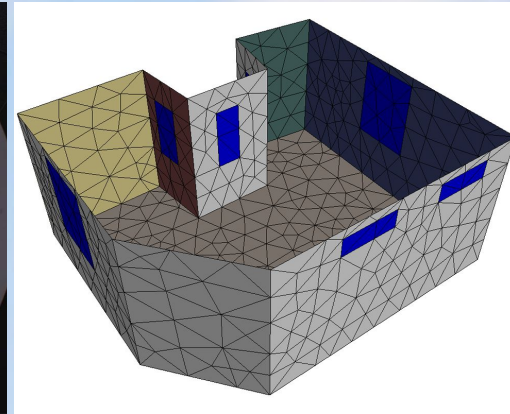
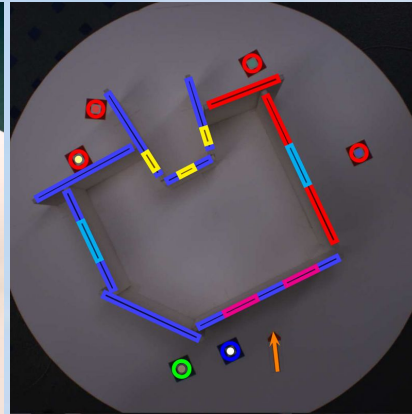
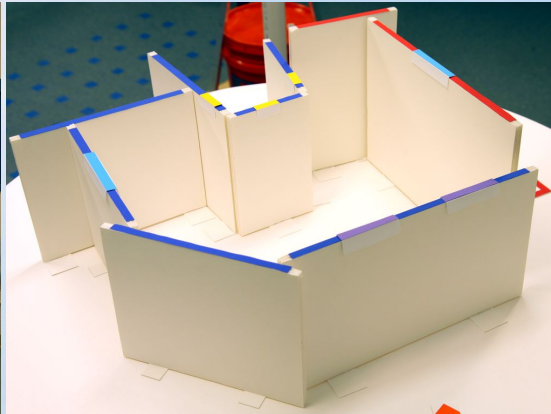


(d) **Violin plot**: the width of the colored region corresponds to the probability density function of a t-distribution.

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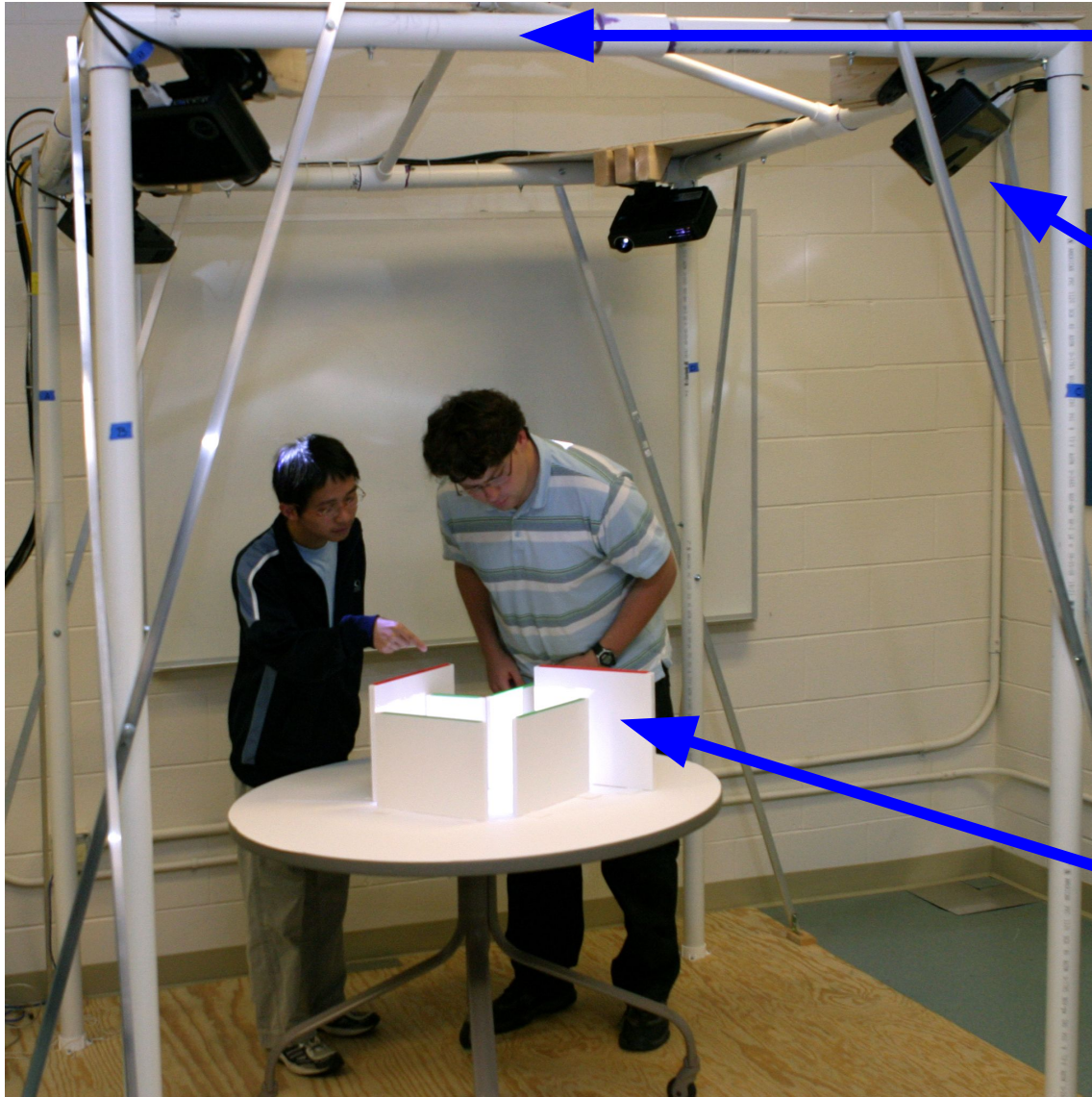
Interpreting Physical Sketches as Architectural Models



Barbara Cutler and Joshua Nasman

Department of Computer Science
Rensselaer Polytechnic Institute

“Virtual Heliodon” for Daylighting Analysis

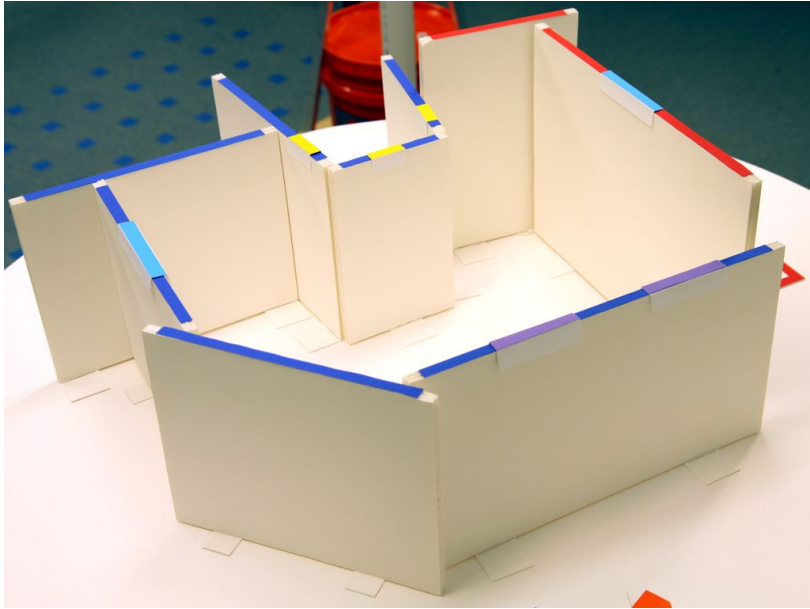


*camera to
detect geometry*

*4 projectors to
display solution*

*design sketched with
foam-core walls*

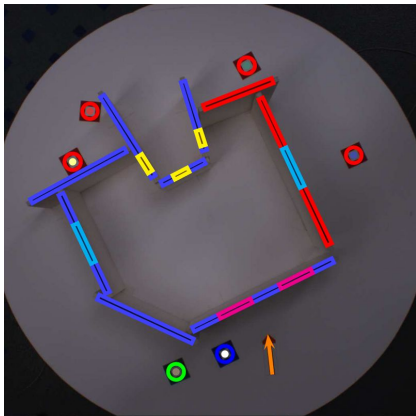
Tangible Interface for Architectural Design



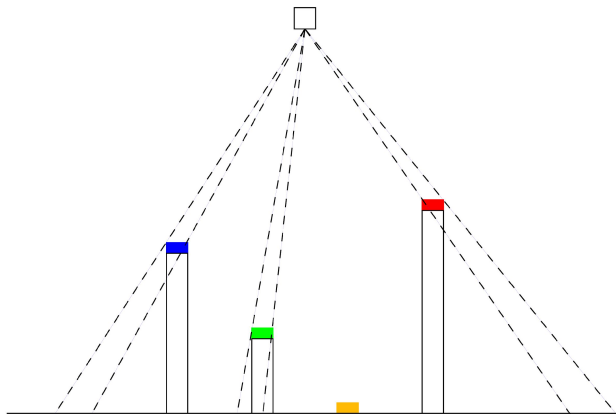
Exterior & interior walls

Tokens for:

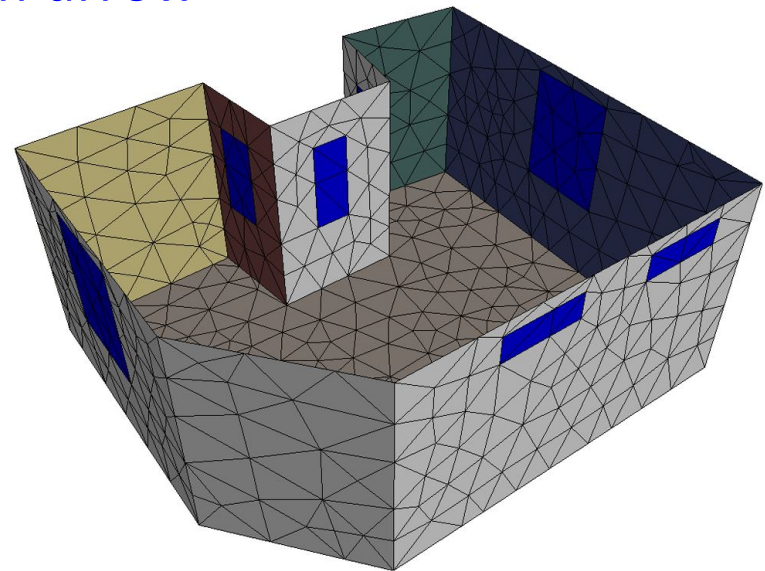
- *Windows*
- *Wall/floor colors*
- *North arrow*



