Uncertainty Part II: Node-Edge Graphs & Maps

Exam 1 on Friday July 2nd

- Class will not be in session on Friday
- You'll have from 6am-midnight to take the exam
- Closed book w/double sided study sheet
  - Worth the same as a homework
- You have 2h5m + 10m to complete the exam
  - Let me know if you have accommodations
  - 10 extra minutes for scan/upload

Exam 1 on Friday July 2nd

- Practice Problems (Exam 1 from 2016) on the course site
- *Note: we read slightly different papers!*

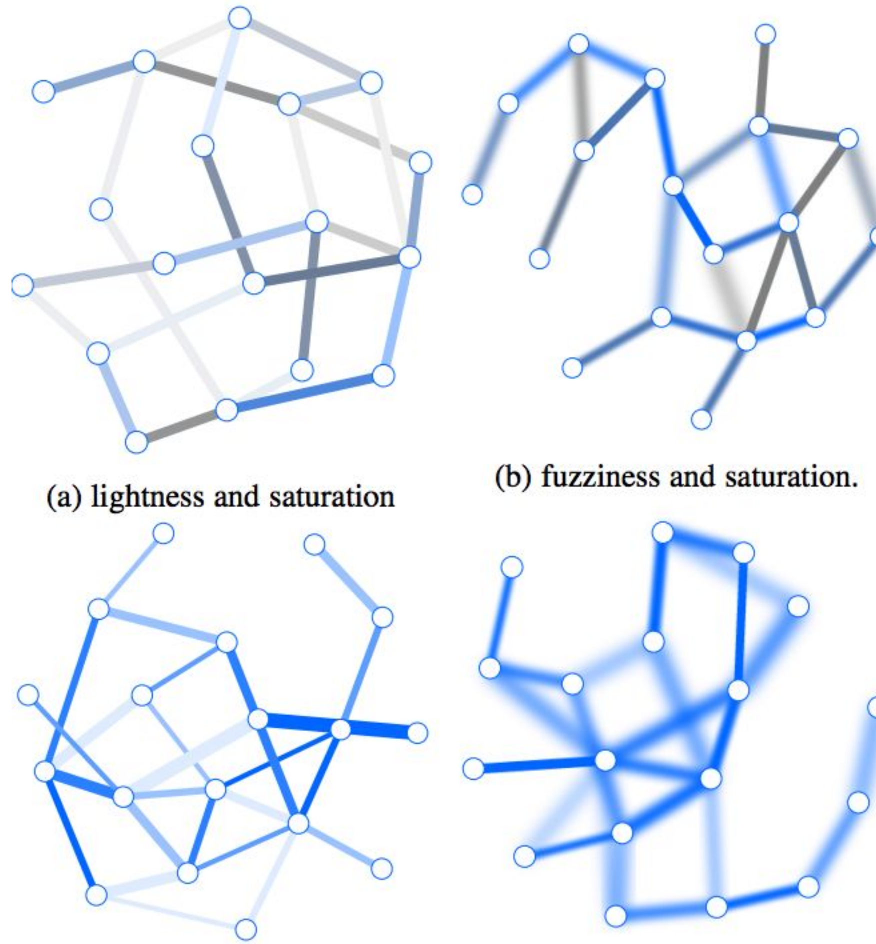
- Short answer based on readings
- Some design sketching (use color!)
  - Draw.io may be useful
- Tips
  - Keep a google doc with your answers open
  - If there are issues submitting, email me your answers

Today

- Exam Practice Problems Posted
- “Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables”
  - Visual Variables (originally from Bertin)
- “Visualizing Uncertain Information”, MacEachren, Cartographic Perspectives, 1992
- “Algorithm and implementation uncertainty in viewshed analysis”, Peter Fisher, J. of Geographical Information Science, 1993.
- Institutional Review Board (IRB)
- Final Project

Reading for Today

- "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.

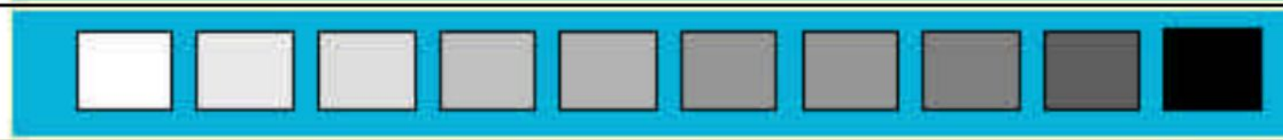
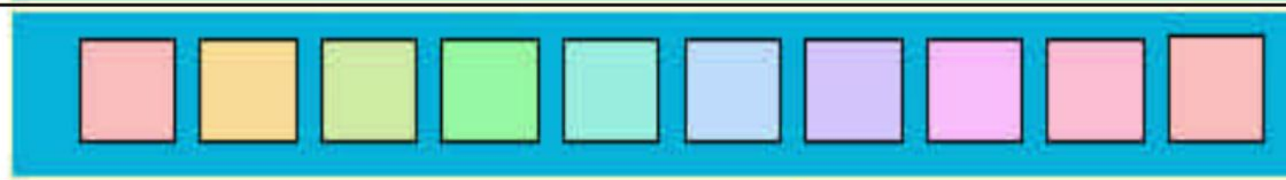
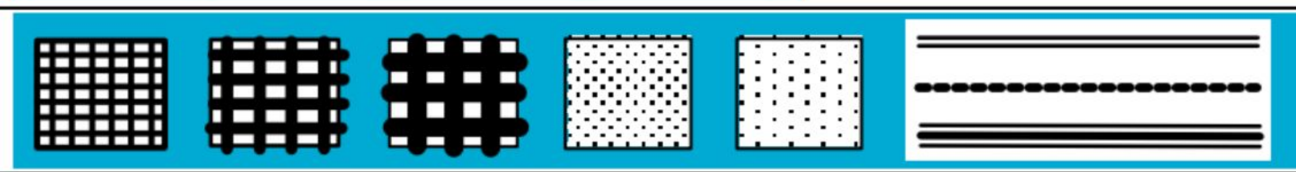
Bertin’s Original Visual Variables	
Position changes in the x, y location	
Size change in length, area or repetition	
Shape infinite number of shapes	
Value changes from light to dark	
Colour changes in hue at a given value	
Orientation changes in alignment	
Texture variation in ‘grain’	

Table 1: These are Bertin's visual variables

https://cdn.mprog.nl/dataviz/excerpts/w2/Carpendale_Considering_Visual_Variables.pdf

- Visual Variables: color based focus based geometry
  - J. Bertin [1967/1983]
    - location/position, size/width, color hue, color value/brightness, grain, orientation, and shape
  - J. L. Morrison [1974]
    - Color saturation, arrangement
  - Cleveland & McGill [1984]
    - Angle, volume curvature
  - A. M. MacEachren [1992]
    - Focus/fuzziness, resolution, transparency
  - M. Carpendale [2003]
    - Motion, depth, occlusion

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

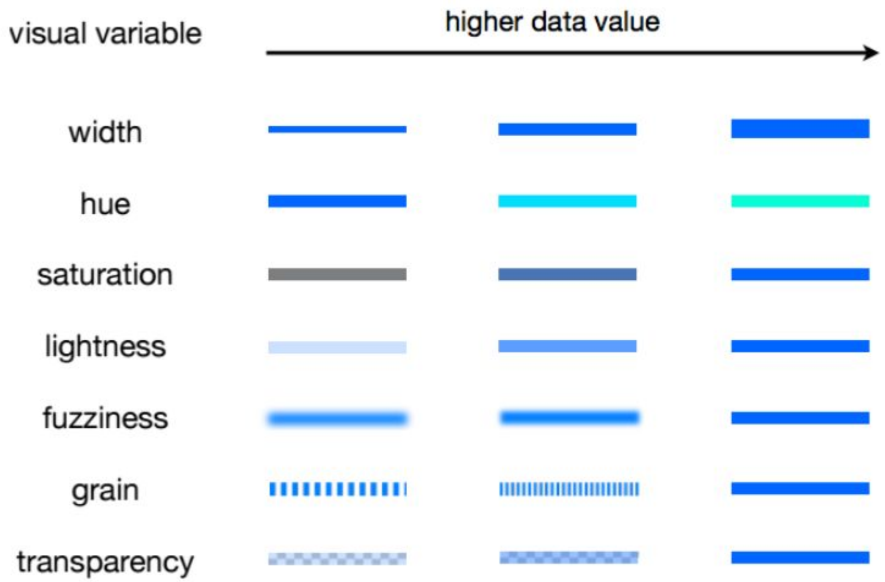


Fig. 1: An illustration of how each of the seven visual variables progress with increasing data value.

