CSCI 4550/6550 Interactive Visualization

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

Lecture 11: Uncertainty in Graphs & Terrain

Today

- Quiz 1 & Homework 6
- Visual Variables
- Readings for Today
  - “Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables”, Guo et al.
  - “Visualizing Uncertain Information”, MacEachren
- Related Papers
  - “Algorithm and implementation uncertainty in viewshed analysis”, Fisher
  - “Siting Observers on Terrain”, Franklin
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Quiz 1 on Friday Feb 16th

- During normal class time, 2-3:50pm
- No laptops/phones/watches/etc.
- 1 page of notes allowed, handwritten or printed
- Sample problems on the calendar
- Crayons/colored pencils/markers will be provided

	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

Homework 6: Stream Graphs

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

- Choose a 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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Jacques Bertin, “Semiologie Graphique”, 1967

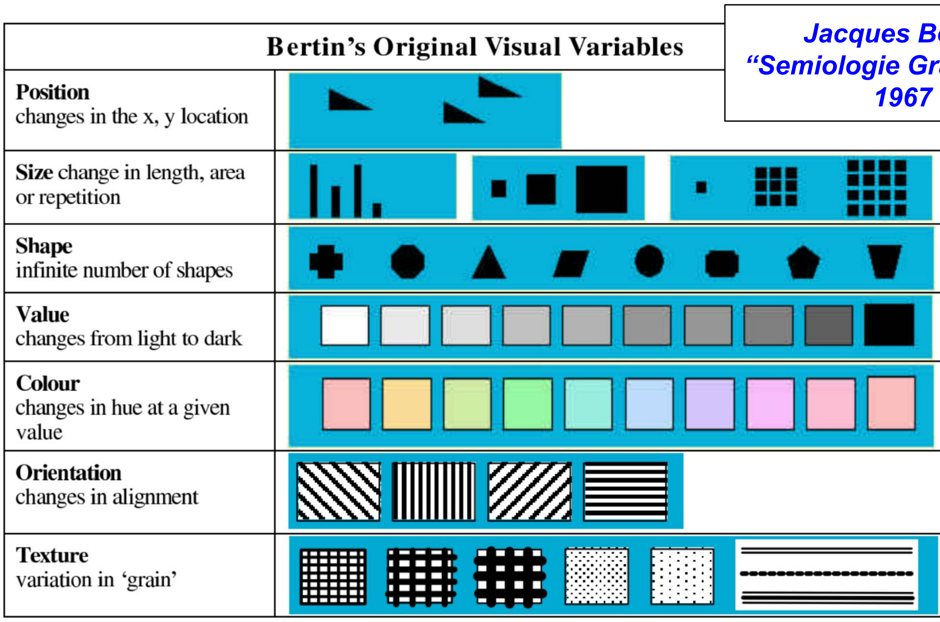

Table 1: These are Bertin's visual variables

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

Visual Variables

color based *focus based* *geometry*

- J. Bertin [1967/1983]
  - ***First to enumerate:*** location/position, size/width, color hue, color value/brightness, grain, orientation, and shape
- J. L. Morrison [1974]
  - ***Added:*** color saturation, arrangement
- Cleveland & McGill [1984]
  - ***Added:*** angle, volume curvature
- A. M. MacEachren [1992]
  - ***Added:*** focus/fuzziness, resolution, transparency
- M. Carpendale [2003]
  - ***Added:*** motion, depth, occlusion

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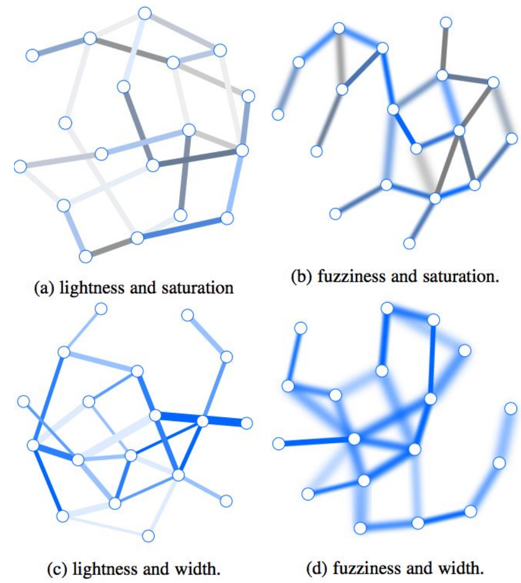
Reading for Today

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



Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables

- Encode "strength" (placeholder data)
  - Width, hue, or saturation
- Encode uncertainty using a visual variable
  - Lightness, fuzziness, grain, or transparency

- Their conclusions only apply to line based marks

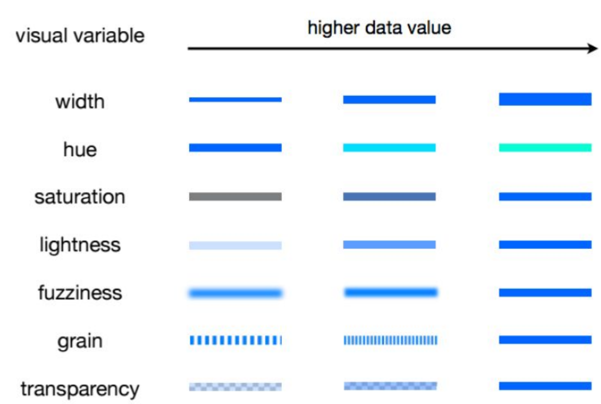


Fig. 1: An illustration of how each of the seven visual variables progress with increasing data value.

Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables

- Which visual variables are most salient? Are most discriminable?
- Disassociativity of each pair of visual variables: Can you differentiate changes in one variable while ignoring changes in another variable?
- Are some visual variables more appropriate (more natural/intuitive?) for certain data?
- Evaluate by studying response time, accuracy
- How much can we (should we?) pack into a single visualization?
- Tangent: Are we good at multitasking?

Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables

- Random graphs
- Each edge one of 5 values for “strength” and “uncertainty”
- Locate one edge of a specific value (max or min) of strength or uncertainty that must be identified (or determined to be missing)
  - “find extremum”
  - “retrieve value”
  - “visual search”
- Which graph has overall higher strength or uncertainty?
  - “characterize distribution
  - “identification-comparison”
  - “visual aggregation”
- Varied the relative discriminability of the two variables
  - Perception of the weaker one is better when they are more similar

- Large number of hypotheses
- 20 participants, 1 hour each, 5760 trials
  - Short teaching/training session with feedback on correctness
  - (personally don't want to have to administer a user study!)
- Provide explicit design recommendations, useful reference
- Not surprised that lightness interferes with hue and width confused with fuzziness; Surprised that grain performed well
- Well written
  - clearly state hypotheses, justified their conclusions well
  - I could recreate the results from this paper
  - "open questions" instead of future work
- How would the results be different with people with visual training (not novices)?
- How would the results be different for colorblind users?
- Would have liked to see a real-world example of this graph style. And specifically high density graphs (requires thin edges).