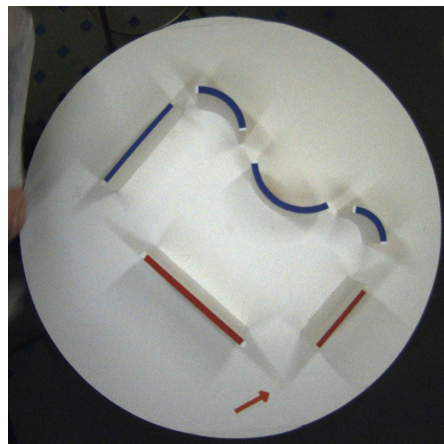
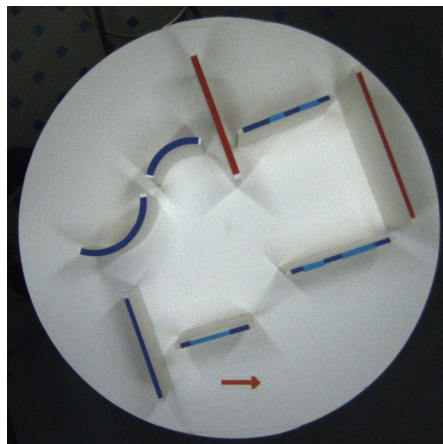
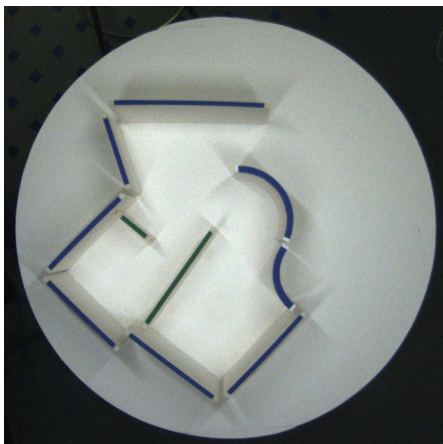
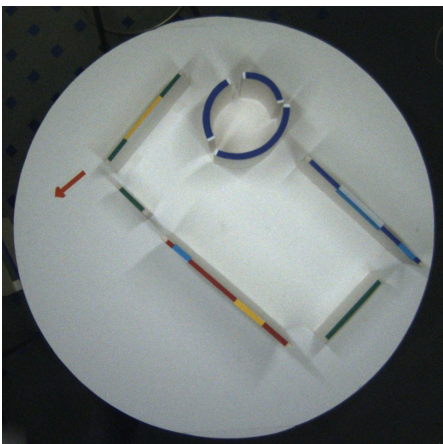
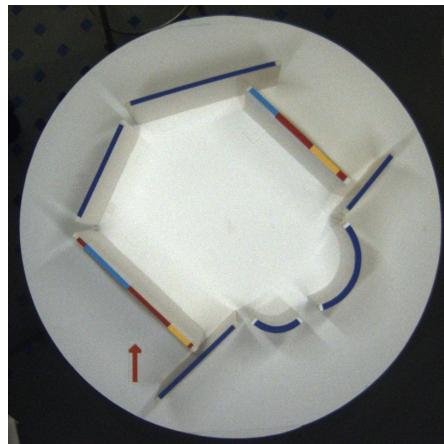
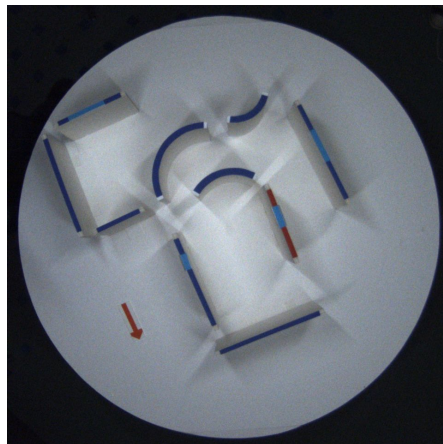
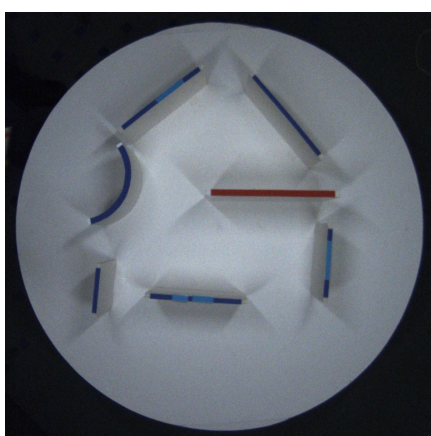
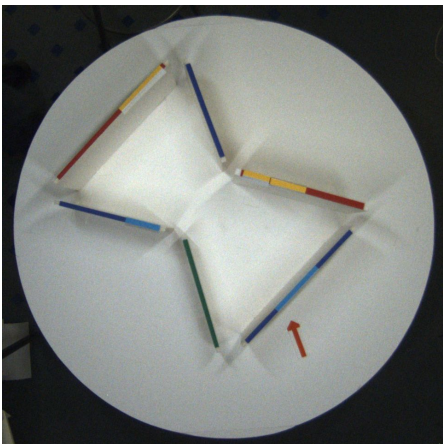
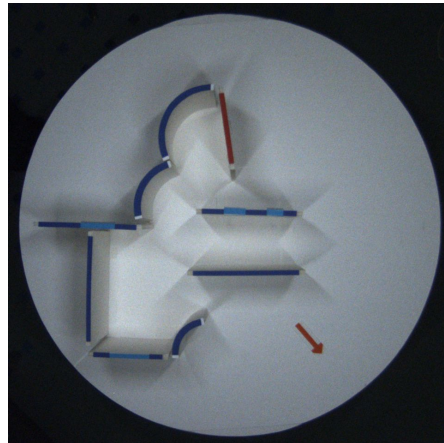
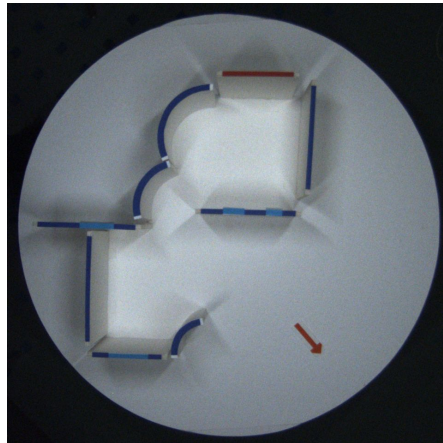
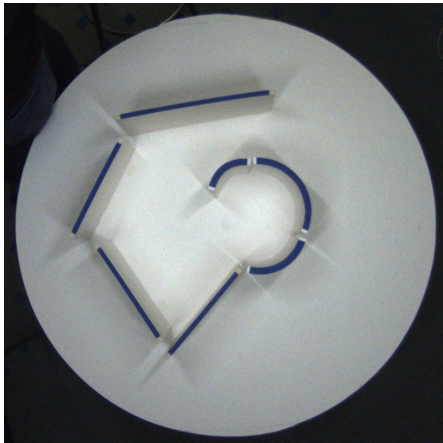
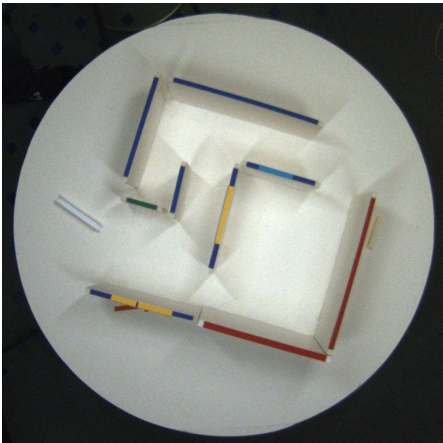
Overhead camera



Projection geometry



Inferred design

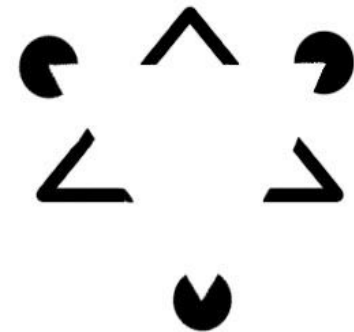


Contributions

- 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

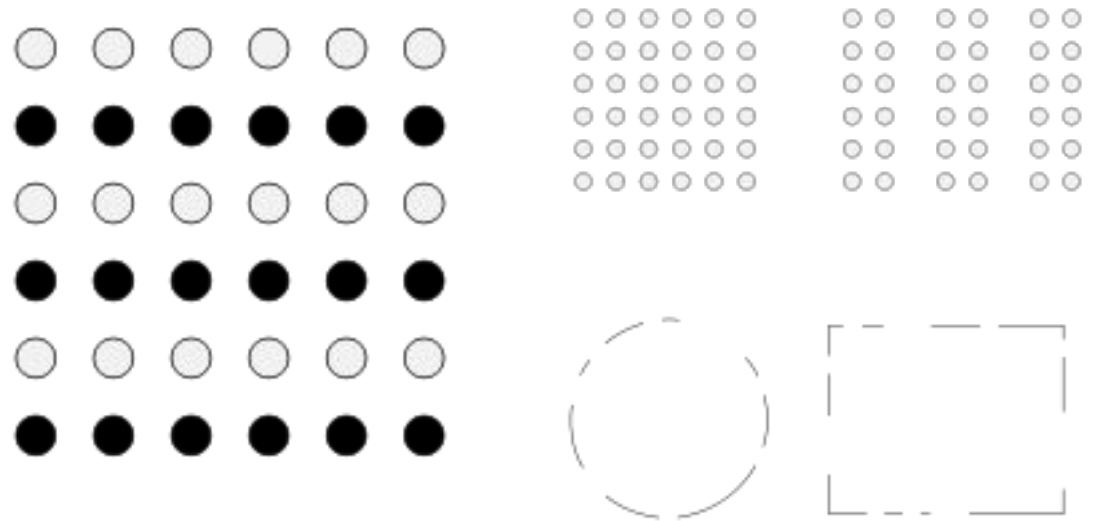
Related Work

- Tangible User Interfaces [e.g., Ben-Joseph et al. 2001]
- Sketch-based Modeling User Interfaces [Zelevnik 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; Lladós 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

