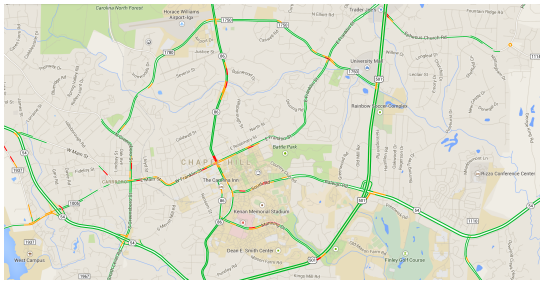
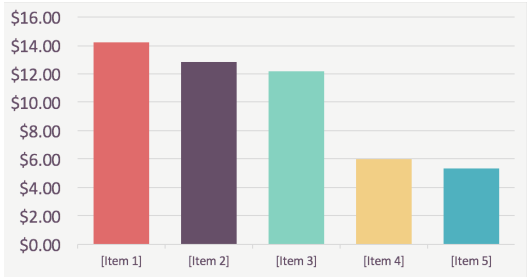
Module #14c:
Validation of Visualization Systems

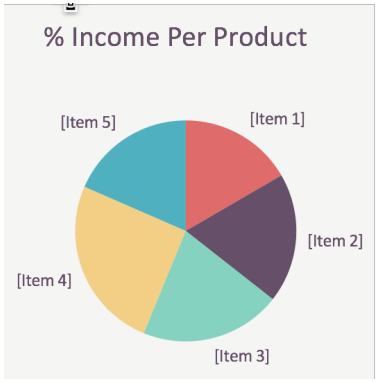
What's Data Visualization?

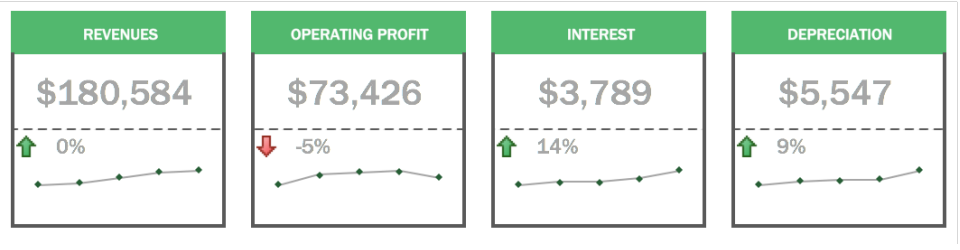
- "**Visualization** is the communication of information using graphical representations."
  - Ward et al., "Interactive Data Visualization"

		North	South	East	West
2011	1Q	$54,423.00	$51,234.00	$59,732.00	$58,534.00
	2Q	$51,345.00	$55,398.00	$57,423.00	$48,423.00
	3Q	$49,123.00	$46,245.00	$49,356.00	$49,976.00
	4Q	$45,923.00	$45,912.00	$54,989.00	$53,234.00
2012	1Q	$56,263.00	$87,690.00	$48,123.00	$63,343.00
	2Q	$52,103.00	$47,233.00	$49,325.00	$78,054.00
	3Q	$54,423.00	$52,344.00	$51,484.00	$53,012.00
	4Q	$51,345.00	$68,453.00	$53,323.00	$52,432.00
2013	1Q	$49,123.00	$45,234.00	$51,376.00	$49,643.00
	2Q	$52,103.00	$46,342.00	$34,376.00	$47,032.00
	3Q	$45,923.00	$35,432.00	$41,234.00	$45,123.00
	4Q	$56,263.00	$34,632.00	$44,532.00	$40,995.00









Taxonomy of Data Types

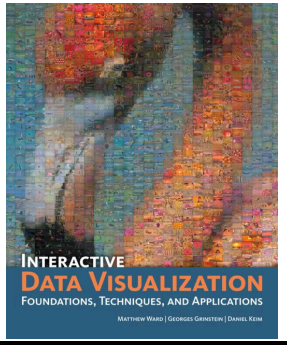
1. 1D/Linear
   - lists of data items, organized by a single feature (e.g., alphabetical order)
2. 2D/Planar (incl. Geospatial)
   - maps
3. 3D/Volumetric
   - medical imaging
4. Temporal
   - T=time series
5. nD/Multidimensional
   - category proportions
6. Tree/Hierarchical
   - Computer file structure
7. Network
   - internet