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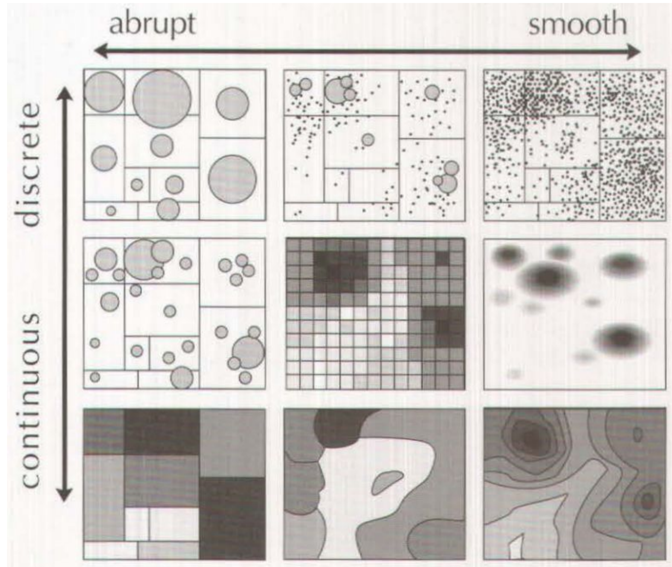
Reading for Today

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

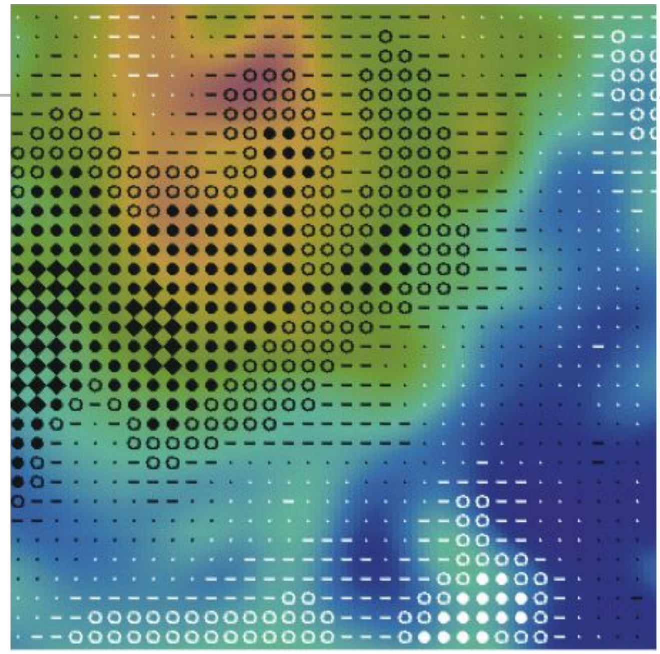


Visualizing Uncertain Information

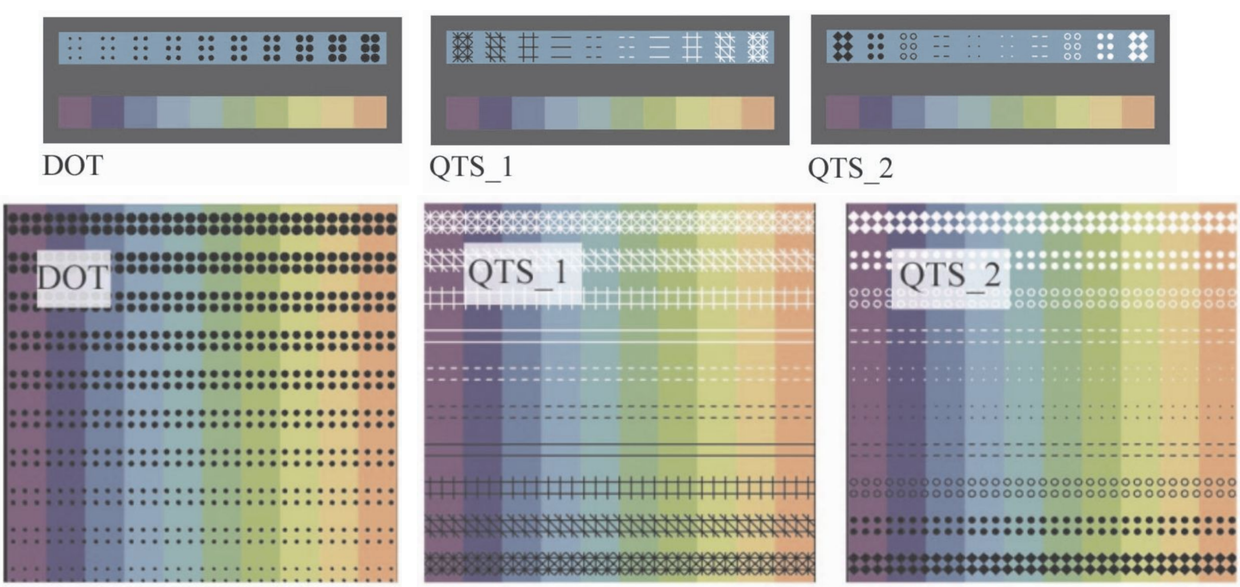
- GIS=Geographic Information System
- Are maps & computers infallible? Less fallible than humans?
- Data "quality" (when referring to error)? Better term is "uncertainty"?
  - Incomplete (census response rate),
  - attribute inaccuracy (misunderstood survey question or deliberate misinformation),
  - spatial inaccuracy (typos introduced by census taker),
  - temporal uncertainty
- What is the importance of uncertainty relative to map data?
- "...few GIS *users* are trained in cartographic symbolization & design…"
- Proposals for map uncertainty:
  - Contour crispness, fill clarity, fog, resolution or Dynamic/Animation (e.g., blinking)
- User Interface: Map pairs, sequential presentation, bivariate maps
- Evaluation/Experiments needed to confirm prior work and test hypotheses of proposed changes
  - Type I Visualization Error: tendency to see patterns that do not exist
  - Type II Visualization Error: failure to notice patterns or relationships

Related Reading

- Colin Ware, "Quantitative Texton Sequences for Legible Bivariate Maps", *IEEE Transactions on Visualization and Computer Graphics*, 2009.



Quantitative Texton Sequences for Legible Bivariate Maps



Examples of Uncertain Graph or Spatial Data

- Endangered animal population (known sitings, estimates)
- Census data (density, measurement accuracy)
- Cell/radiowave coverage (weather interruptions)
- Reliability of network connections in distributed system vs. bandwidth
- Weather data, forecasts (sensor vs simulation estimates)
- GPS location accuracy (size of circle)
- Investment/trade privacy/time delay
- Historical maps, records are incomplete/missing/inaccurate
- Traffic - sensor distribution/accuracy

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“Algorithm and implementation uncertainty in viewshed analysis”, Peter Fisher, J. of Geographical Information Science, 1993.