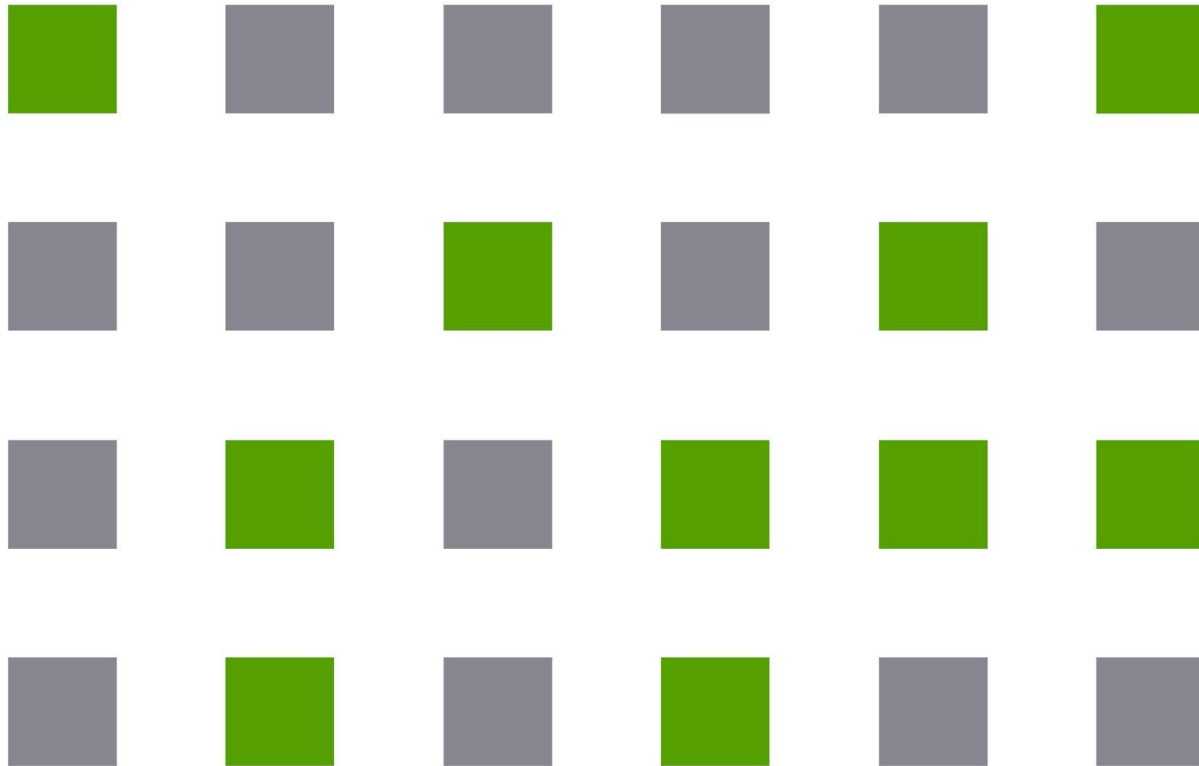


Pragnanz: Gestalt Laws of Grouping

- Similarity
- Continuation
- Closure
- Proximity
- Figure/ground
- Symmetry
- *NEW! Common fate
- “Good” gestalt (regular, simple & orderly, eliminate complexity & unfamiliarity)
- Past experience



Gestalt Principles: Similarity

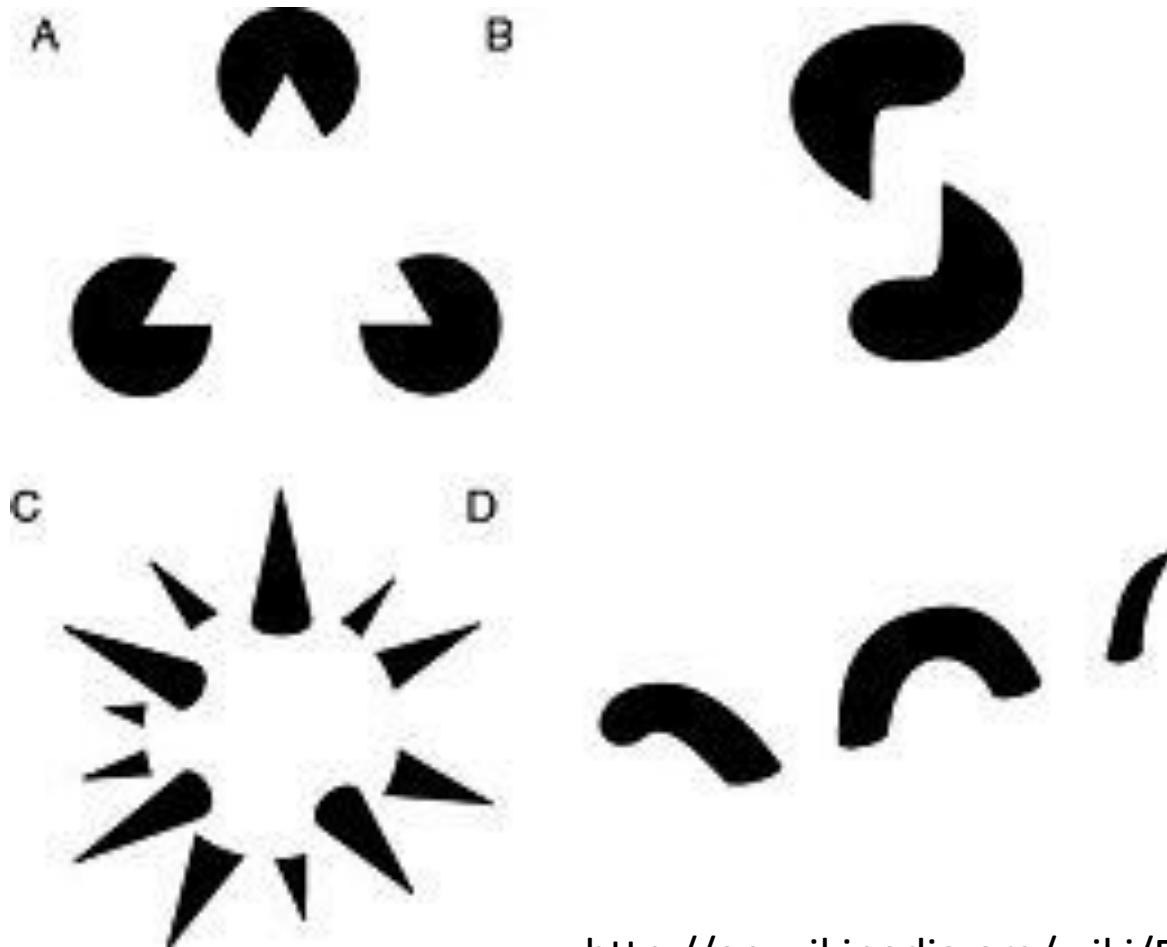


Gestalt Principles: Continuation

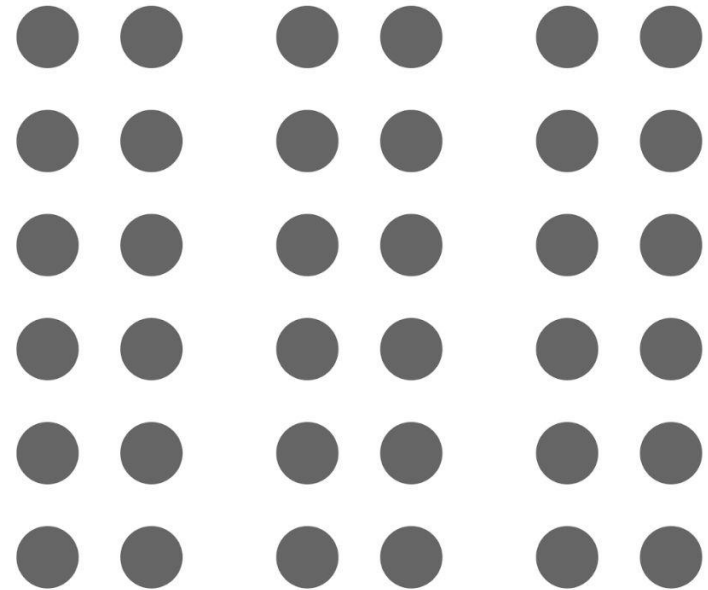
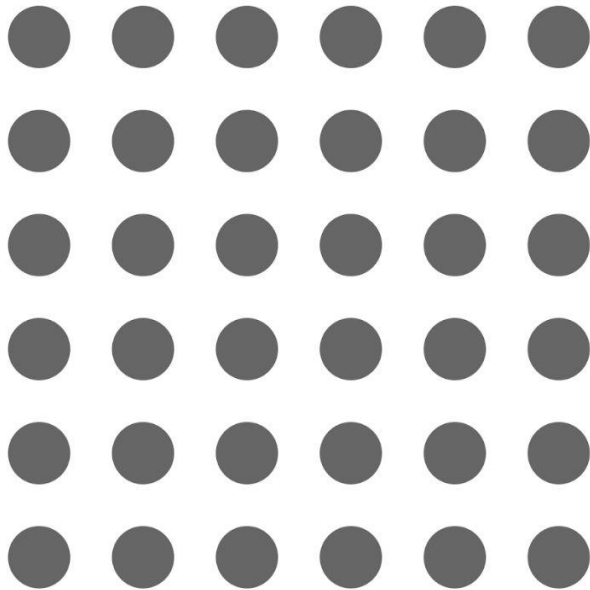