1. Nominal
2. Ordinal
3. Quantitative
   1. Interval
   2. ratio

The Visual Variables

- **Eight "visual variables"** that can be controlled during the mapping process
  1. Position
  2. Mark
  3. Size
  4. Brightness
  5. Color
  6. Orientation
  7. Texture
  8. Motion

"Interactive Data Visualization"
by Matthew Ward, Georges Grinstein and Daniel Keim

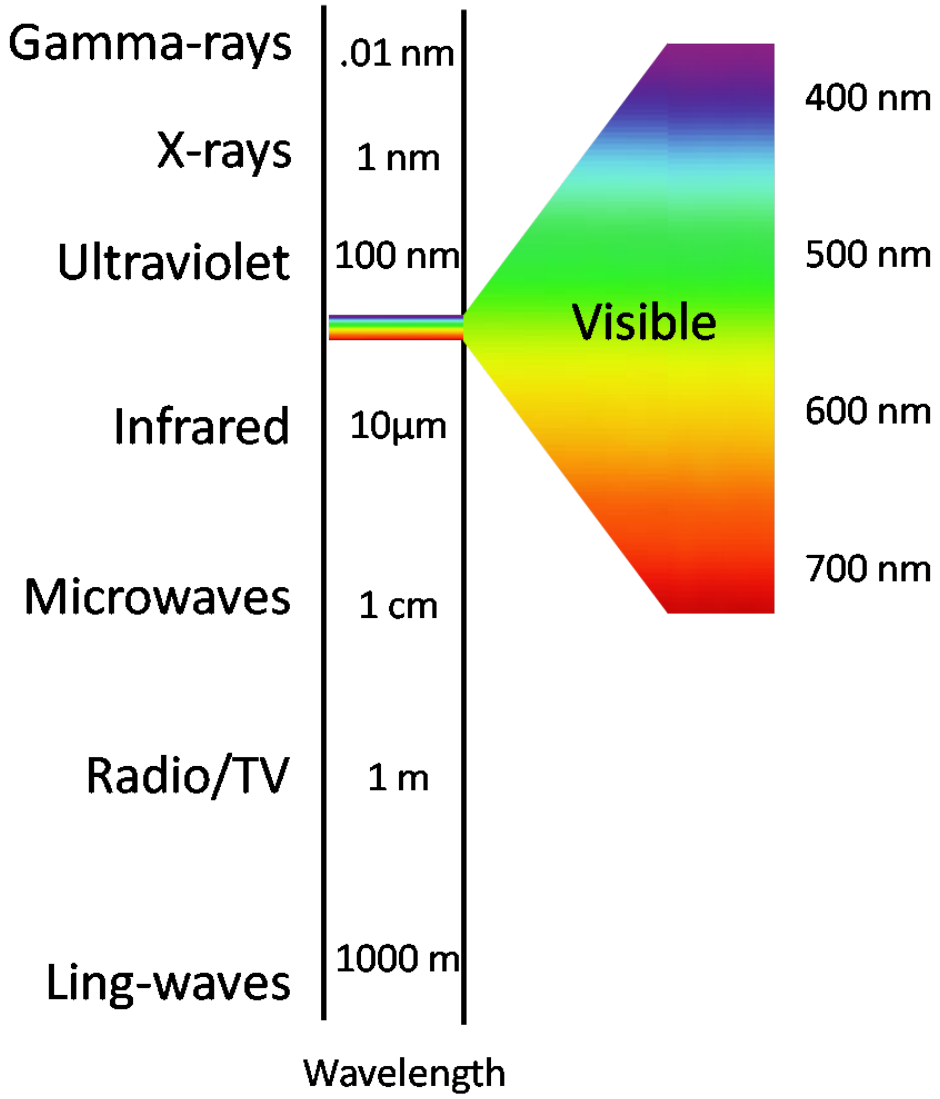


Visual Design: Rules of Thumb

1. Keep it simple
2. Be consistent
3. Create organization and structure

Visible Light

- Chromatic light spans the electromagnetic spectrum from approximately 400 to 700 nm