- Their conclusions only apply to line based marks

- 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?

- 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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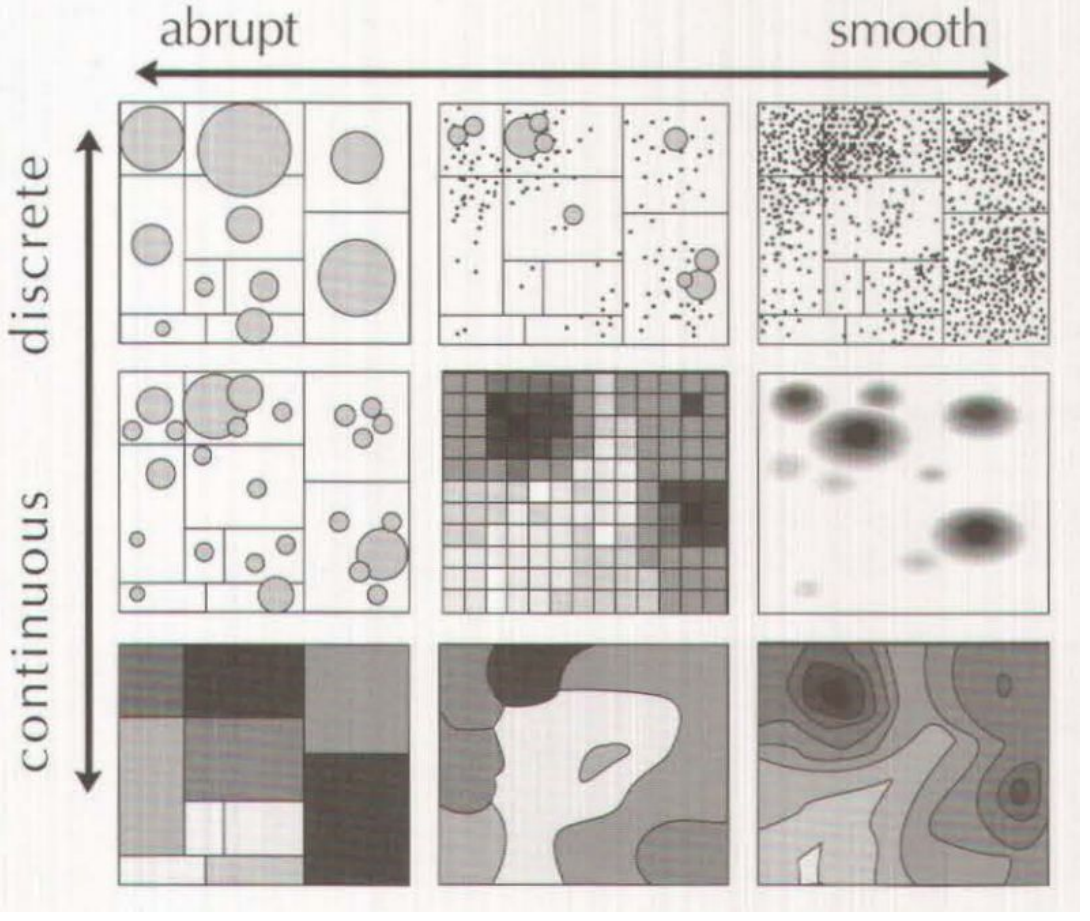
- “Visualizing Uncertain Information”, MacEachren, Cartographic Perspectives, 1992
  - "Quantitative Texton Sequences for Legible Bivariate Maps"
- “Algorithm and implementation uncertainty in viewshed analysis”, Peter Fisher, J. of Geographical Information Science, 1993.
- Institutional Review Board (IRB)
- Final Project

Reading for Today

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



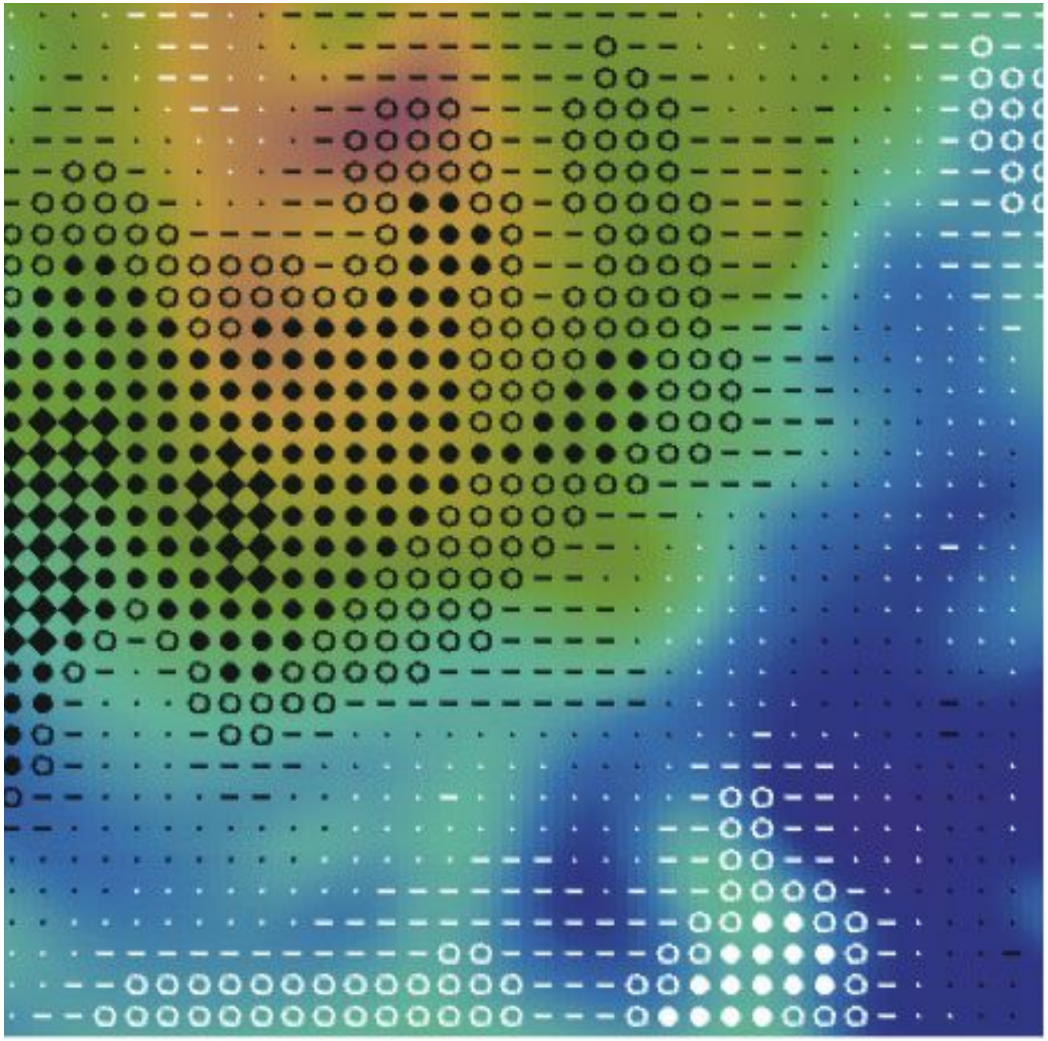
- GIS=Geographic Information System
- Are maps & computers infallible? Less fallible than humans?
- Data "quality" (when referring to error)? Better term is "uncertainty"?
  - Incomplete (census response rate),
  - attribute inaccuracy (misunderstood survey question or deliberate misinformation),
  - 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