Gestalt Principles: Closure/Rectification

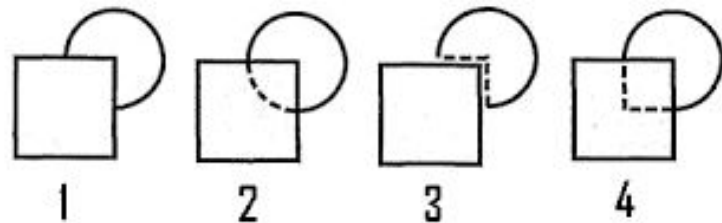
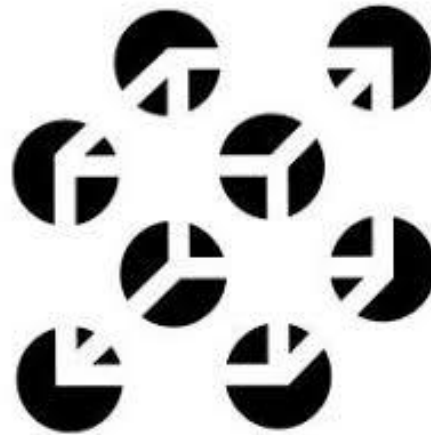
- Constructive or generative aspect of perception



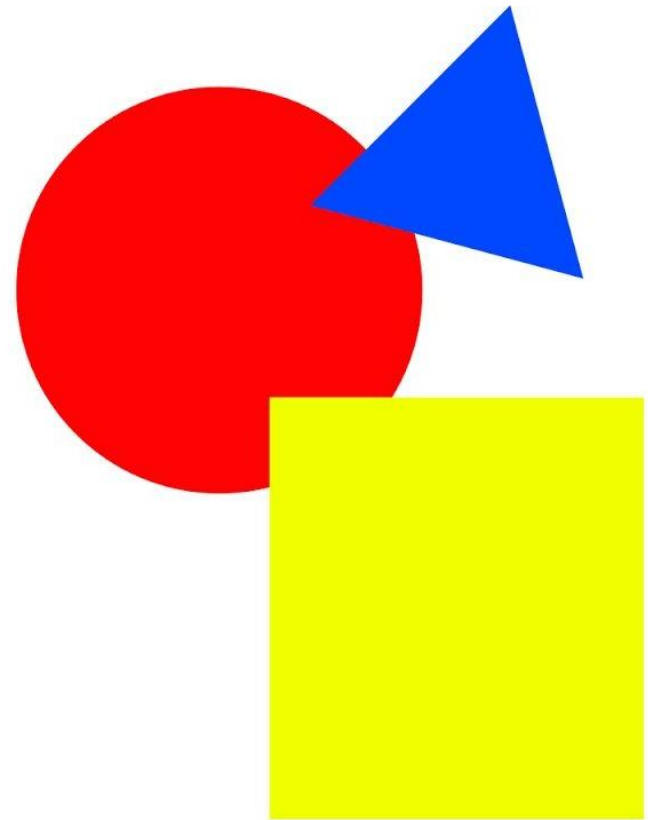
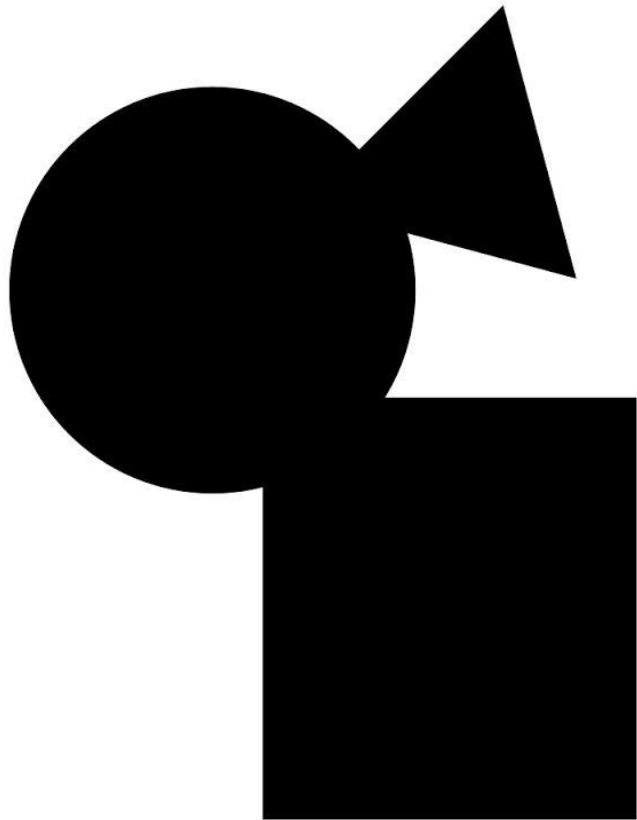
Gestalt Principles: Proximity



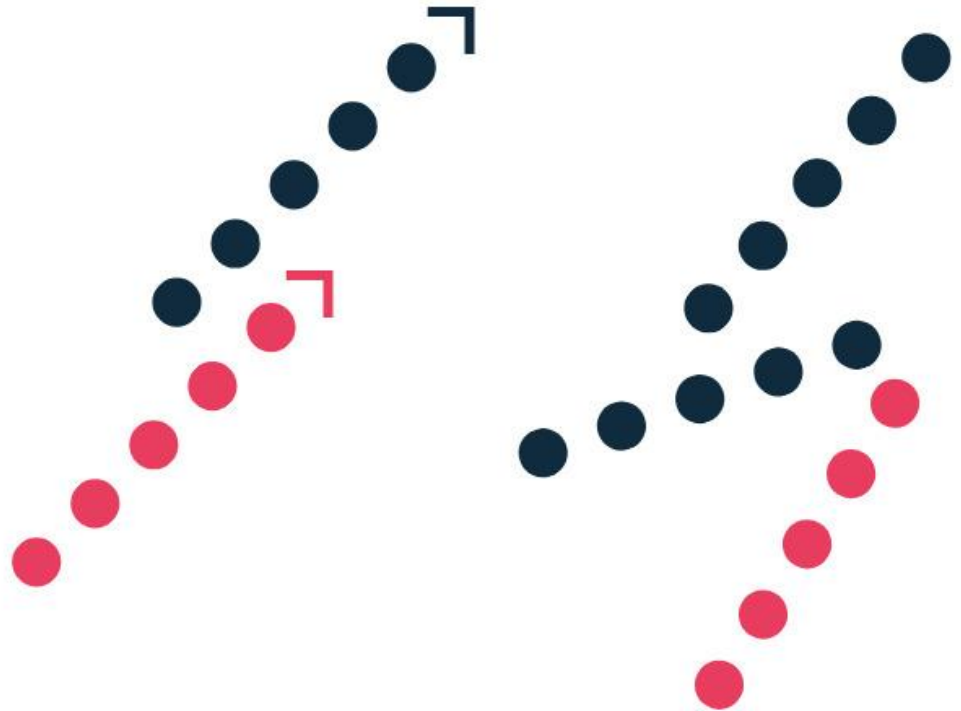
Gestalt Principles: Figure/Ground



Gestalt Principles: Symmetry/Order

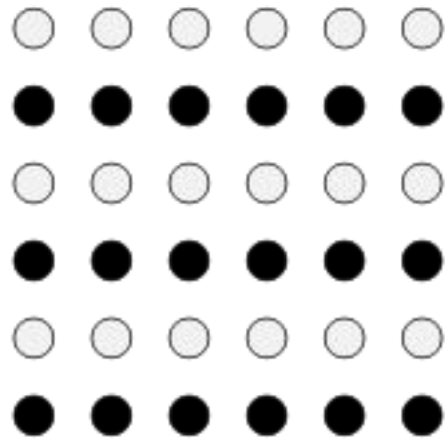


Gestalt Principles: Shared Fate



Gestalt Principles

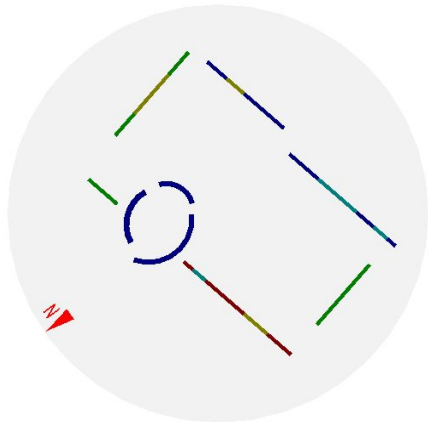
- Why are they useful?



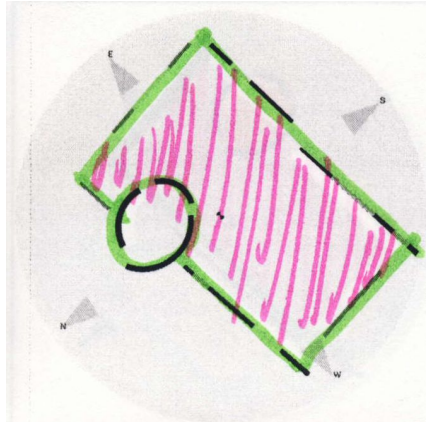
Overview of Algorithm

- 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)

