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
● Institutional Review Board (IRB)
● Readings for Next Lecture (after the Quiz)
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

<table>
<thead>
<tr>
<th>Date</th>
<th>Lecture/Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 13</td>
<td>Lecture 11: Uncertainty II: Node-Edge Graphs &amp; Maps</td>
</tr>
<tr>
<td>Feb 19</td>
<td>No classes</td>
</tr>
<tr>
<td>Feb 20</td>
<td>Monday schedule</td>
</tr>
<tr>
<td>Feb 22</td>
<td>Homework 6: Stream Graphs</td>
</tr>
<tr>
<td>Feb 23</td>
<td>Lecture 12: Ethics &amp; Privacy</td>
</tr>
<tr>
<td>Feb 26</td>
<td>Final Project</td>
</tr>
<tr>
<td>Feb 27</td>
<td>Lecture 13:</td>
</tr>
</tbody>
</table>

Homework 6: Stream Graphs

- 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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Bertin’s Original Visual Variables

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

Table 1: These are Bertin's visual variables

Visual Variables

- 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” by 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
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 crisinness, 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

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

- Software quality & different/inconsistent outcomes from different GIS products
- Simple computation/algo (calculate slope) vs. more complex algo (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
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?

Terrain Height Visualization
red = higher elevations
blue = lower elevations
• 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 is uncertain!
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
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.

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!
Are Projectors Dangerous?

Light from a point source falls off with the square of distance.

Looking into a projector at 30 cm is 100 times the light exposure 3 meters from the projector and > 1000 times the light exposure at 10 meters.
Spatially Augmented Reality (SAR) Projection

- Contacted projector manufacturer
  - Requested user safety information regarding containment for bulb explosion
even't receive anything
- Contacted bulb manufacturer
  - Requested light output data sheets & safety information
even'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

https://listart.mit.edu/art-artists/baker-house-1949
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

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
CIF 9015110 8th Street
Troy, NY 12180
(518) 276-4873
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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

![Graphs showing control vs. deceptive visualization comparisons.](image)

Reading for Next Lecture *pick one*


![Graphs illustrating visual uncertainty model.](image)