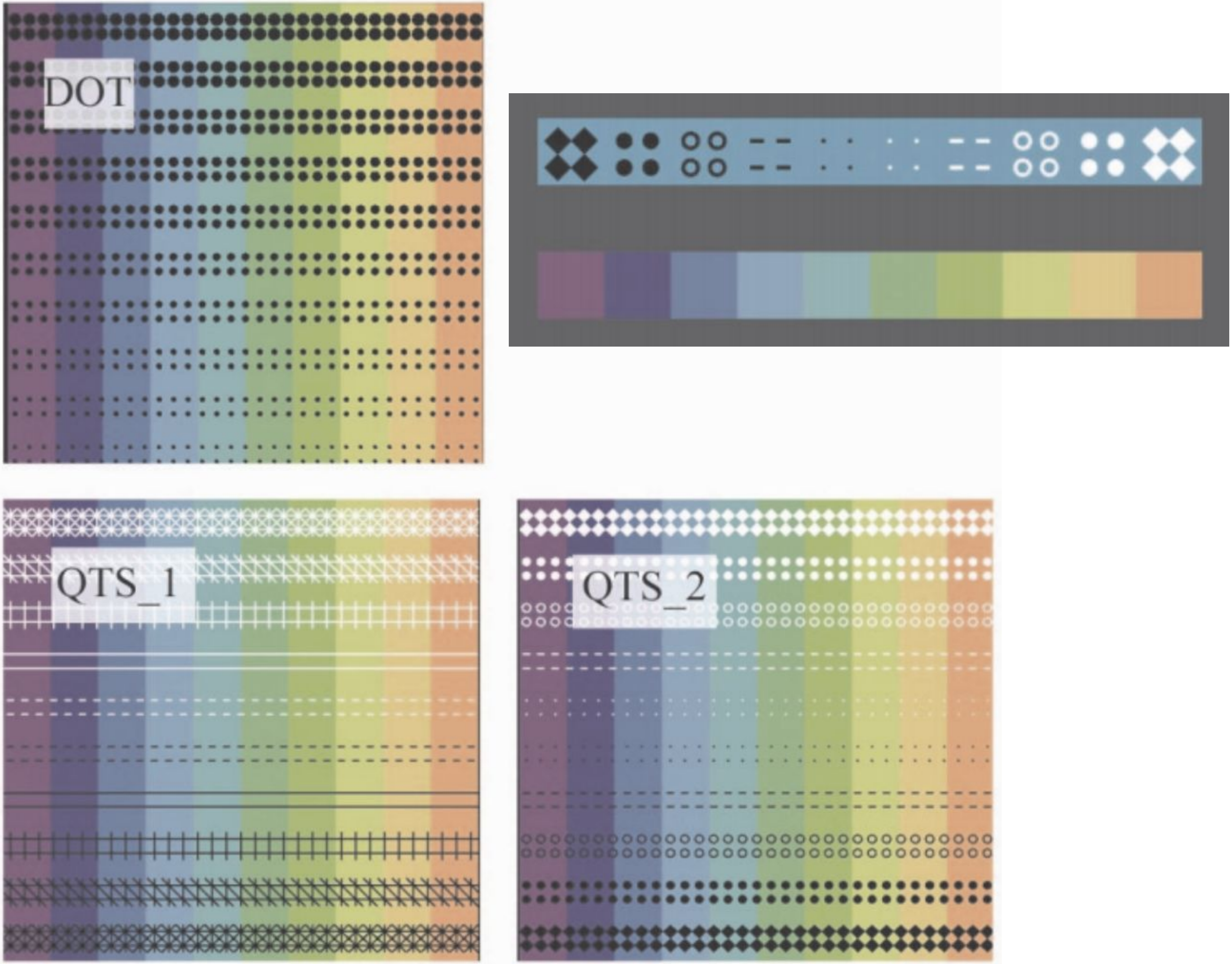
Visualizing Uncertain Information

- Methods of Encoding Uncertainty
  - Contour Crispness
  - Fill Clarity
  - Fog
  - Resolution
- Precision vs Accuracy
  - 1,115 people per square mile in a 100 square mile county
- Private vs Public Maps
  - Private: Exploration/Confirmation
  - Public: Synthesis/Presentation

Related Reading

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




DOT
QTS_1
QTS_2

Examples of Uncertain Graph or Spatial Data

- Endangered animal population (known sightings, estimates),
- general 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.
  - Prof Franklin’s work on Observer Siting
- Institutional Review Board (IRB)
- Final Project