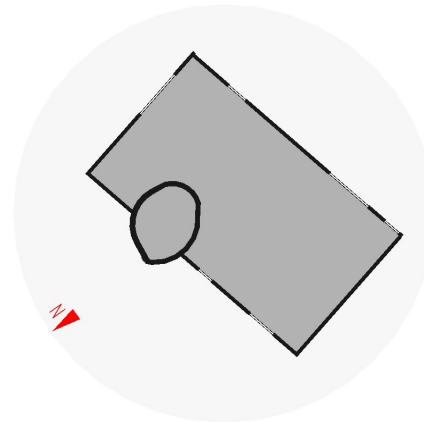
Tolerance Example: Collinearity



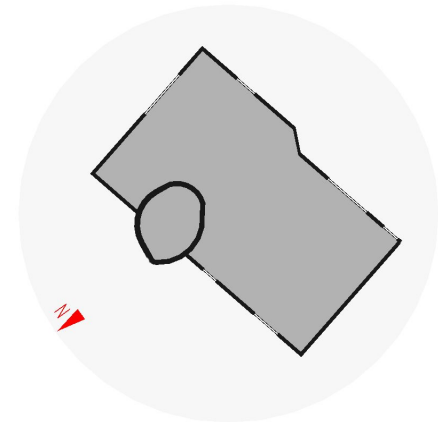
Detected Geometry



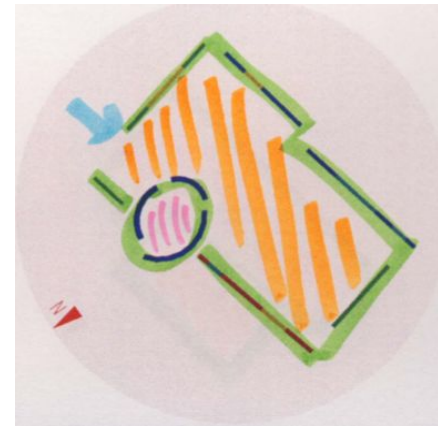
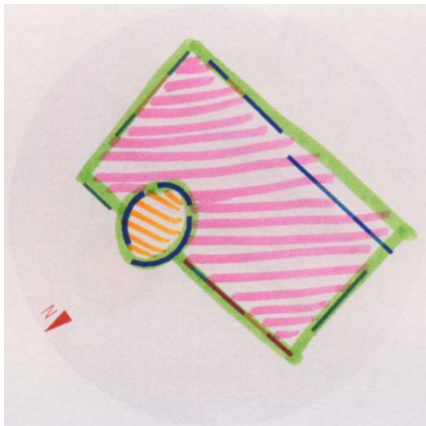
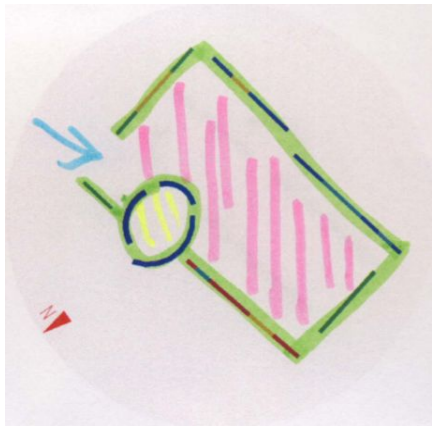
Designer's Intention



Favor Collinearity



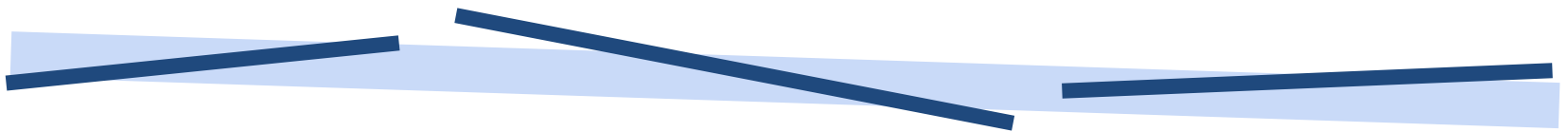
Favor Skew Lines



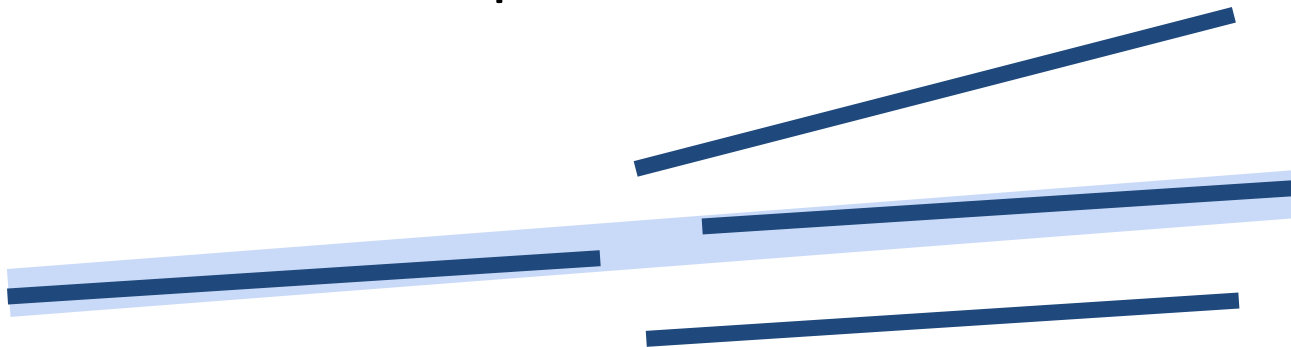
Other Users' Interpretations

Connecting segments together

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

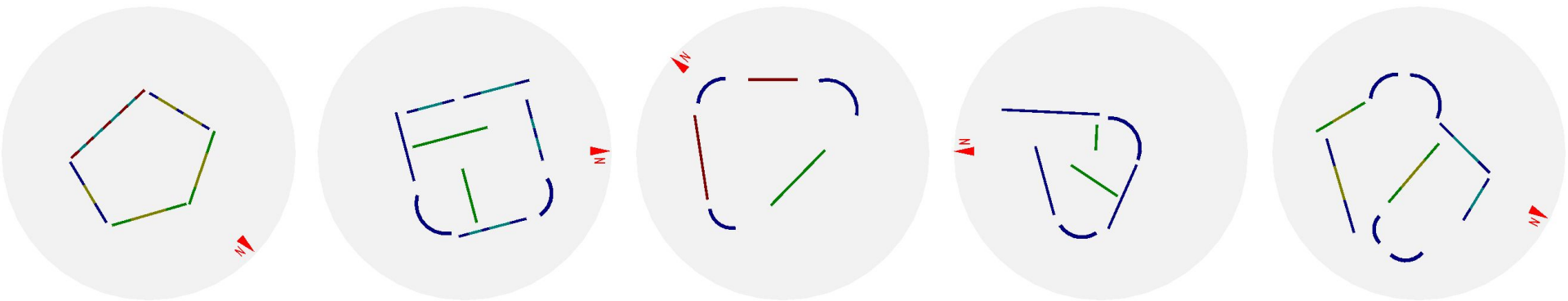


- Snap to perfect line? Or preserve original shape?
- What if we have multiple matches?