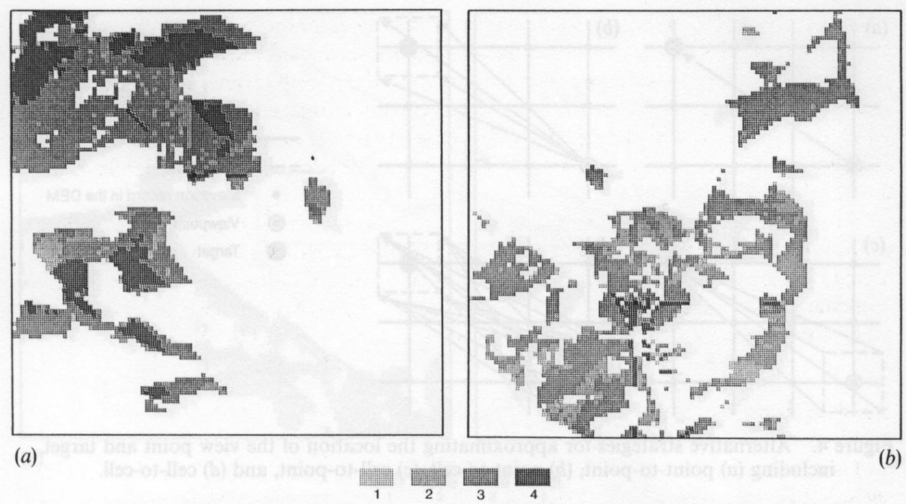
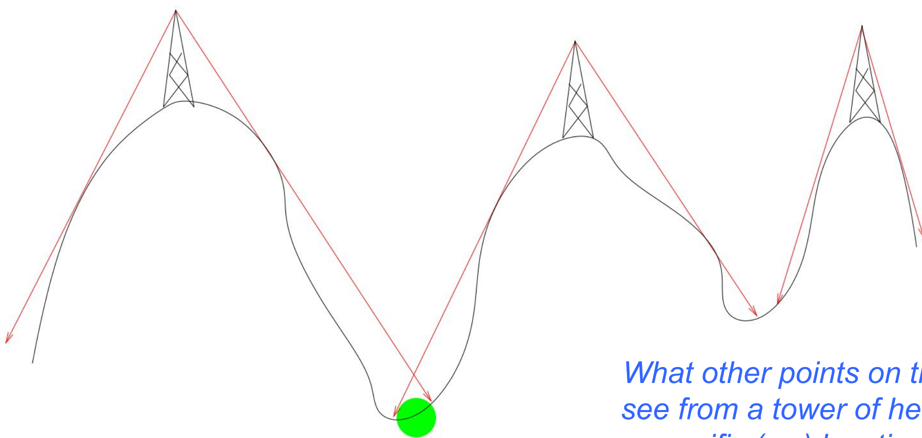


Figure 3. The pattern of grid cells included in viewsheds derived from alternative methods of inferring elevations.

Algorithm and implementation uncertainty in viewshed analysis

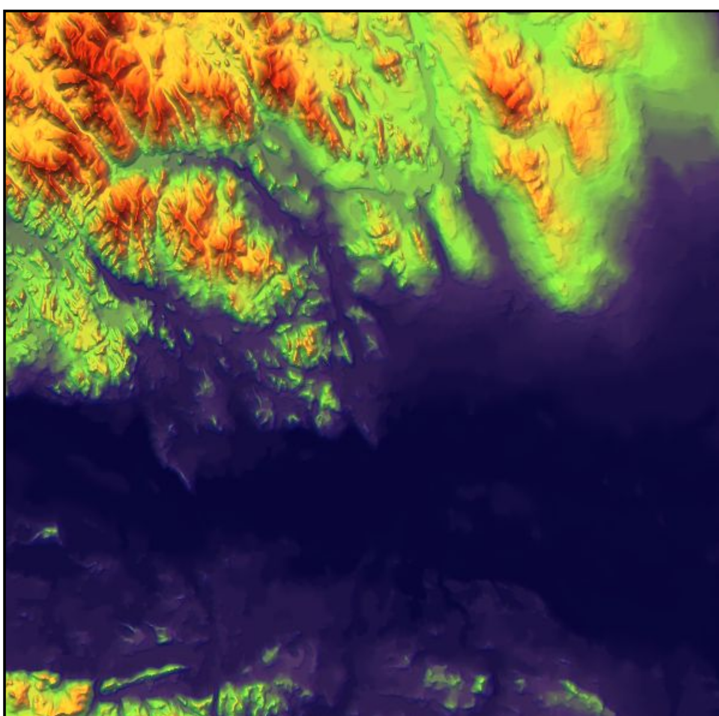
- Software quality & different/inconsistent outcomes from different GIS products
- Simple computation/algorithm (calculate slope) vs. more complex algorithms (calculate drainage network, representation conversion raster/grid->vector/mesh)
- Viewshed challenges:
  - Vegetation
  - Earth curvature
  - Small errors can result in large changes
  - “Ground truth” comparison not possible
- How to compute line of sight?
  - Bilinear interpolation
  - Convert to triangle mesh (but which diagonal?)
  - Subgrid w/ interpolation (is this the same as bilinear?)
  - Stepped (constant height within each cell), a.k.a. nearest neighbor
  - Point-to-point, point-to-cell,cell-to-point,cell-to-cell?
- Rounding errors in the geometry computation can yield inconsistent outcomes with what should be geometrically identical comparisons

“Siting Observers on Terrain”, Wm Randolph Franklin, RPI ECSE, 2004



What other points on the terrain can we see from a tower of height h placed at a specific (x,y) location on the terrain?

Slide from W. Randolph Franklin



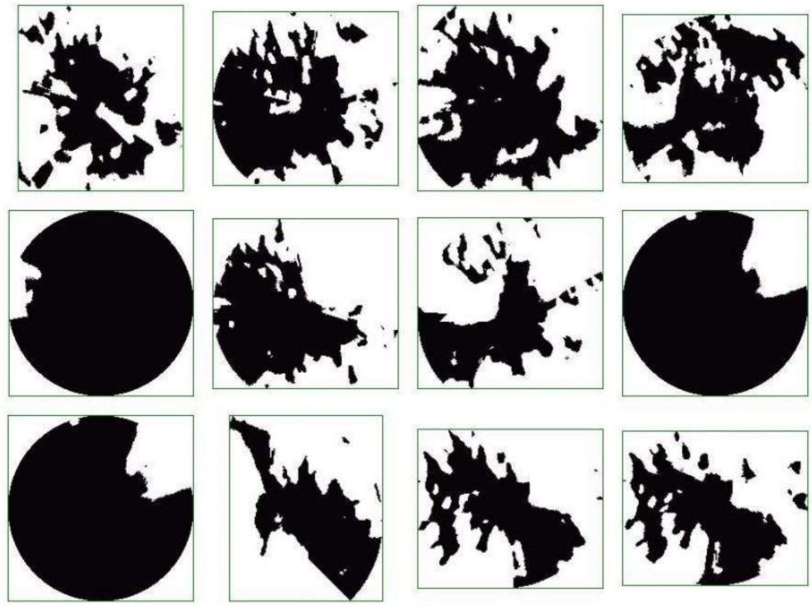
Terrain Height Visualization

red = higher elevations

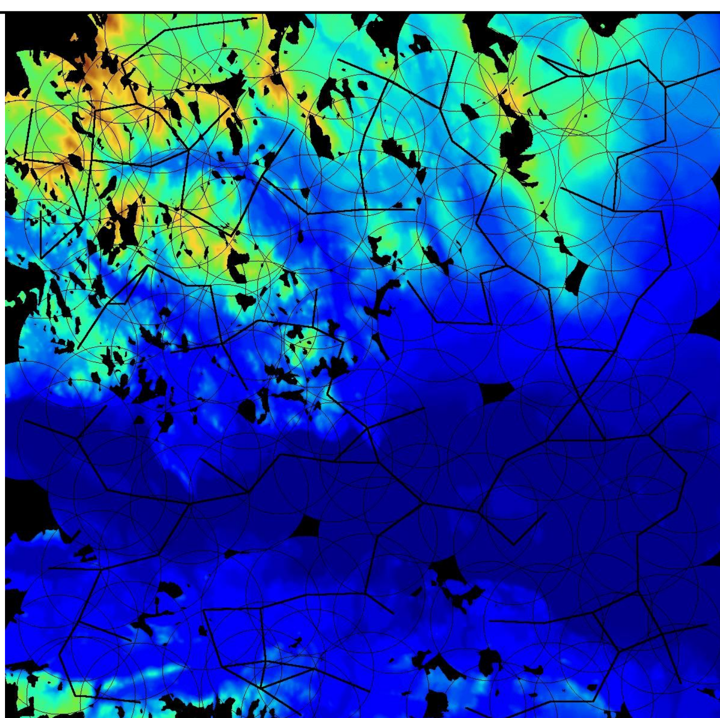
blue = lower elevations

Slide from W. Randolph Franklin

- Observers have a specified maximum straight line sight distance
- Some observer placements see more (black)
- Regions that are white are occluded or too far from observer