Reading for Today

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

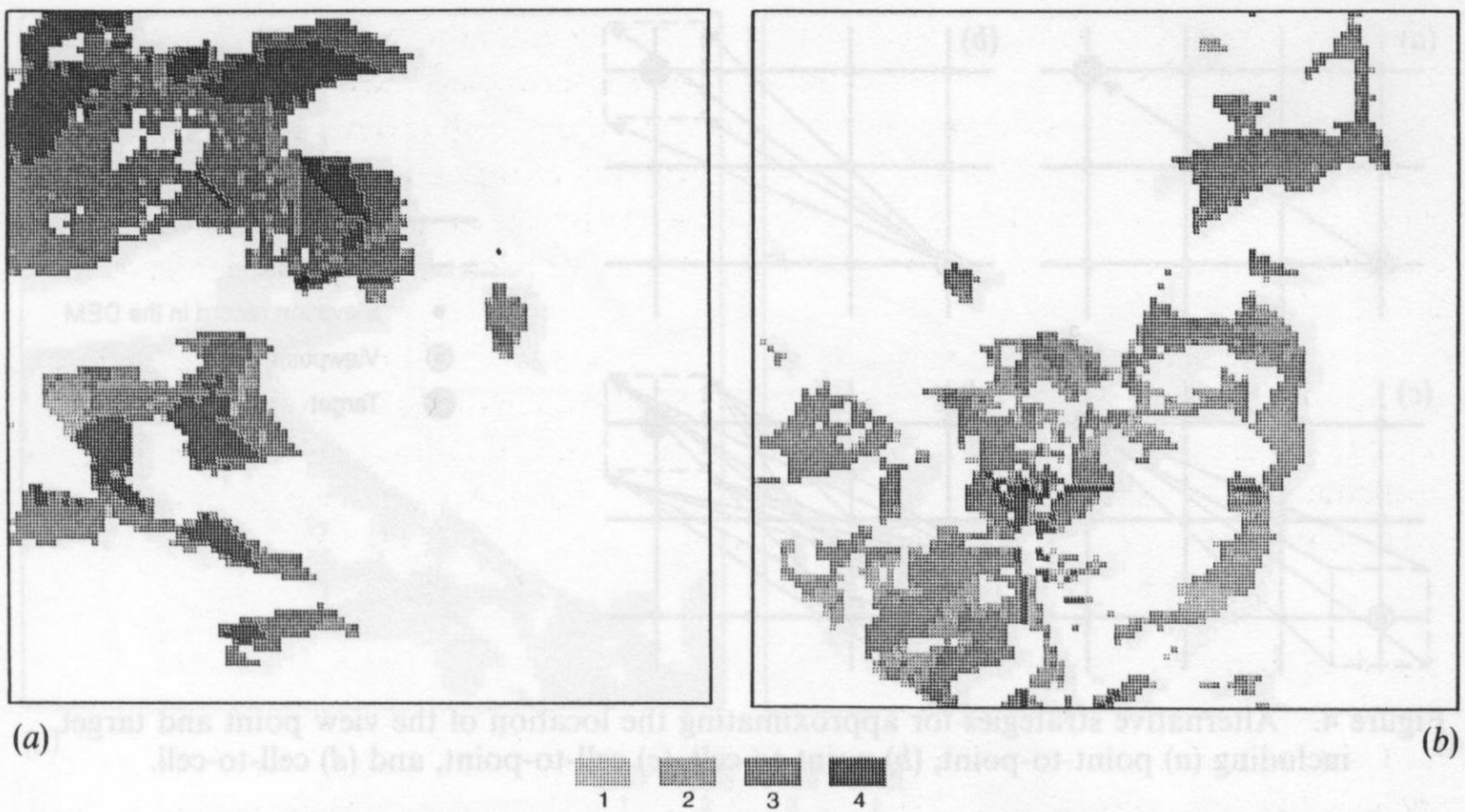
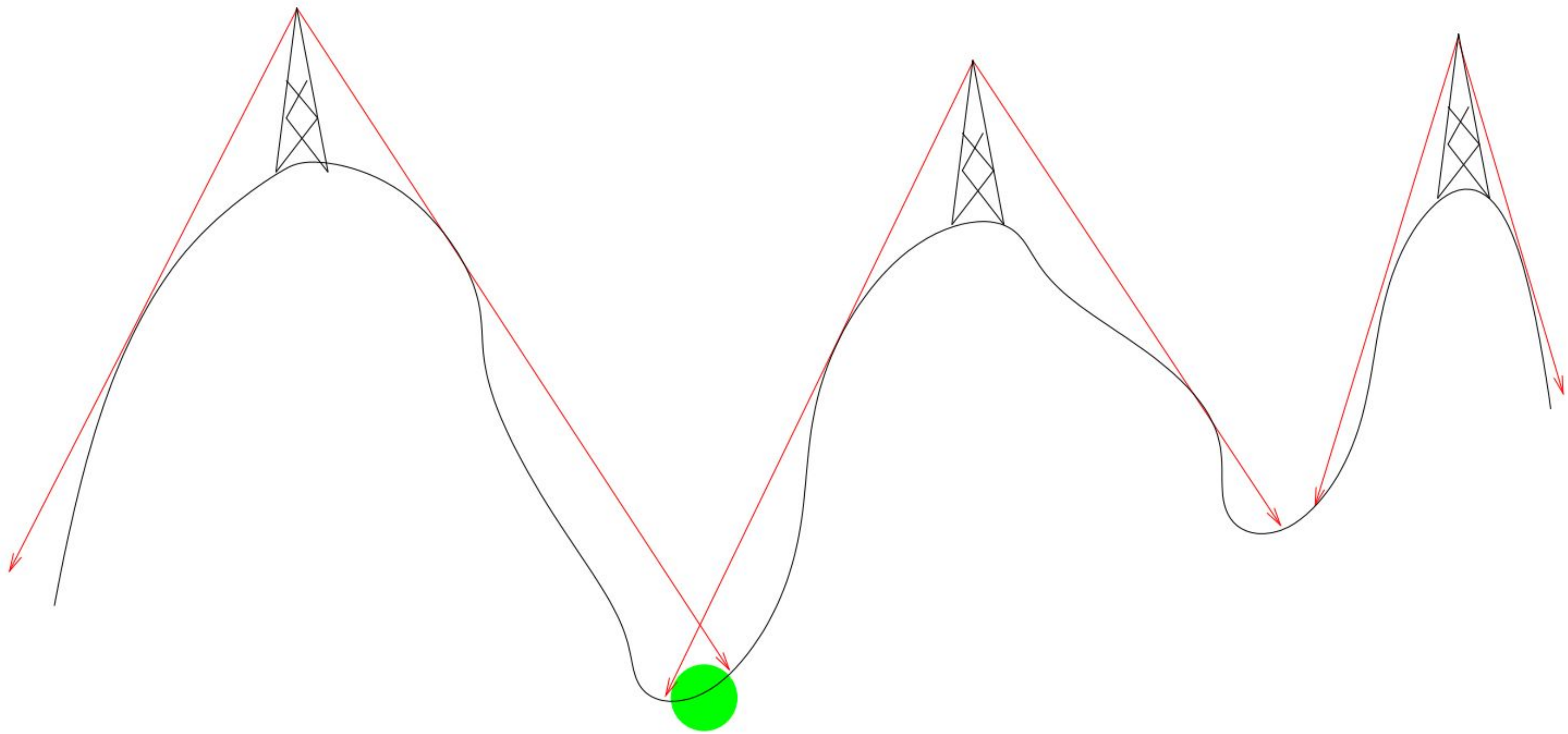


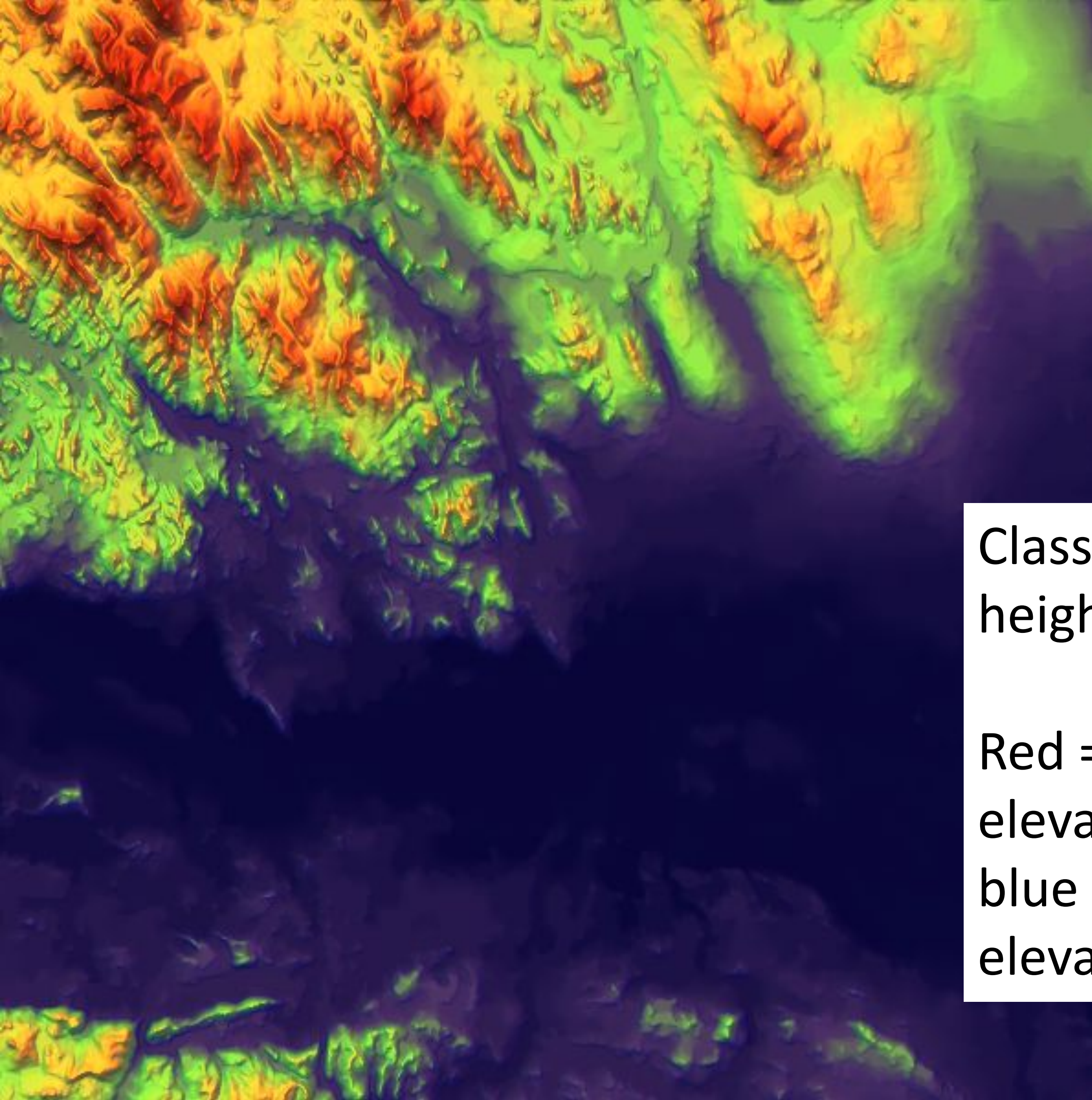
Figure 3. The pattern of grid cells included in viewsheds derived from alternative methods of inferring elevations.