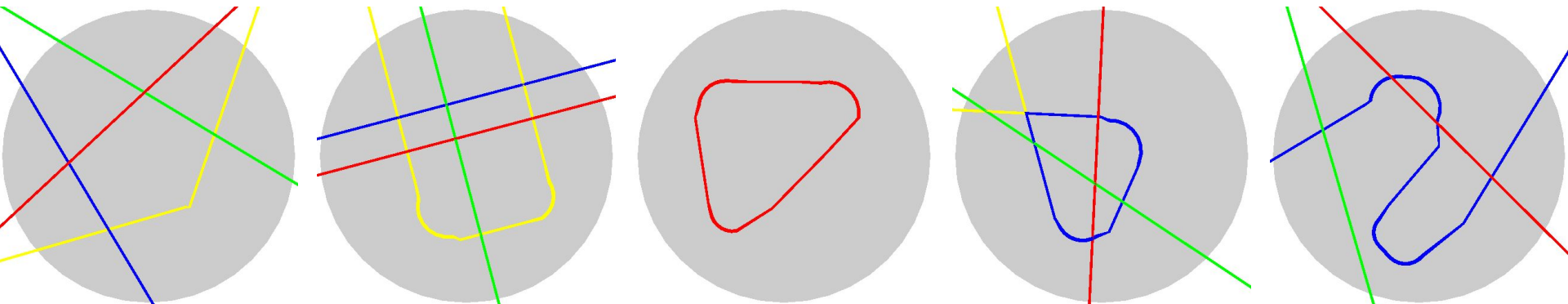


Linking Elements to Form Chains

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



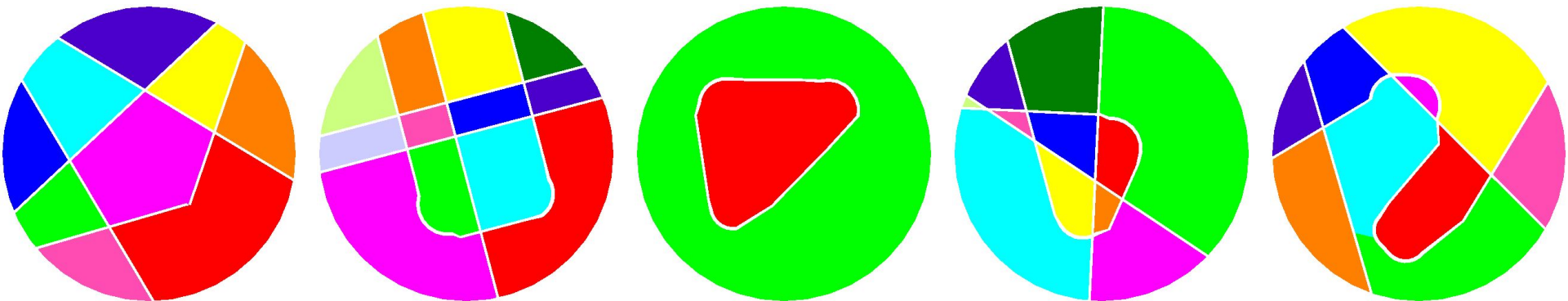
Detected Geometry



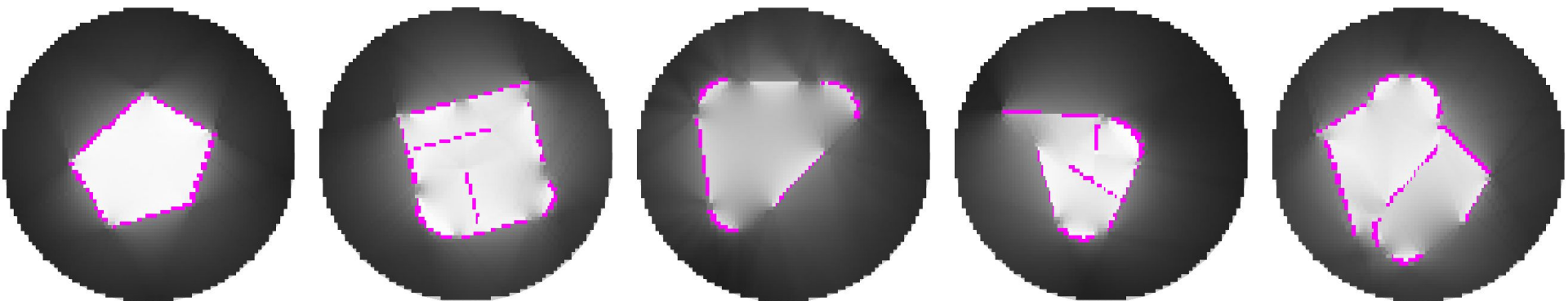
Wall Chains, Extended to Infinity

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

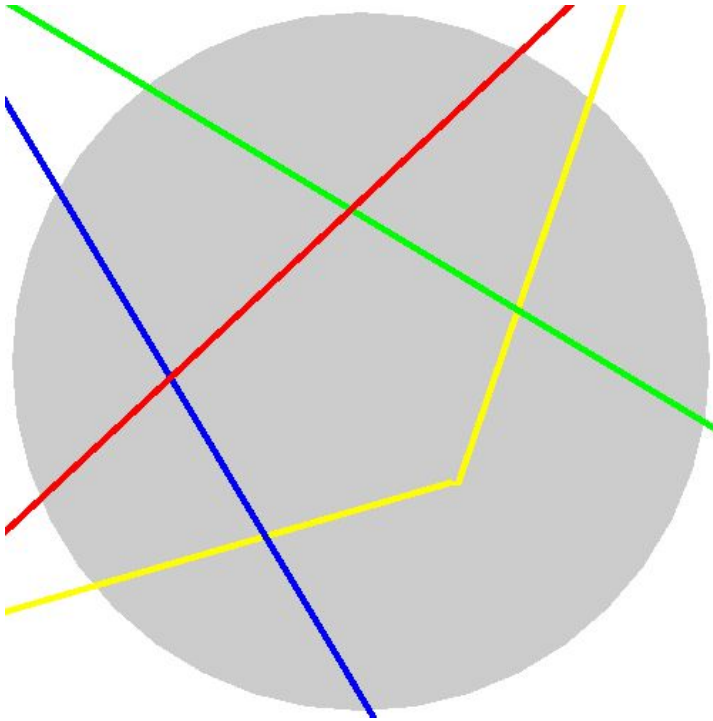
- How many endpoint-endpoint connections?
- How to reduce # of comparisons?

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

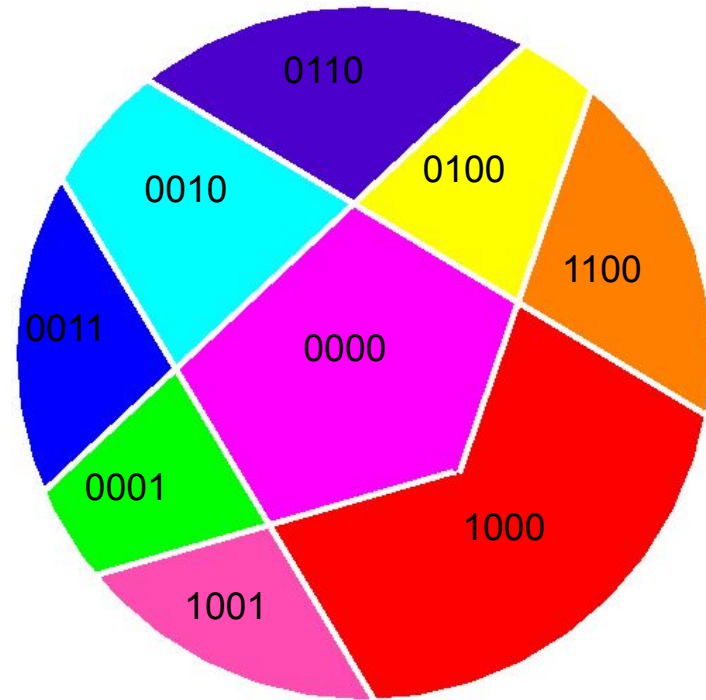
- How many point intersections (between wall chains)?
 - What if the wall chains are perfect lines?
 - What if they wall chains are general curves?
- How many zones/cells/faces (assume lines)?
- How to uniquely label faces?

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.



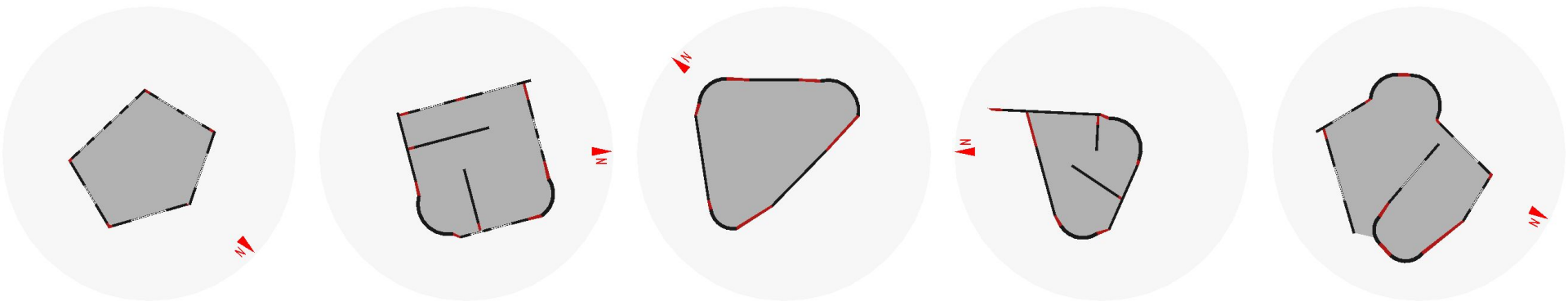
4 lines (wall chains)



*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



Compare to Designer's Intention

Complexity Analysis?

Input: n physical walls or sketched pen strokes

Consider connecting into chains

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

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

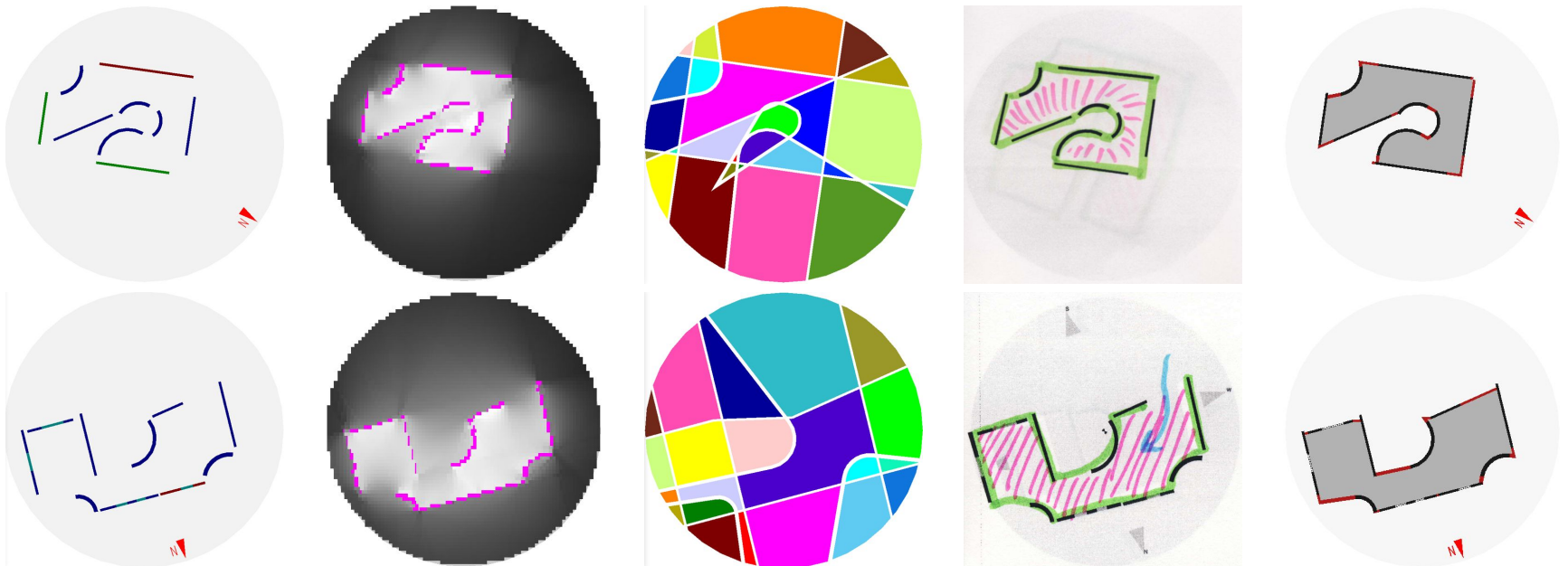
- How many point intersections (between wall chains)?
 - What if the wall chains are perfect lines? $O(m^2)$
 - What if they wall chains are general curves? $O(\infty)$
- How many zones/cells/faces (assume lines)? $O(2^m)$
- How to uniquely label faces? *Binary code, each bit represents which “side”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