Slide from W. Randolph Franklin



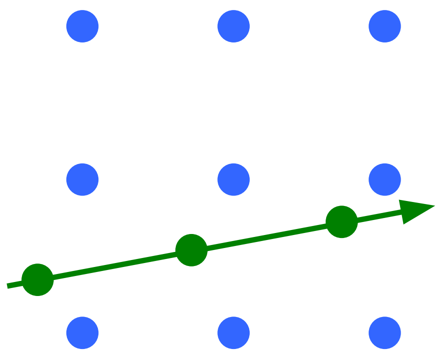
- Place *k* observers to maximize coverage
- Additional constraint: The observers must also be connected by line-of-sight

Slide from W. Randolph Franklin

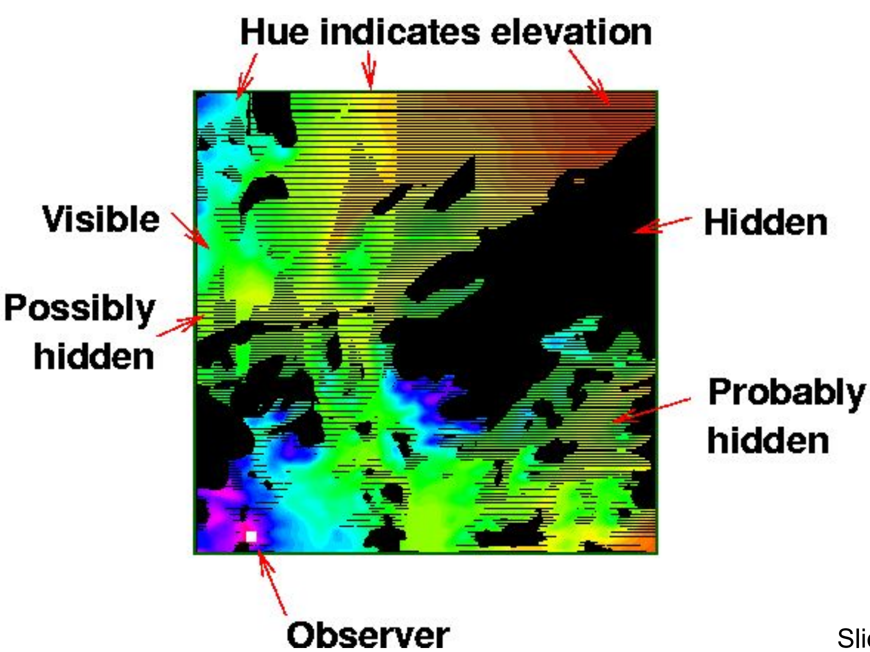
Incorrect Interpolation

Regular grid of height samples

Query for occlusions along sight line



Slide from W. Randolph Franklin



Possibly Hidden / Probably Hidden: If height is changed by epsilon, the visibility flips!

The visibility of one half of the points in uncertain!

Slide from W. Randolph Franklin

Place "Observers" (e.g., Cell Phone Towers) on a Complex Terrain

- Where should they be placed to maximize coverage?
- What if the observers need to see each other?
  e.g., form a connected network for communication
- How much error is introduced because of the original sensor measurements?
  e.g., discrete sample points might miss significant ridges or valleys
- How much error is introduced if the dataset is compressed for storage or transmission and then lossily reconstructed?
  e.g., erroneous visibility, or erroneous occlusions
- Knowing the terrain and placement of "red team" observers what path should the "blue team" take to avoid being seen?
- Knowing that it will be used to do siting tasks, can we design a better compression algorithm reducing lossy artifacts that cause significant errors?

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History of Human Subjects in Research

- World War II (1939-1945): German physicians conducted medical experiments on concentration camp prisoners without their consent. Tested blood clotting (shooting them), vaccines (infecting them), effectiveness of poison bullets, effects of high altitude & low oxygen.
- In the 1950's, Thalidomide (now known to cause birth defects) was given to pregnant women to help with sleep and nausea, but they did not know it was experimental nor did they give consent.
- Tuskegee, Alabama (1940s-1970s): Low-income African-American males with high incidence of syphilis infection were given free medical examinations, but not told about their disease, and researchers intervened to prevent treatment.

History of Human Subjects in Research, *continued*

- 1961 Milgram Obedience Study, participants instructed to punish another (fake) participant with a (fake) shock machine: Lacked proper debriefing, didn't reveal the purpose of the study, didn't comfort subjects ethical qualms about having inflicted pain on a fellow human, didn't offer his participants an opportunity to opt out of the study.
- 1971 Stanford Prison Experiment by Zimbardo: Participants assigned randomly as guards or prisoners for a 2 week simulation. Study terminated after 5 days of psychological abuse. The study did meet the criteria of his IRB in 1973!
- In the 1970's various federal regulations established Institutional Review Board (IRB) at all research institutions in the United States.

Institutional Review Board (IRB)

- Voluntary informed consent
  - capacity to consent
  - freedom from coercion
- Minimize risk (physical / mental / privacy)
  - favorable risk/benefit analysis
  - qualified researchers
  - appropriate research designs
- Right to withdraw without repercussions
- Interests of the subject must be placed ahead of interests of society
- Every subject must be given best known treatment
- Participant's privacy and confidentiality must be preserved

Rensselaer

Office for Research

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Compliance › Oversight Committees

Institutional Review Board

Rensselaer's **Institutional Review Board (IRB)** is a federally mandated, independent committee that reviews, approves, and monitors all Human Subject Research, as defined in Protection of Human Subjects (45 CFR 46), when it involves Rensselaer-affiliated faculty, staff, students, or visiting researchers. Rensselaer embraces the ethical principles for research with human subjects articulated in The Belmont Report: *Respect for Persons, Beneficence, and Justice*. The rights and welfare of human subjects are also protected by federal law under Title 45 Code of Federal Regulations Part 46, Protection of Human Subjects (45 CFR 46).

The IRB's mission is to review all institutional activities that fit the definition of Human Subject Research found in 45 CFR

Oversight Committees

- Institutional Review Board
- Institutional Animal Care and Use Committee
- Institutional Biosafety Committee

What is “Blue Light”?

- 380-500nm
- ⅓ of all visible light
- Most of it from the sun, but also from fluorescent lights, LCDs, computer monitors, & smartphones
- Health Benefits: boosts alertness, helps memory and brain function, elevates mood, regulates wake/sleep rhythm, and important for development of eyes and vision.
- Blue light immediately before bedtime can negatively impact sleep.

https://health.ucdavis.edu/blog/cultivating-health/blue-light-effects-on-your-eyes-sleep-and-health/2022/08#:~:text=Constant%20exposure%20to%20blue%20light,white%20part%20of%20the%20eye.

Dangers of “Blue Light”?

- Our eyes are not good at blocking blue light
- Nearly all visible blue light passes through the cornea and lens and reaches the retina
- Exposure over time could damage retinal cells, cause age-related macular degeneration, cataracts, eye cancer
- People also tend to blink less when using digital devices, causing dry eye, eye strain, headaches, blurred vision, and neck and shoulder pain.
- Children are at more risk than adults – they absorb more blue light from devices!