Interaction

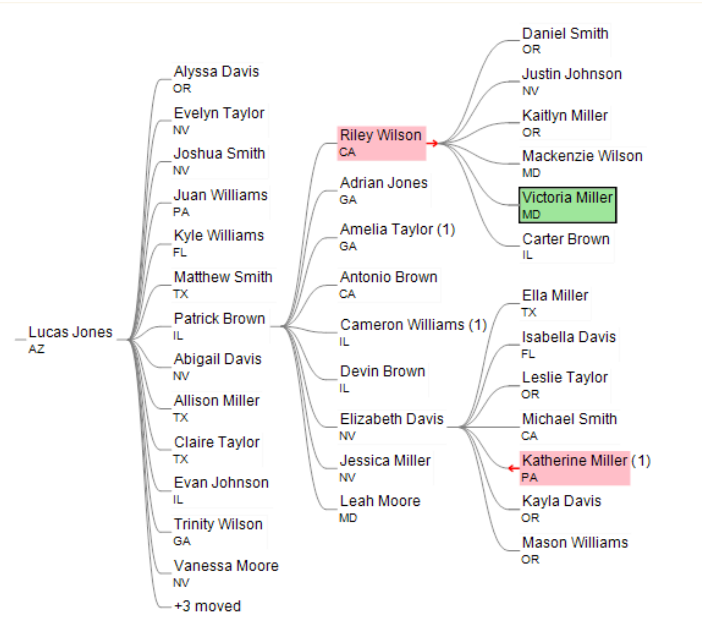
1. Tell storyline (usually over time)
   - Time-based playback
   - Sequence of actions based playback

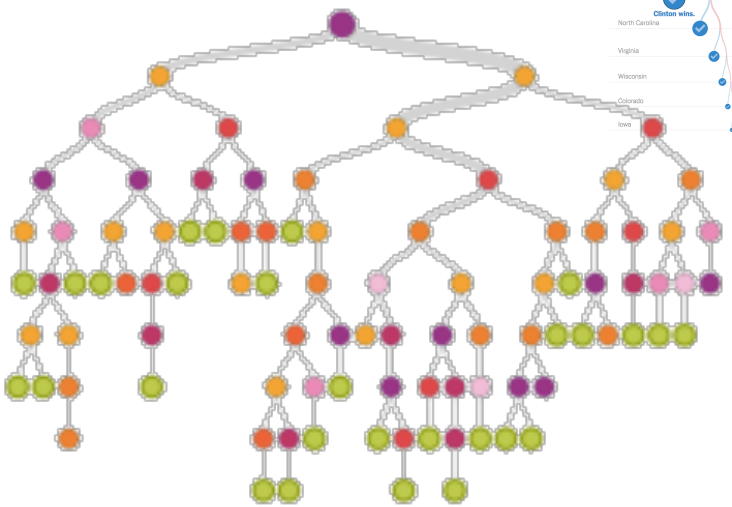
2. Allow user to explore data (visual analytics)
   - Zoom in on details
   - Create different views into data
   - Change/Filter values
   - Show connections between data (including to other datasets)

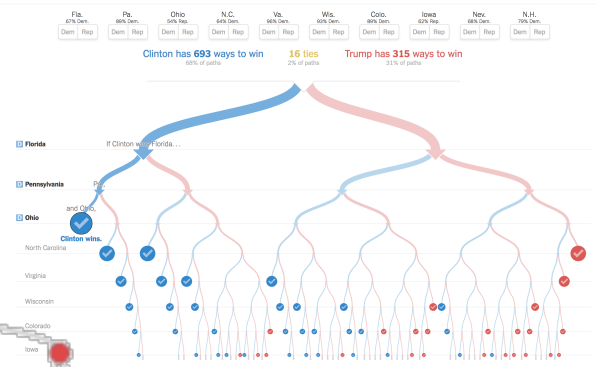
Tree Layout

- Similar to graph layouts, many layout algorithms have been proposed for trees.