Labeling Interior vs. Exterior

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

Interior/Exterior Optimization

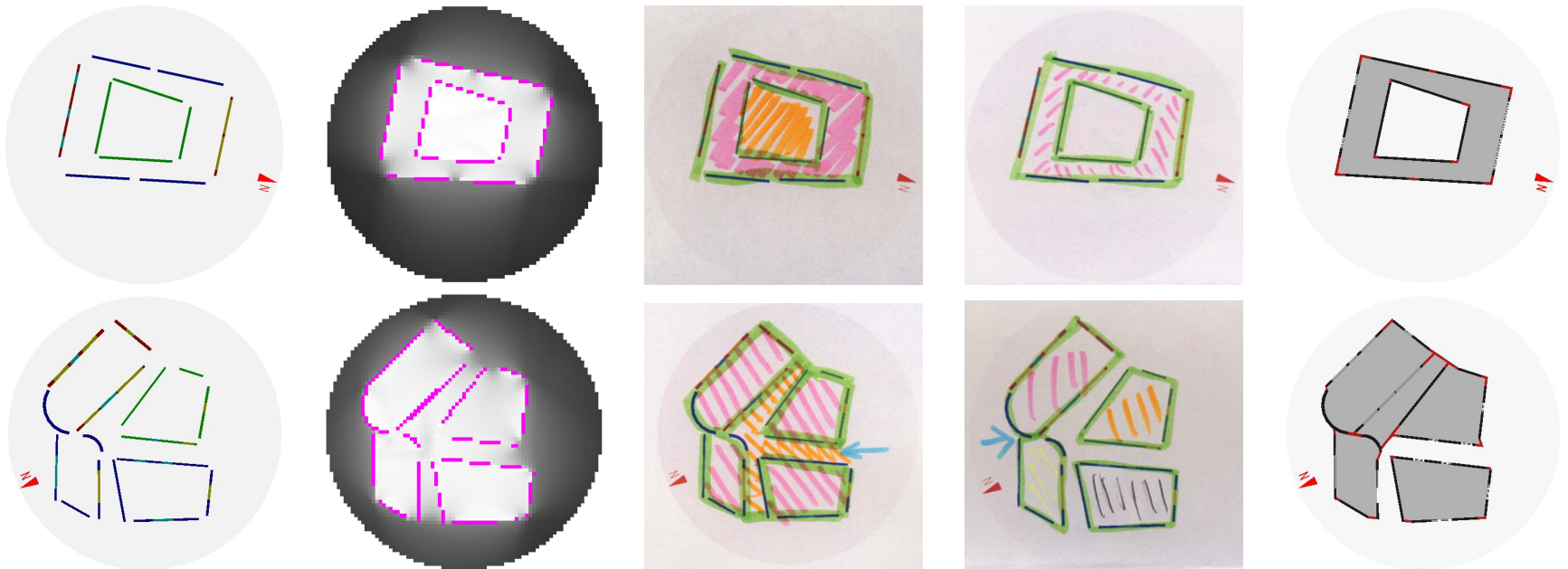
- Analyze histogram of point-sampled enclosure values
- Maximize usage of lengths of real wall elements
- Minimize length of inferred (added) walls
- Minimize area assigned in opposition of simple threshold metric



Complex Boundaries & Varying Gaps

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
- (Courtyard option) Minimize total enclosed area



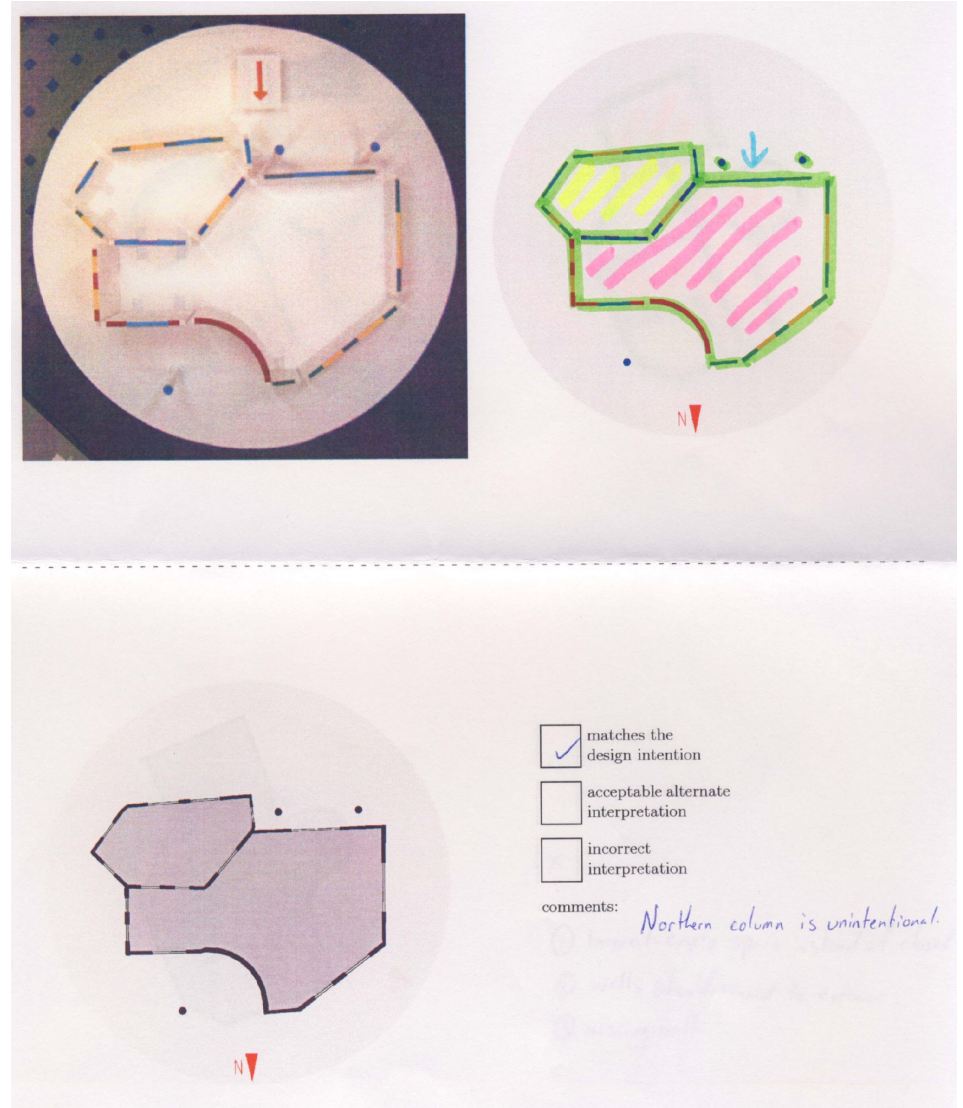
Open Courtyards & Multiple Buildings

Goals in Conducting User Studies

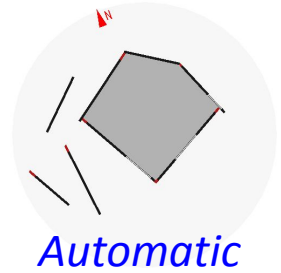
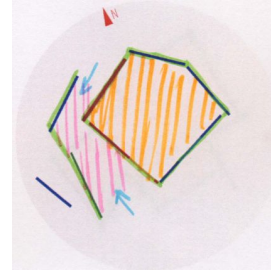
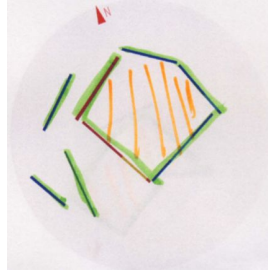
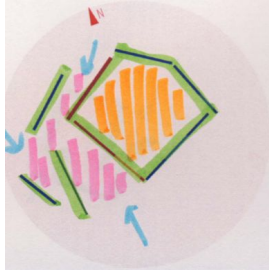
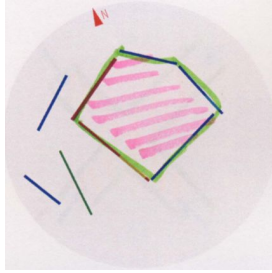
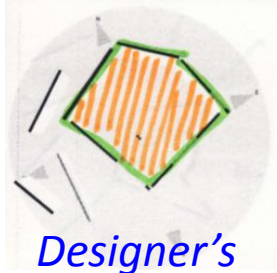
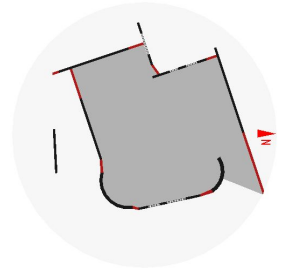
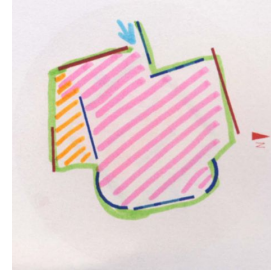
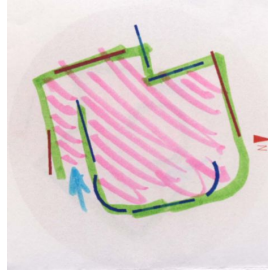
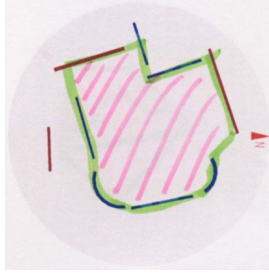
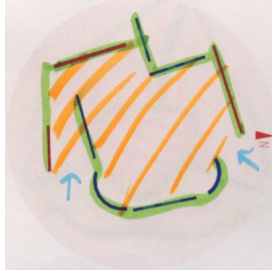
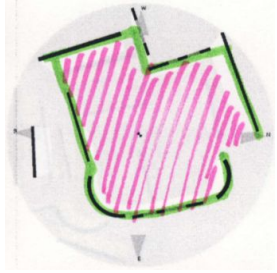
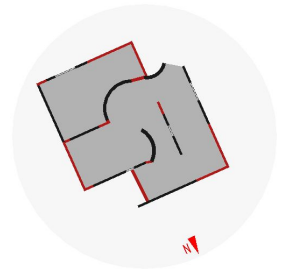
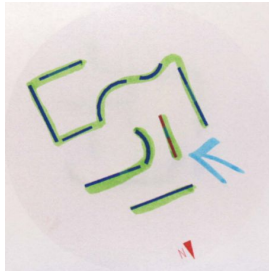
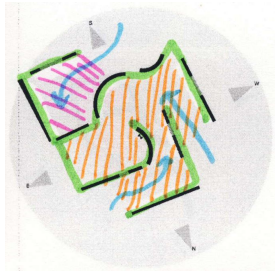
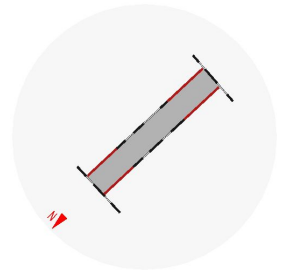
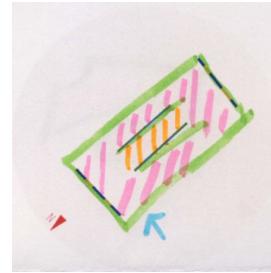
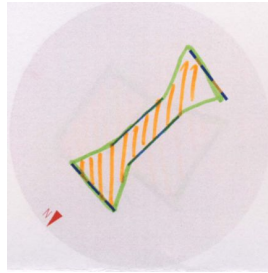
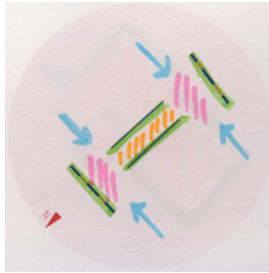
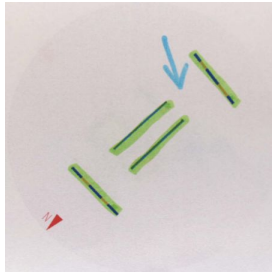
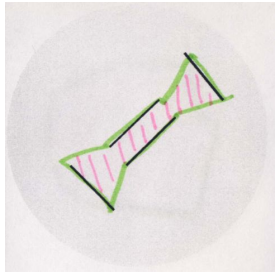
- Understand **range of designs** possible
- Improve physical sketching user interface
- Improve algorithm for sketch recognition of interior/exterior space
 - **Learn common human interpretation “rules”**
 - **Quantify design ambiguity**
- Measure effectiveness of *Virtual Heliodon* as an architectural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