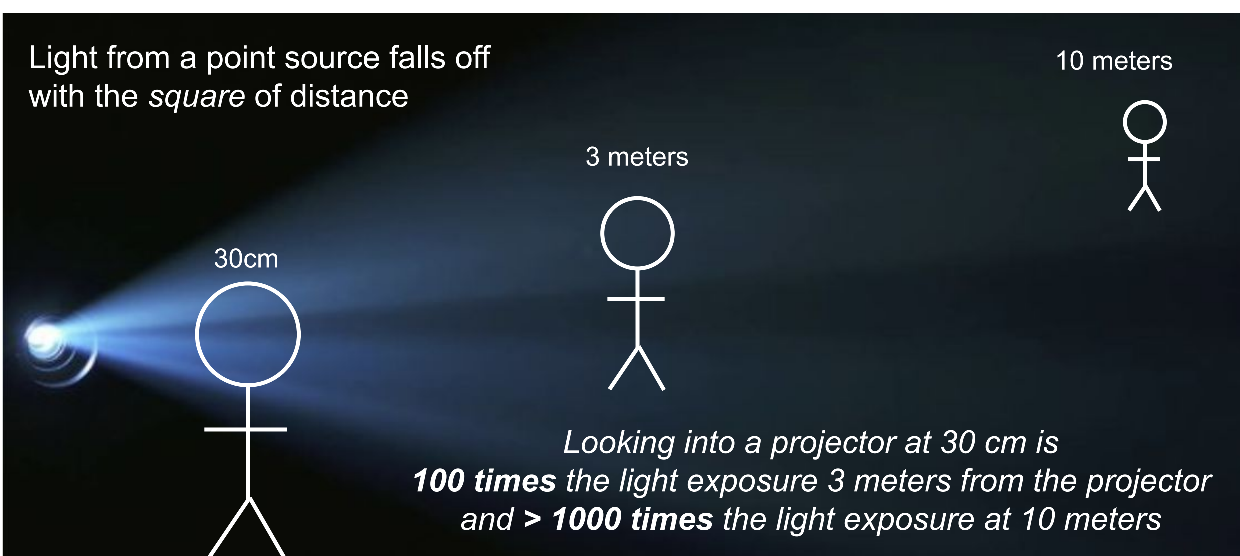
https://health.ucdavis.edu/blog/cultivating-health/blue-light-effects-on-your-eyes-sleep-and-health/2022/08#:~:text=Constant%20exposure%20to%20blue%20light,white%20part%20of%20the%20eye.

Are Projectors Dangerous?

https://www.shutterstock.com/image-photo/conference-business-meeting-presentation-ceo-businessman-2140347385

https://visualfinds.com/projector/do-projectors-emit-blue-light/

Are Projectors Dangerous?



Spatially Augmented Reality (SAR) Projection

6 projectors augment design

- Contacted projector manufacturer
  - Requested user safety information regarding containment for bulb explosion
    didn't receive anything
- Contacted bulb manufacturer
  - Requested light output data sheets & safety information
    didn't receive anything
- Bought spectrometer to measure actual blue light emitted
- Calculated conservative limit for worst-case-scenario exposure

Institutional Review Board
Rensselaer Polytechnic Institute

Informed Consent Form

I understand that Barbara Cutler, who is a professor of Computer Science at Rensselaer Polytechnic Institute, wishes to interview me as part of the research project on a new Spatially Augmented Reality (SAR) system for education and entertainment applied to games. I understand that she will be making her best possible effort to guarantee me every possible protection, including the following:

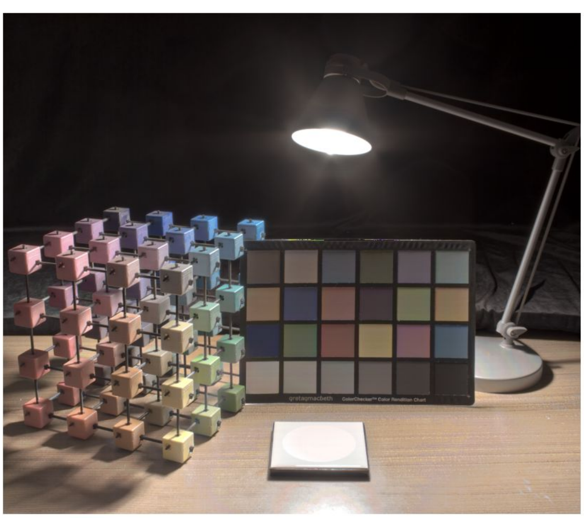
1. I am under no obligation to be participate in the study or to be interviewed if I do not wish to do so.
2. I am not obligated to perform any of the game play exercises or answer any of the questions. I may decline to answer any or all of the questions, and I may terminate the study or interview at any point, without giving any reason.
3. Participants for this study will be compensated for their time in the form of a gift certificate at the rate of $10 per hour. This compensation is not contingent upon the subject completing the entire study and will be prorated if the subject withdraws.
4. I will be identified by a randomly assigned ID number that is used only for this study. All recordings and game state files will be labeled with this ID. All information and data relating to the user study will be protected to secure confidentiality. All electronic files will be stored on password protected computers. All paper forms will be stored in a locked office. The correspondence between the ID number and my name will be recorded by Barbara Cutler and be accessible only by her. This correspondence will be destroyed once analysis of the data is complete, within 1 year after participation in the study.

5. If there is anything that I do not wish to have quoted, or any game state files that I do not want made public, I may say at any point during or after the interview what I wish to have kept off the record and it will not be quoted or used in a publication.
6. I understand that if Barbara Cutler decides to use any portions of this interview or any examples of my game play in subsequent publications, that she will send me a copy of the portions of the interview and any game play, including any quotations and paraphrases that she decides to use, for my editing and written approval. I will have the right to edit the material and I will receive a copy of the final publication. She will only use the material that I have approved and the use of all material will be anonymous. I may also change my mind at any point up to and including the review of any quotations and paraphrases and game play that might be used.
7. Based on reading this form (check one):
   ____ I agree to be interviewed.
   ____ I do not agree to be interviewed.
8. The basic camera-projection Spatially Augmented Reality (SAR) setup has been described to me and I have been warned not to look directly at the projector lenses. Standing close to the projector (30cm) and looking directly into the projector bulb for 2 seconds or longer may cause permanent eye damage.

Name of Participant	Signature	Date

For further information contact:

"Modeling Human Color Perception under Extended Luminance Levels", Kim, Weyrich, & Kautz, University College London, ACM SIGGRAPH 2009

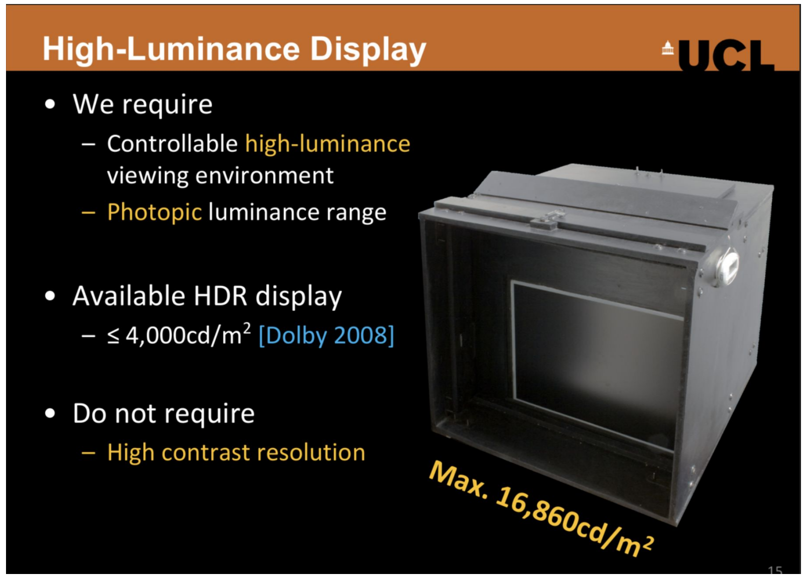


prior work

new model

"Modeling Human Color Perception under Extended Luminance Levels", Kim, Weyrich, & Kautz, University College London, ACM SIGGRAPH 2009