- 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



Slide from W.R. Franklin

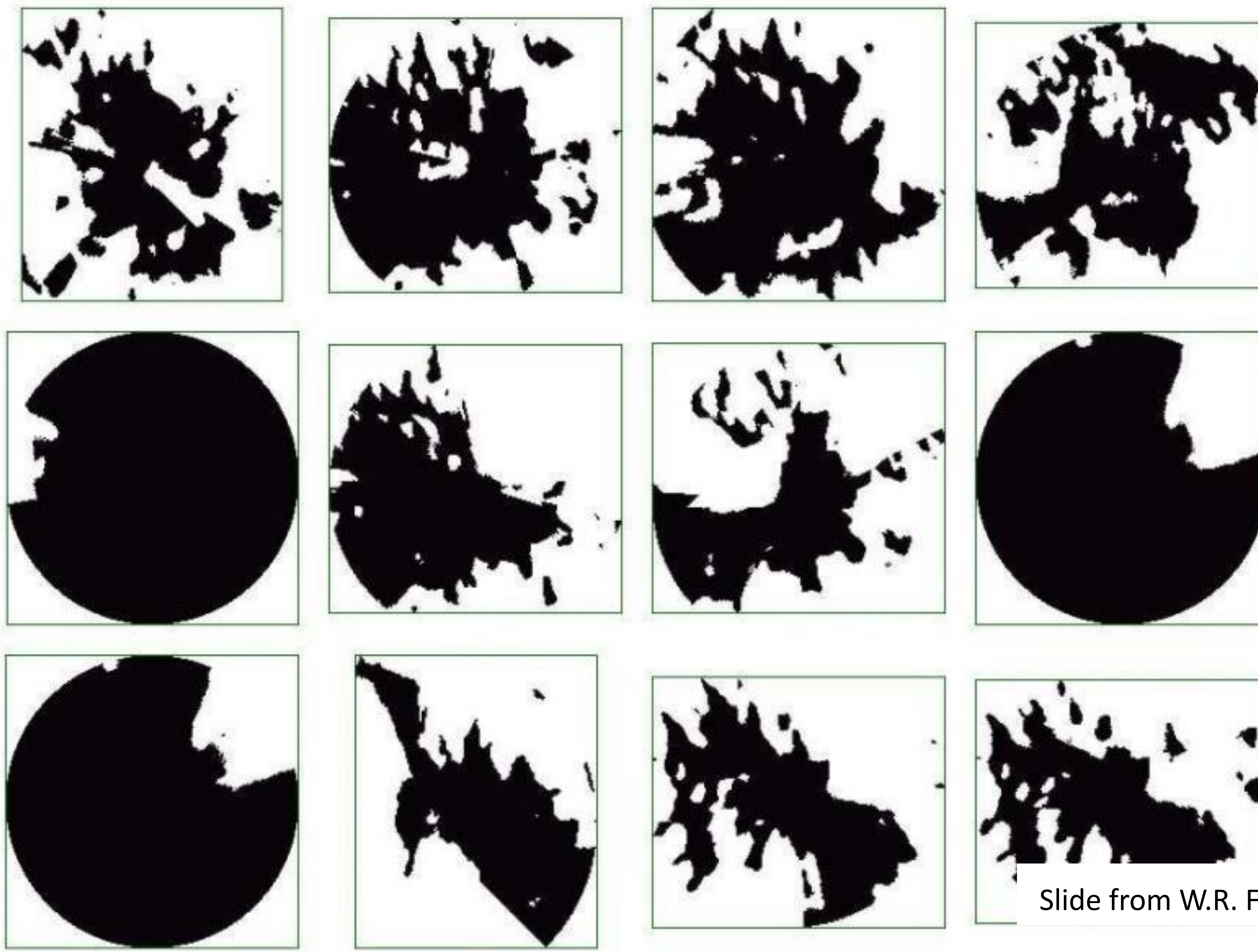


Classic terrain height visualization

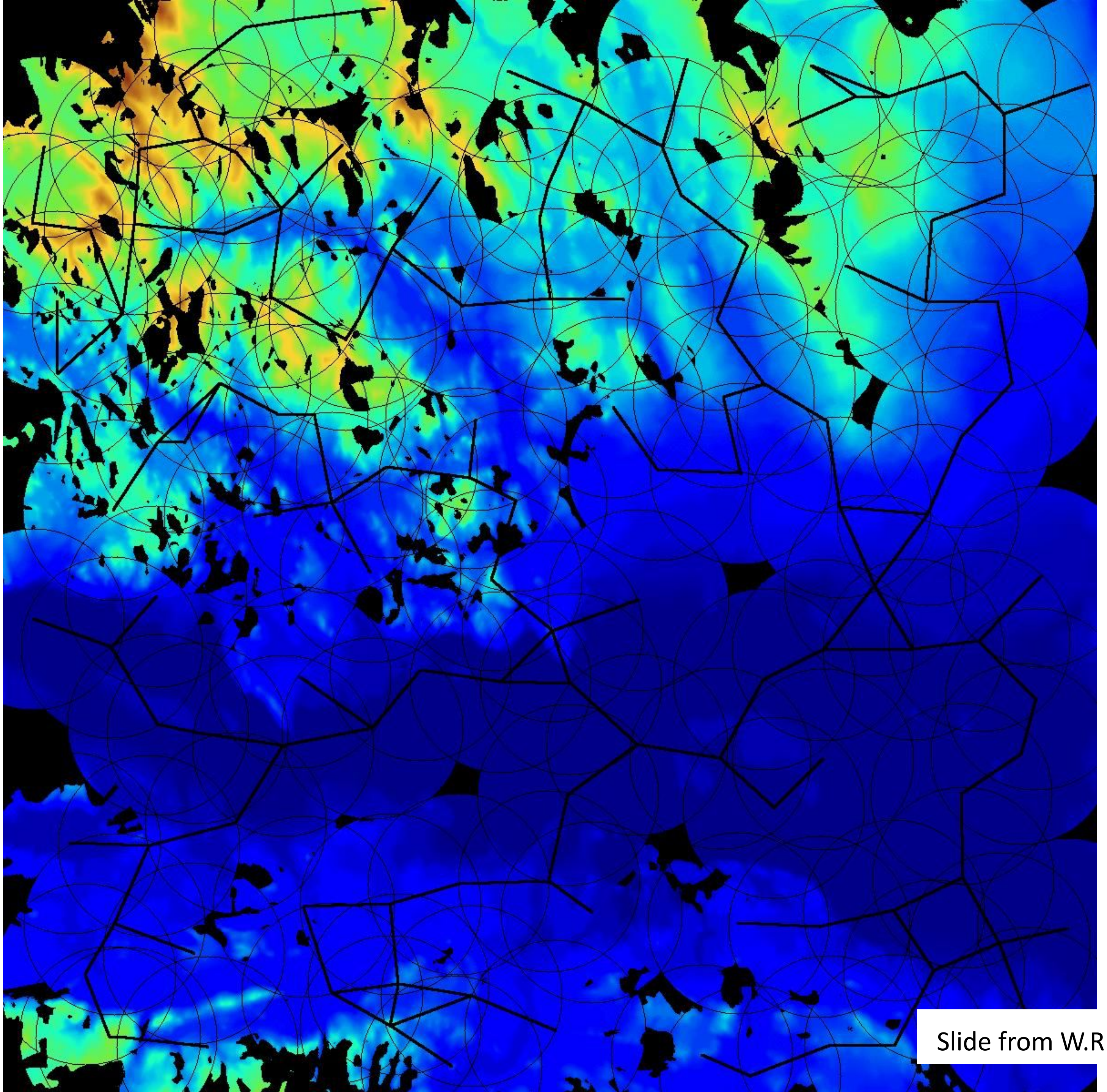
Red = higher elevations
blue = lower elevations