- The most population approach is the classic layout

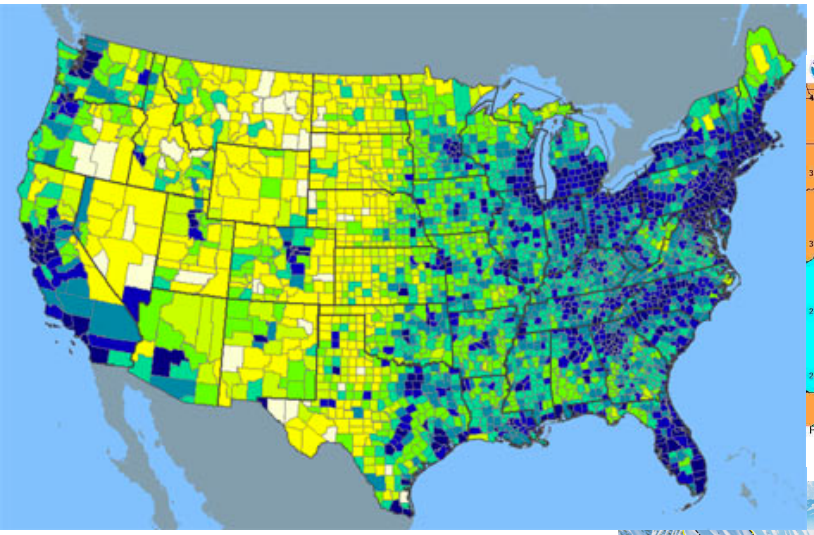


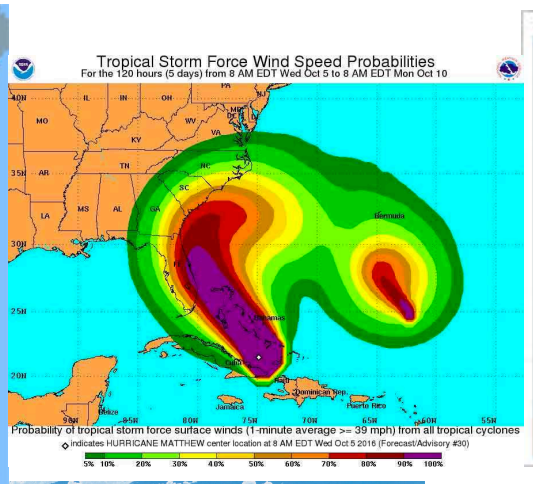