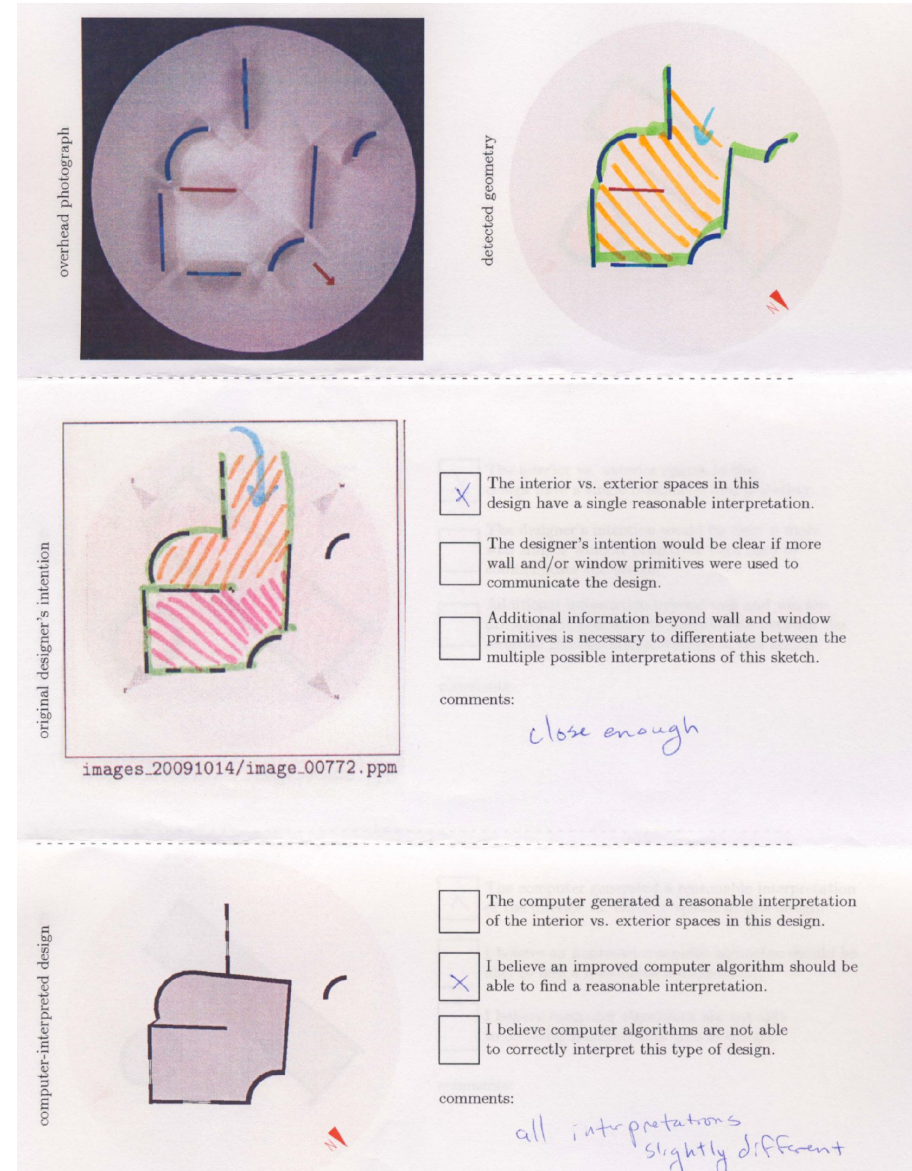
*Designer's
Annotation*

Re-Interpretation by Other Users

*Automatic
Interpretation*

User Study 2: Re-Interpretation

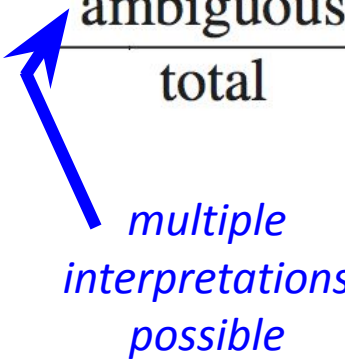
- 114 designs from Study 1
 - All ambiguous designs included
 - Some clear designs (as controls)
- 15 participants
- Re-interpreted by another user
 - 3-6 new annotations for each
 - 346 total (124 by architects)
- Then compare to original designer's annotation
- And finally, to our automatic interpretation



Re-Interpretation Results

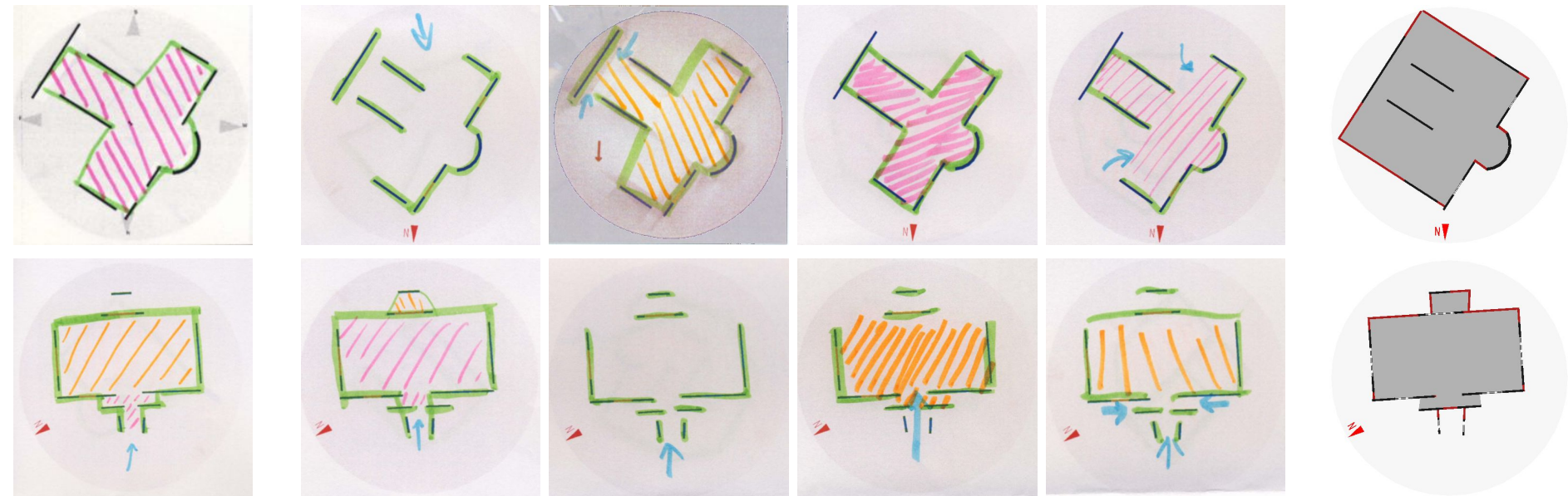
*matches the original
designer's intention*

	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

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

Domain-Specific Knowledge Required

- Standard vocabulary of architectural forms (e.g., cruciform, portico, etc.)



*Designer's
Annotation*

Re-Interpretation by Other Participants

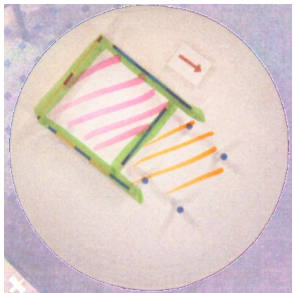
*Automatic
Interpretation*

Future Work

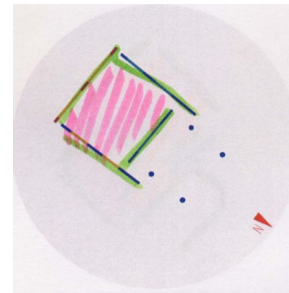
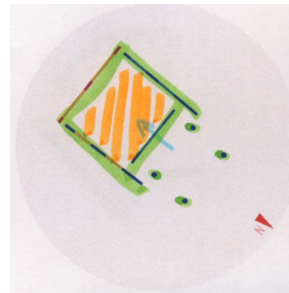
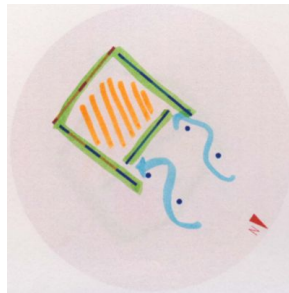
- Improve/robustify interpretation algorithm
 - Detect symmetry & repetition
 - Multi-zone interiors & circulation paths
- Incorporate domain-specific knowledge
- Enhance user interface
 - Additional tokens, more complex element shapes
 - Alternative to sketching in plan:
sketch (double height, multi-floor)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

Thanks!

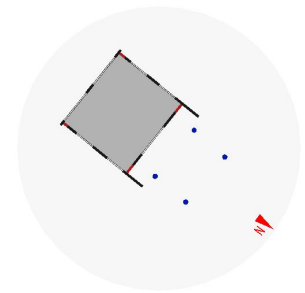
- Yu Sheng, Ted Yap, & Andrew Dolce
- Our user study volunteer participants
- Funding from NSF & IBM



*Designer's
Annotation*



Re-Interpretation by Other Participants



*Automatic
Interpretation*