Slide from W.R. 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



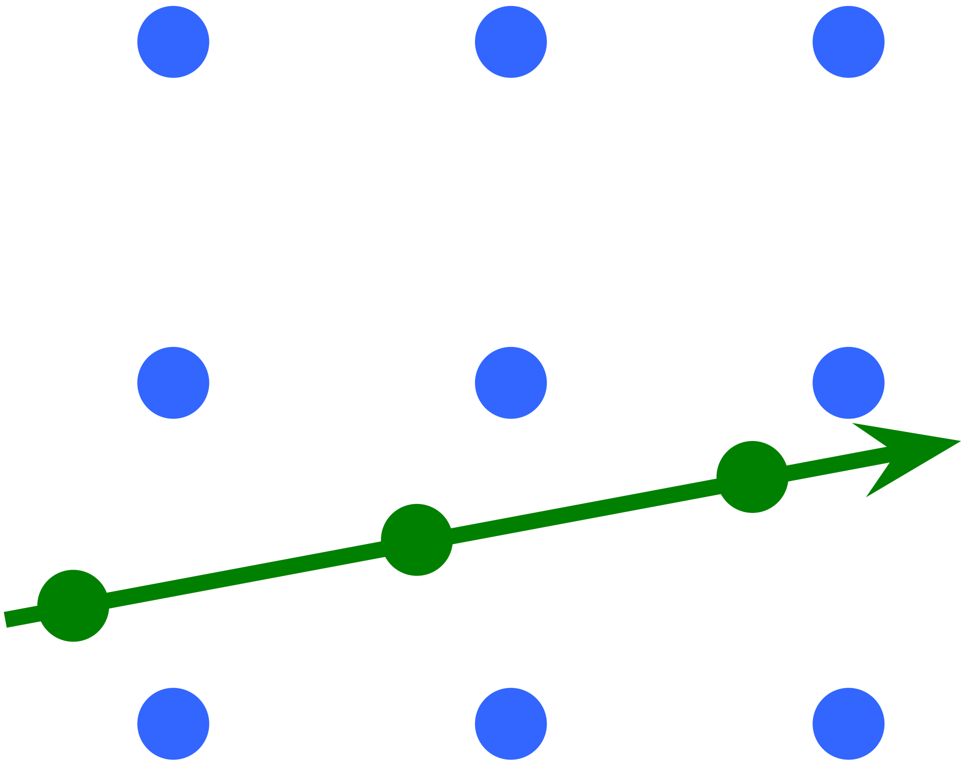
Slide from W.R. Franklin



Slide from W.R. Franklin

- Let’s 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? (form a connected network for communication)
  - How much error is introduced because of the original sensor measurements (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?
    - Erroneous visibility, 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 you design a better compression algorithm that reduces lossy artifacts that cause significant errors?

Regular grid of
height samples



Query for occlusions
along sight line

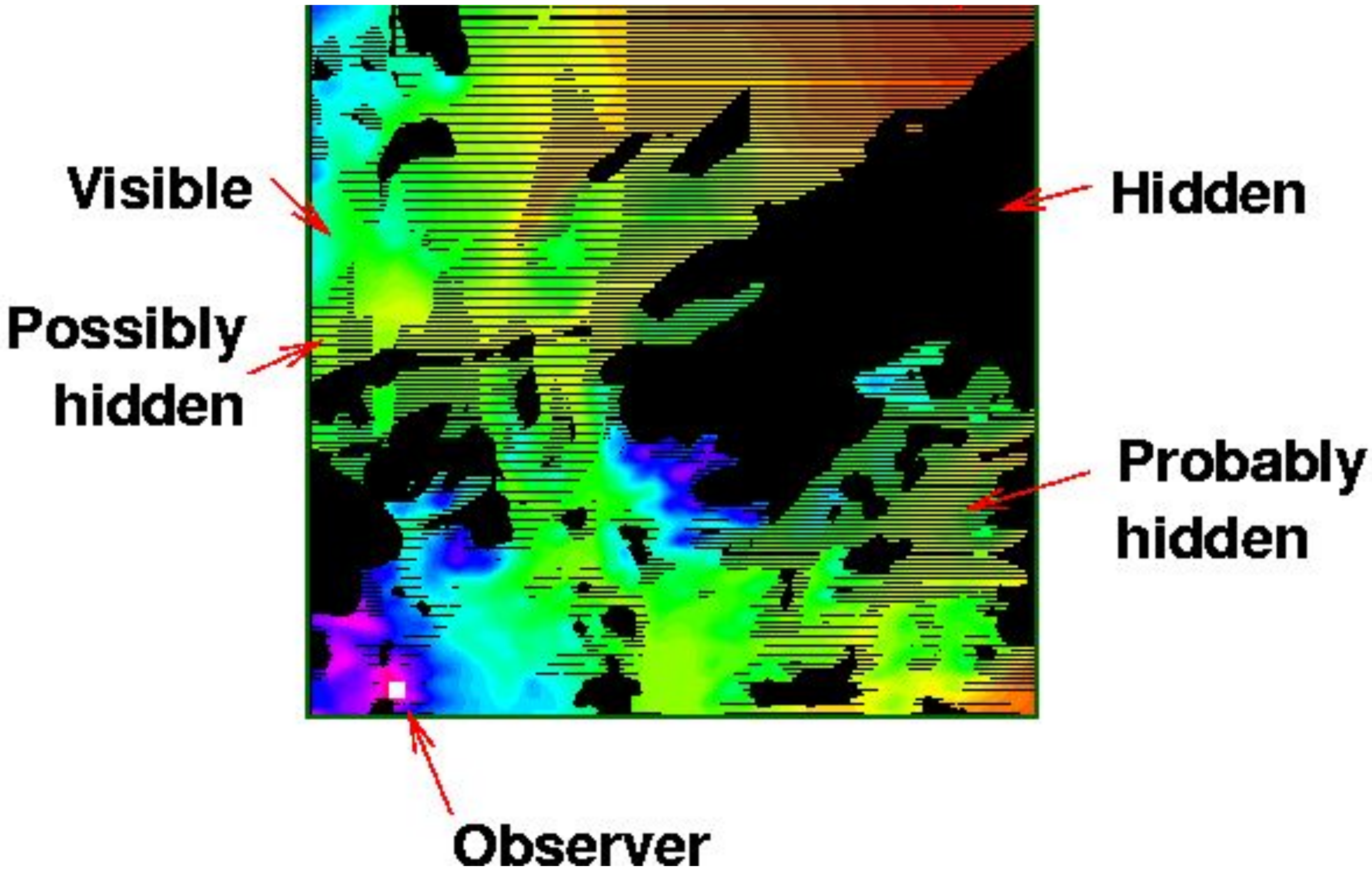
*Data interpolation
might be incorrect!*

Hue = terrain height

Value (binary color/black) = visibility

Grain/texture = uncertainty

If height is changed by epsilon, the visibility flips!



The visibility of one half of the points in uncertain!

Slide from W.R. Franklin

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- World War II: German physicians conducted medical experiments on concentration camp prisoners without their consent. Tested blood clotting (shooting them), vaccines (infecting them), effectiveness of poison bullets, and effects of high altitude and low oxygen.
- In the 1950's, thalidomide 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.
- 1961, Milgram obedience study (the shock machine): lack of proper attention to 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.
- Zimbardo's prison experiment (Stanford): The study did meet the criteria of his IRB in 1973!
- In the 70's various federal regulations established IRB at all research institutions.

Institutional Review Board (IRB)

- Privacy, Confidentiality, Anonymity, and Informed Consent
- Reduce risk (physical/mental/privacy) to the participants engaged in research

www.rpi.edu/research/office/irb/index.html

Office for Research

- Faculty Interest Inventory
- Constellations
- Invention
- Centers
- Platforms & Facilities
- Student Research

Research Compliance

Responsible Conduct of Research

- Institutional Review Board (IRB)
- Institutional Animal Care and Use Committee

Institutional Review Board (IRB)

Rensselaer Polytechnic Institute is committed to protecting the rights and welfare of human subjects of research conducted on the campus or sponsored by the Institute.