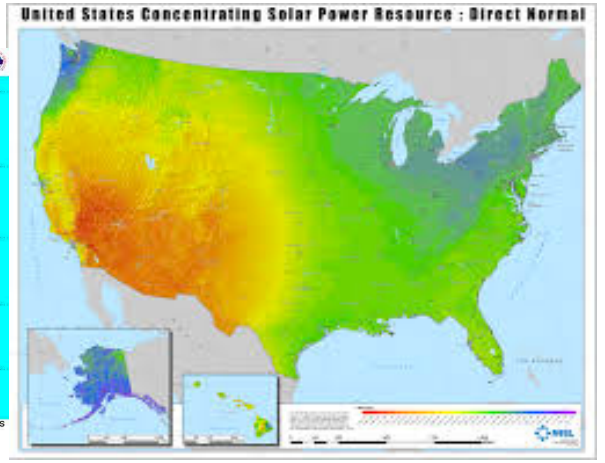


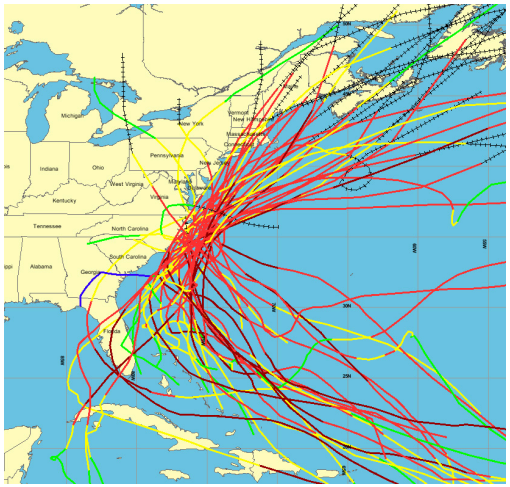
Recall: Module #8

Maps





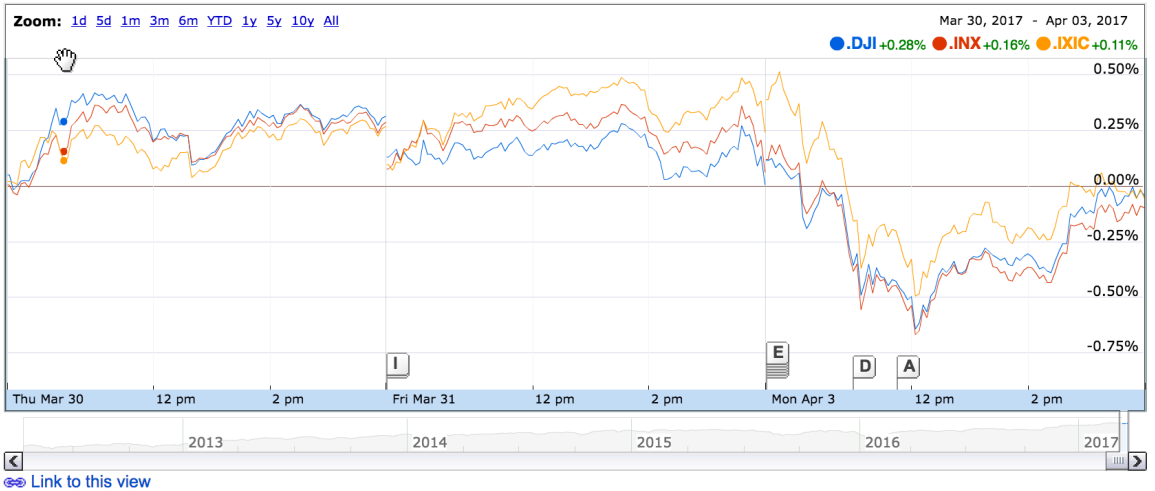