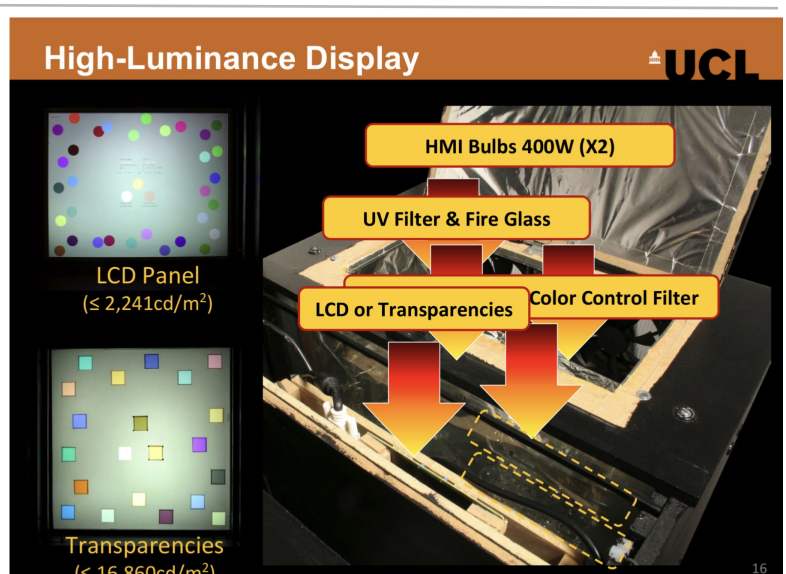
"… we built a custom display device which is capable of delivering up to approximately 30,000 cd/m2 … The setup consists of a light box, powered by two 400 W HMI bulbs, … LCD panel (original backlight removed), … HMI bulbs stay cool enough to keep the LCD panel from overheating."



"Modeling Human Color Perception under Extended Luminance Levels", Kim, Weyrich, & Kautz, University College London, ACM SIGGRAPH 2009

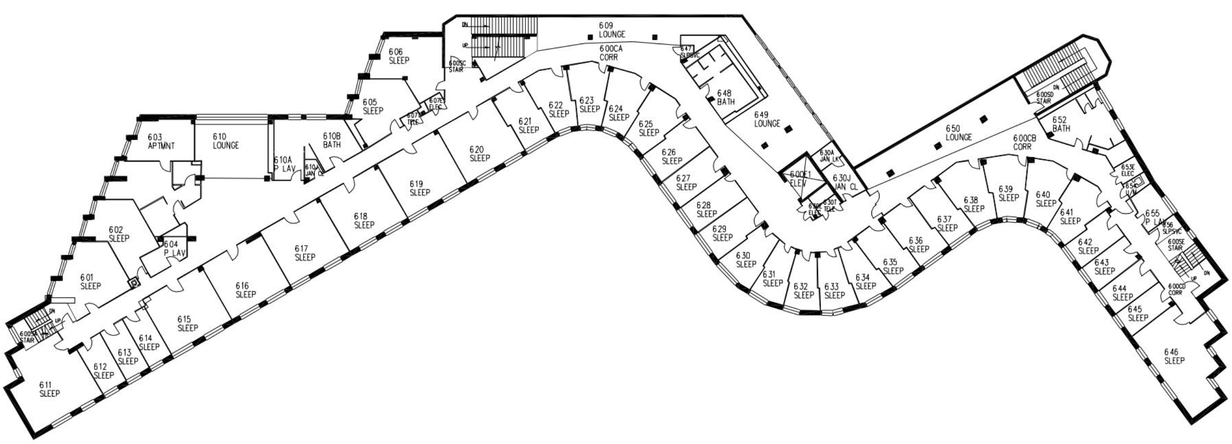
"… six fully trained expert observers, all of whom were research staff from our institution … Each observer spent around 10 hours on the experiment, usually distributed over two days."

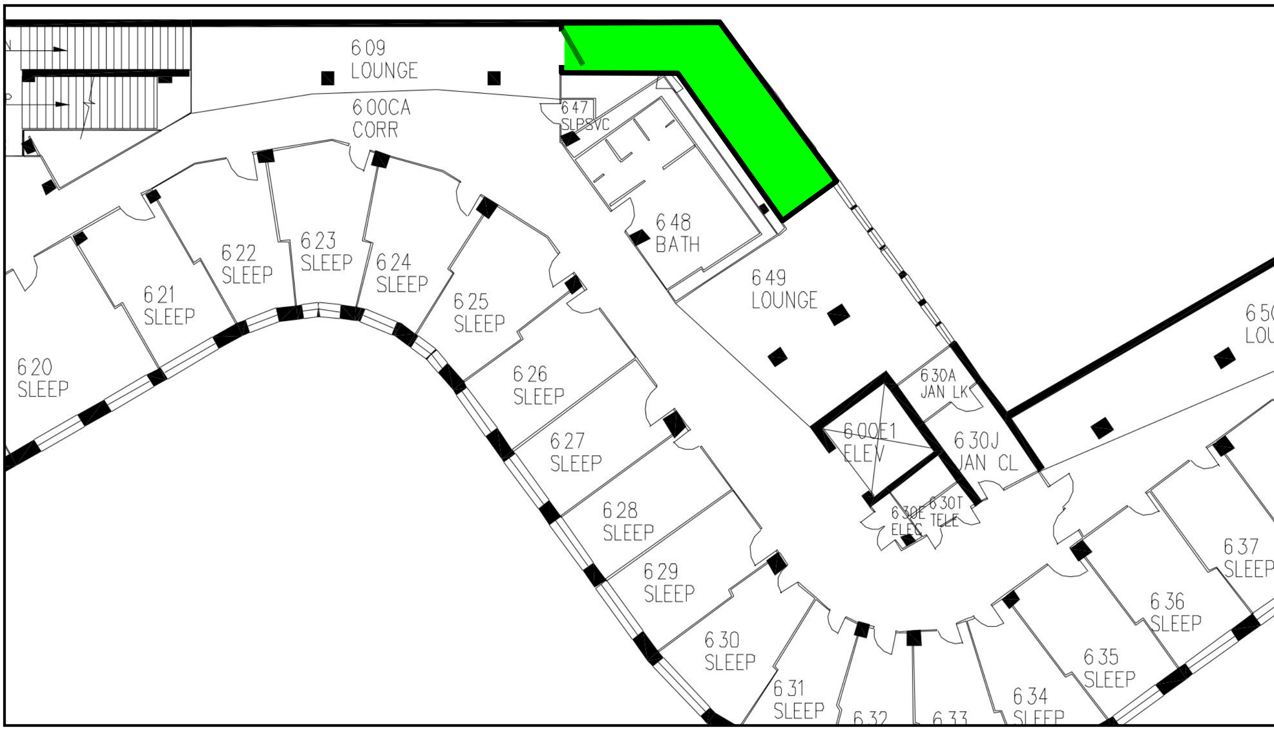
"We performed experiments up to a peak luminance of 16,860 cd/m2; higher luminance levels were abandoned as too uncomfortable for the participants."