Rensselaer subscribes to the basic ethical principles that underlie the conduct of biomedical and behavioral research involving human subjects as set forth in the Belmont Report, and in accordance with Title 45, Code of Federal Regulations, Part 46.

The Institutional Review Board (IRB) has the responsibility and authority to review, approve, disapprove, or require changes in research activities involving human subjects. This policy applies to all faculty, staff, and student projects, regardless of whether the project is funded externally, internally, or receives no funding support.

Researchers should refer to Rensselaer's Guidelines for Human Subjects Research to determine whether or not their research is indeed human subjects research, and/or if their research satisfies the requirements for expedited review by the IRB.

IRB Training Requirements

As federally mandated and required by the Rensselaer IRB, all investigators must complete a self-study course in human subject protection via the CITI Training Program. Each investigator on a research project involving human subjects is required to certify that they have completed the required course(s) before engaging in the

Direct all inquiries to irb@rpi.edu

Rensselaer Resources for Human Subjects Research

- IRB Proposal Template
- IRB Renewal/Closure Form

Consent Form Templates:

- Faculty
- Student

Additional Resources

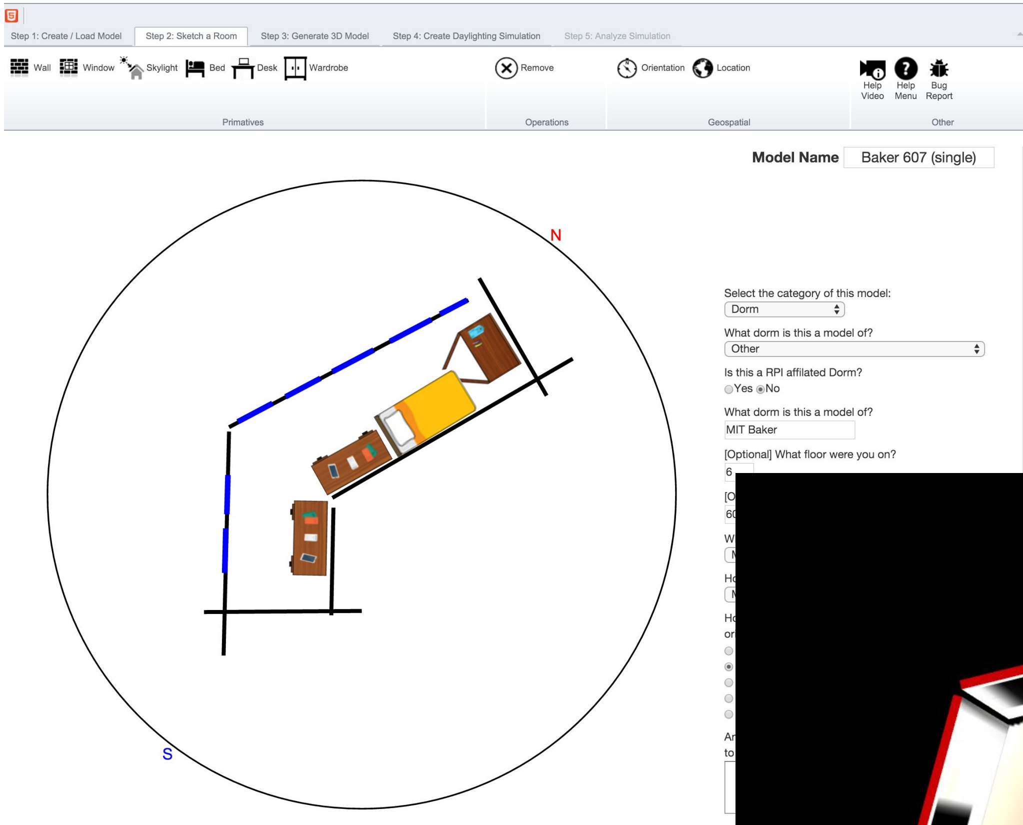
CITI Training Programs

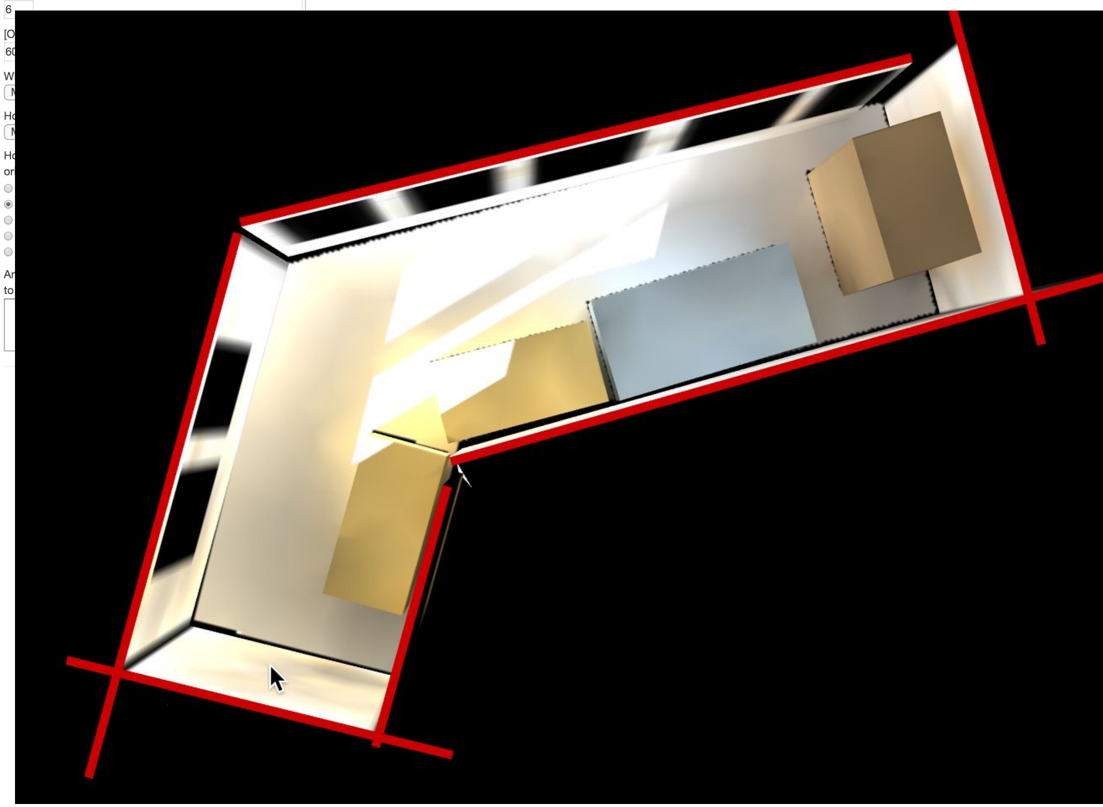
Decision Chart

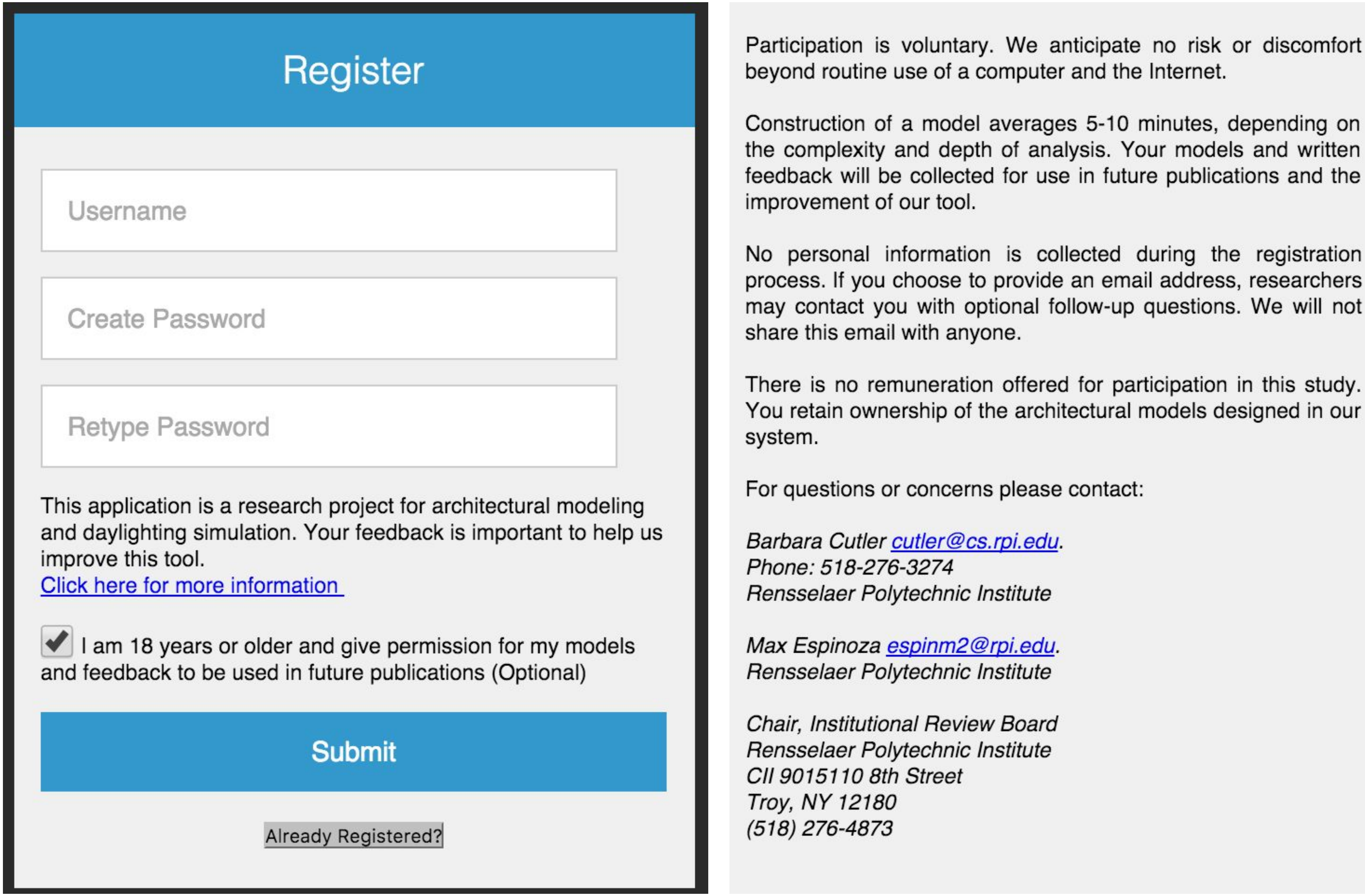