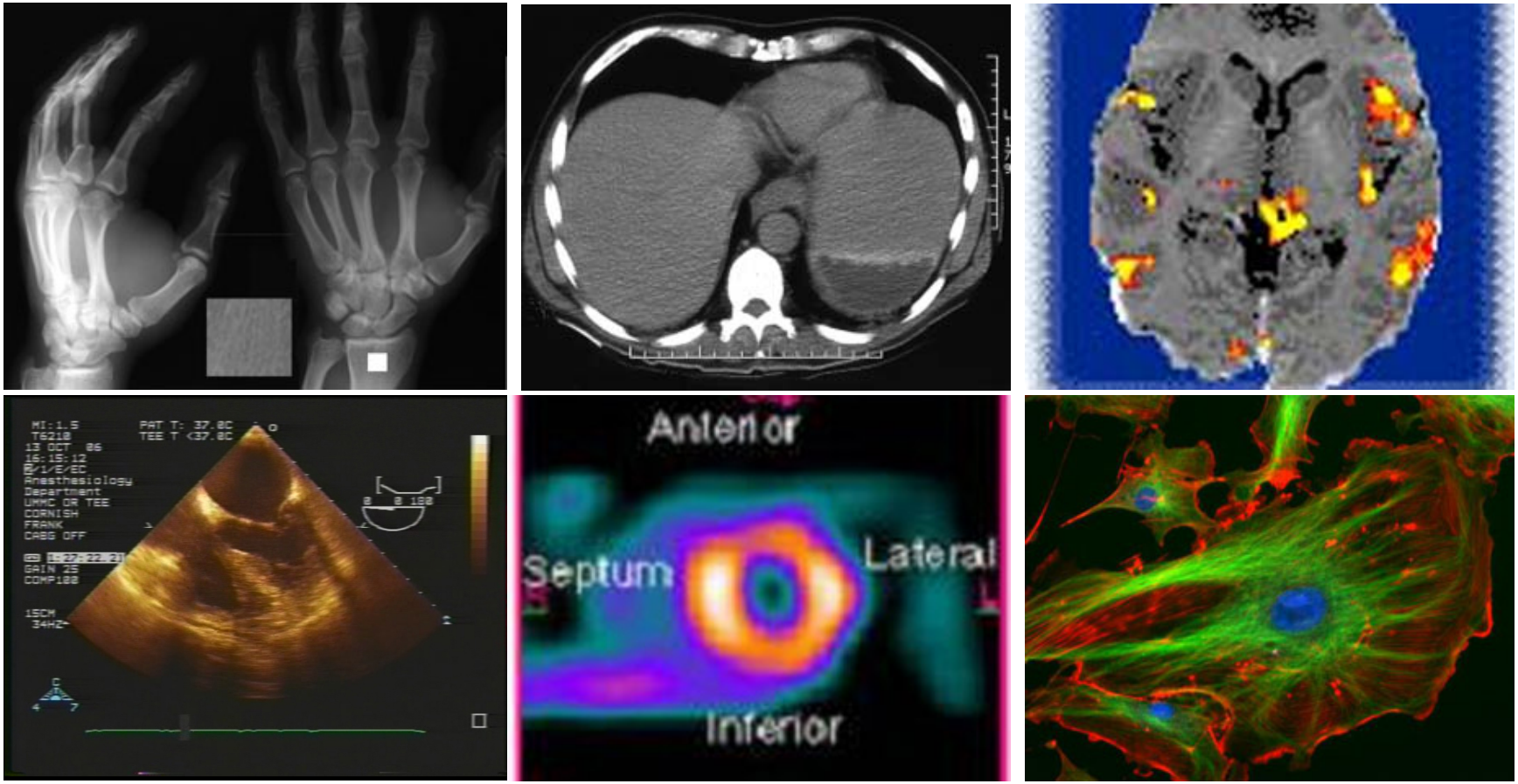
Recall: Module #9

Recall: Module #10

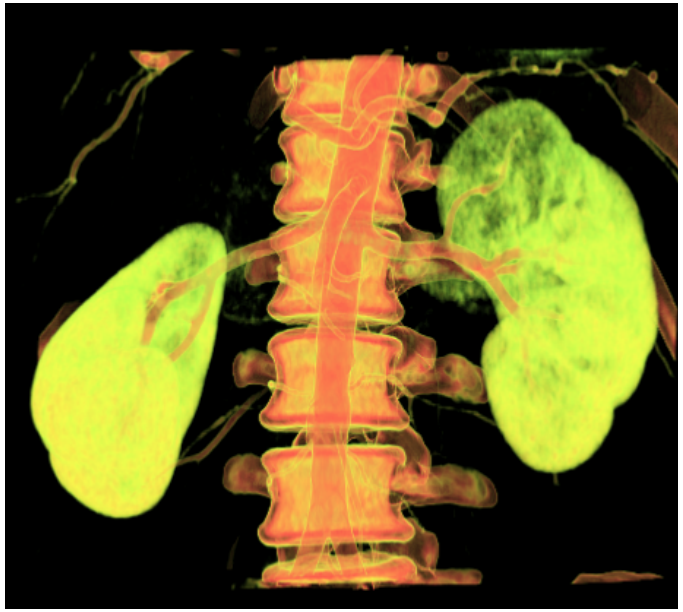
Temporal Visualization