MIT Baker House Dorm - Alvar Aalto 1949

MIT Baker House Dorm - Alvar Aalto 1949

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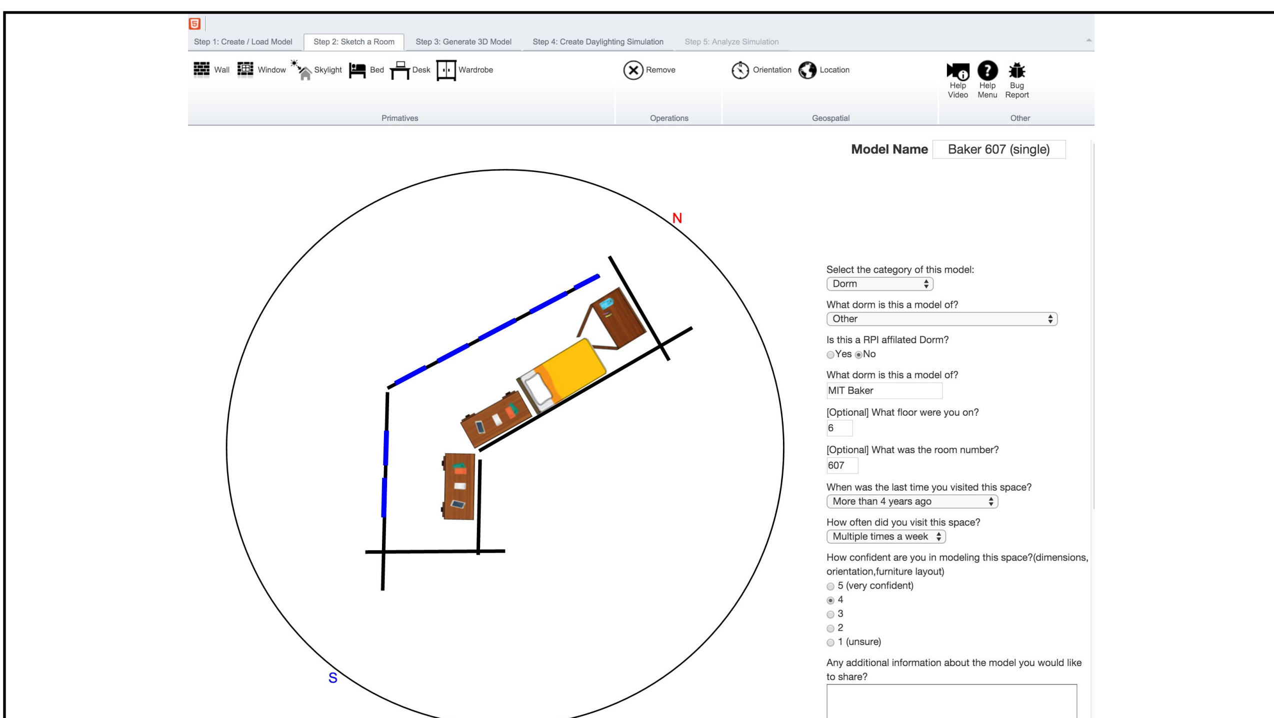
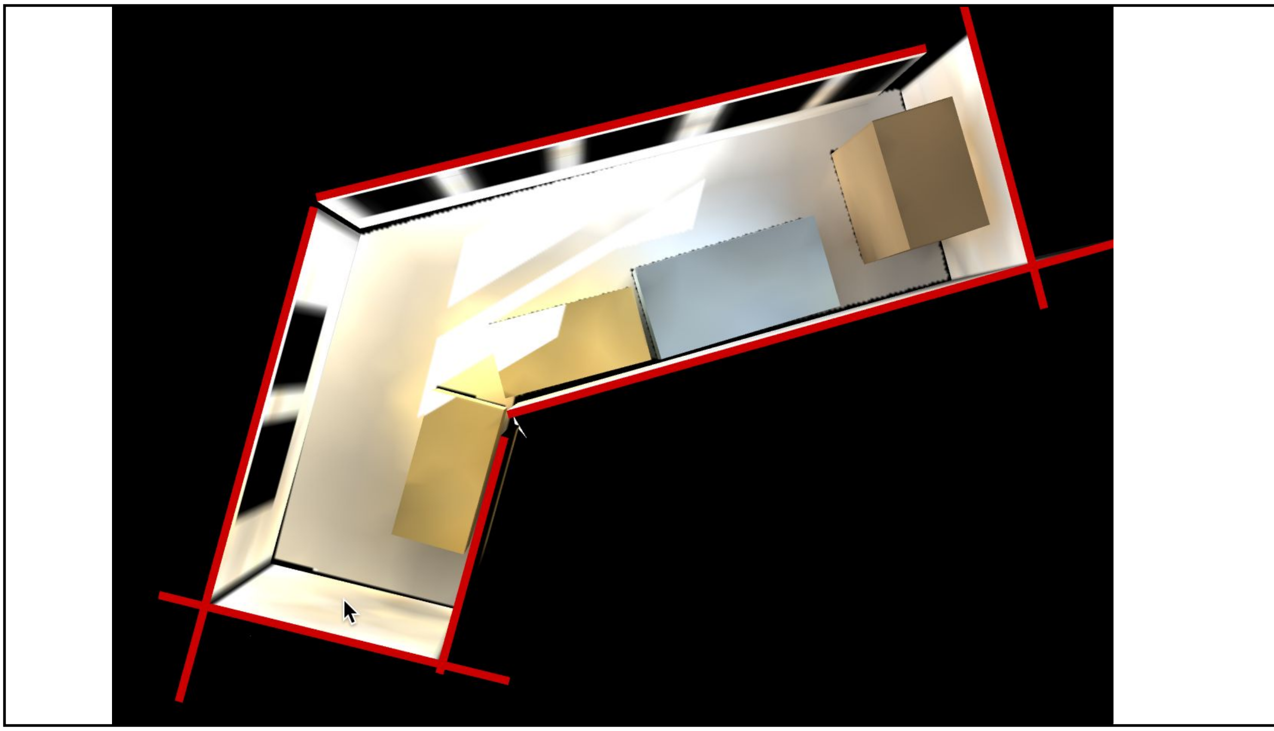
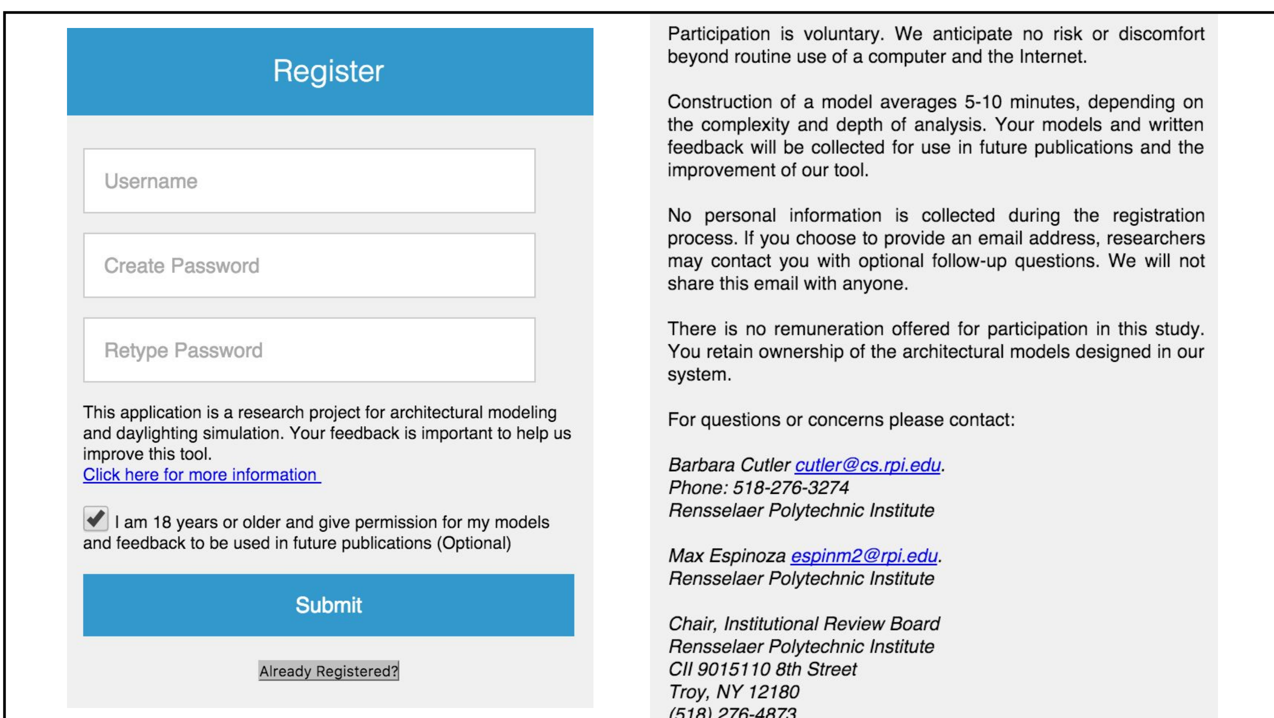