NIH Office of Human Subjects Research

Office for Human Research

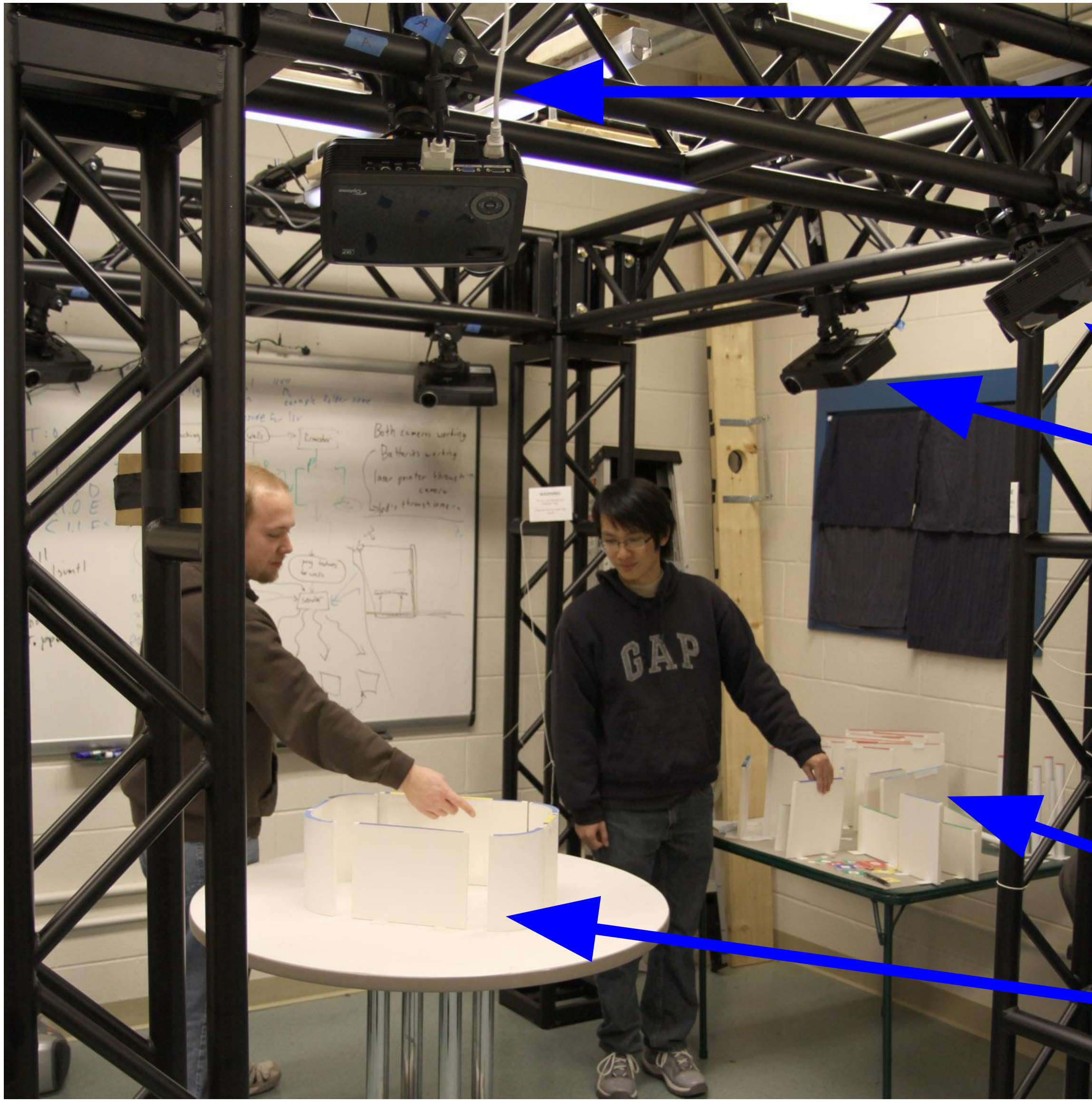
https://oasis.cs.rpi.edu/






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:
Barbara Cutler cutler@cs.rpi.edu.
Phone: 518-276-3274
Rensselaer Polytechnic Institute
Max Espinoza espinm2@rpi.edu.
Rensselaer Polytechnic Institute
Chair, Institutional Review Board
Rensselaer Polytechnic Institute
CII 9015110 8th Street
Troy, NY 12180
(518) 276-4873

Spatially Augmented Reality (SAR) Projection



camera detects design geometry

6 projectors augment design

design sketched with foam-core walls

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

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Final Project

- (Required) Teams of 2
- Worth 25% of your overall score
  - Proposal
  - Check-ins (x2)
  - Presentation
  - Report
  - Visualization

Final Project

- A final project:
  - Requires a significant amount of coding
    - Gathering data
    - Preprocess/clean/transform/ data
    - Create a robust, interesting, **interactive** visualization
    - Leverage one or more visualization/graphics packages/toolkits.
  - Answers a question
    - Who is your target audience? What is your hypothesis?
  - Is non-trivially interactive
  - Looks good!

Final Project Ideas

- Come up with 2x ideas over the break
- When we come back, we'll post them to the forum
- You will read over your classmates ideas and provide constructive feedback
- We will take time on the Friday that we come back to form teams