Step 1: Create / Load Model
Step 2: Sketch a Room
Step 3: Generate 3D Model
Step 4: Create Daylighting Simulation
Step 5: Analyze Simulation
Wall
Window
Skylight
Bed
Desk
Wardrobe
Remove
Orientation
Location
Help Video
Help Menu
Bug Report
Primatives
Operations
Geospatial
Other
Model Name
Baker 607 (single)
N
S
Select the category of this model:
Dorm
What dorm is this a model of?
Other
Is this a RPI affilated Dorm?
Yes No
What dorm is this a model of?
MIT Baker
[Optional] What floor were you on?
6
[Optional] What was the room number?
607
When was the last time you visited this space?
More than 4 years ago
How often did you visit this space?
Multiple times a week
How confident are you in modeling this space?(dimensions, orientation,furniture layout)
5 (very confident)
4
3
2
1 (unsure)
Any additional information about the model you would like to share?





Register

Username

Create Password

Retype Password

This application is a research project for architectural modeling and daylighting simulation. Your feedback is important to help us improve this tool.
Click here for more information

☑ I am 18 years or older and give permission for my models and feedback to be used in future publications (Optional)

Submit

Already Registered?

Participation is voluntary. We anticipate no risk or discomfort beyond routine use of a computer and the Internet.

Construction of a model averages 5-10 minutes, depending on the complexity and depth of analysis. Your models and written feedback will be collected for use in future publications and the improvement of our tool.

No personal information is collected during the registration process. If you choose to provide an email address, researchers may contact you with optional follow-up questions. We will not share this email with anyone.

There is no remuneration offered for participation in this study. You retain ownership of the architectural models designed in our system.

For questions or concerns please contact:

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Max Espinoza espinm2@rpi.edu.
Rensselaer Polytechnic Institute

Chair, Institutional Review Board
Rensselaer Polytechnic Institute
CII 9015110 8th Street
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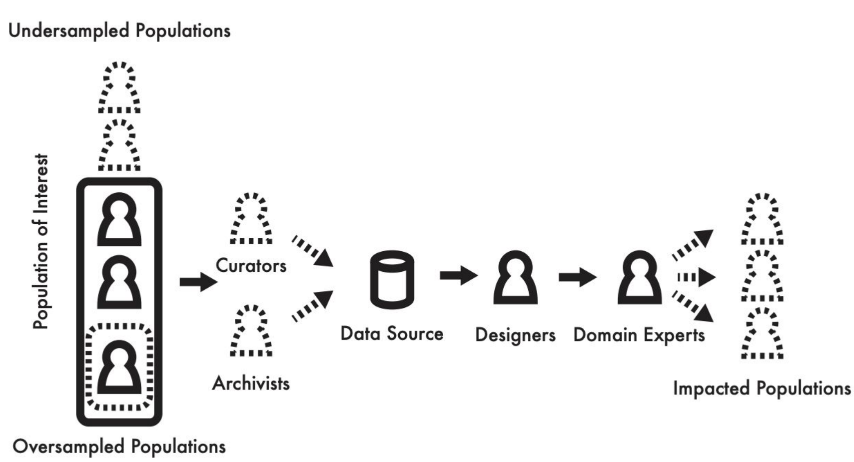
Today

- Quiz 1 & Homework 6
- Visual Variables
- Readings for Today
  - “Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables”, Guo et al.
  - “Visualizing Uncertain Information”, MacEachren
- Related Papers
  - “Algorithm and implementation uncertainty in viewshed analysis”, Fisher
  - “Siting Observers on Terrain”, Franklin
- Institutional Review Board (IRB)
- Readings for Next Lecture (after the Quiz)

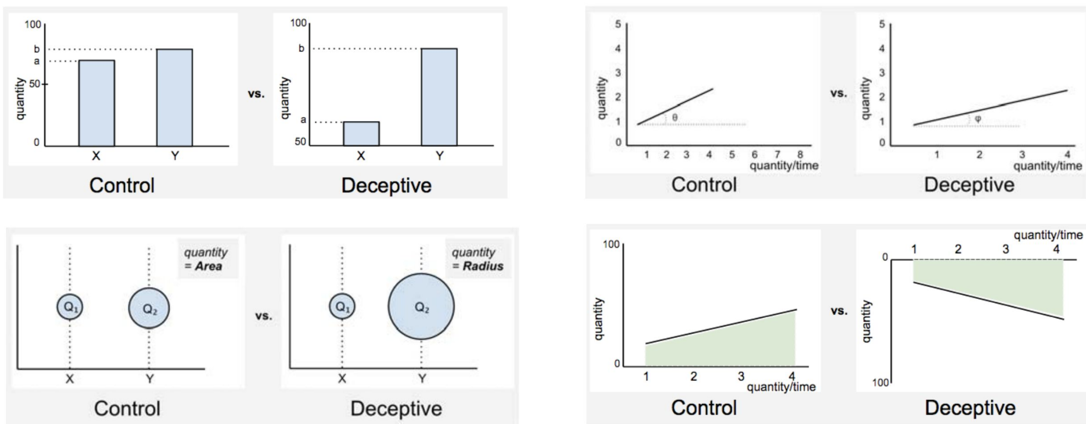
Reading for Next Lecture *pick one*

- "Ethical Dimensions of Visualization Research", Michael Correll, ACM CHI 2019



Reading for Next Lecture *pick one*

- How Deceptive are Deceptive Visualizations?, Pandey, Rall, Satterthwaite, Nov, & Bertini, ACM CHI 2015



Reading for Next Lecture *pick one*

- "Guess Me If You Can: A Visual Uncertainty Model for Transparent Evaluation of Disclosure Risks in Privacy-Preserving Data Visualization", Dasgupta, Kosara, & Chen, IEEE VizSec 2019