Examples of Medical Images

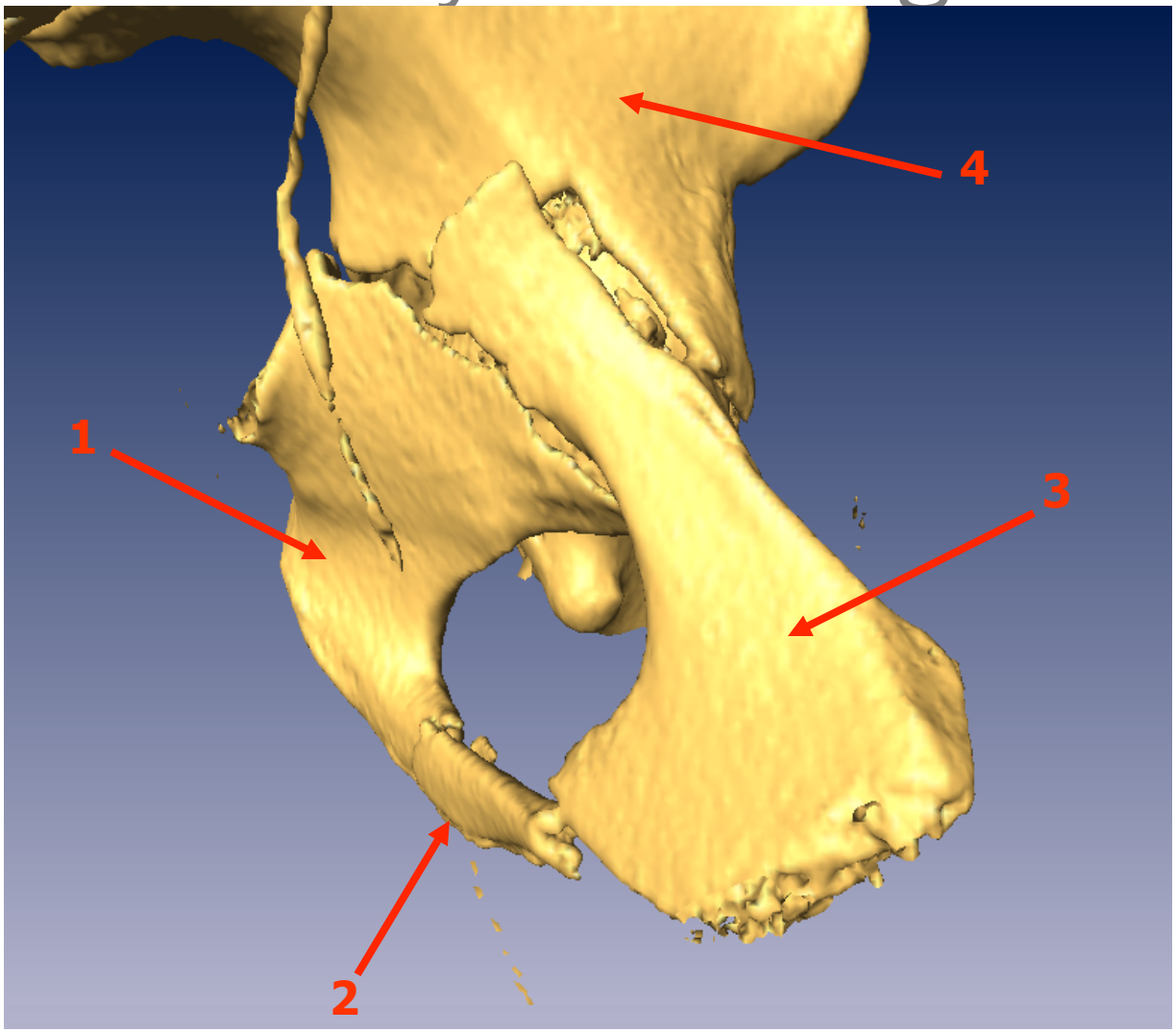


Direct Volume Rendering



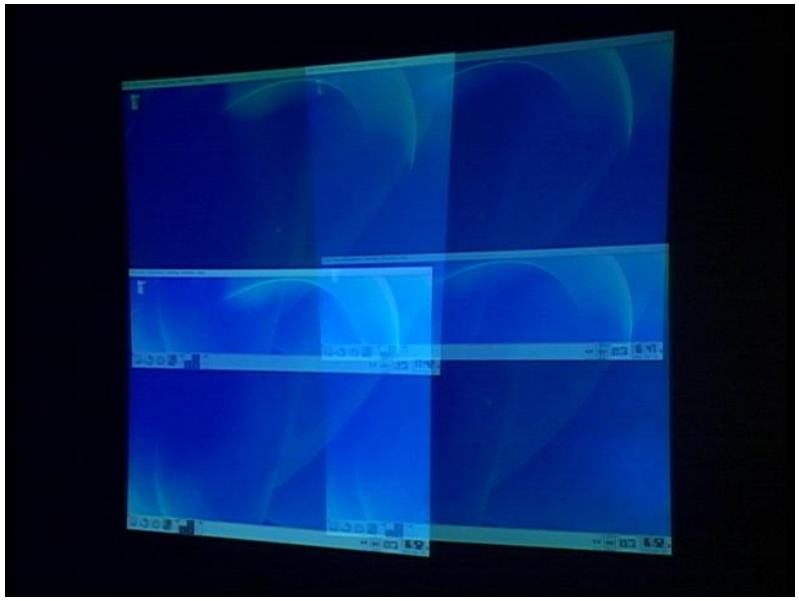
Recall: Module #13

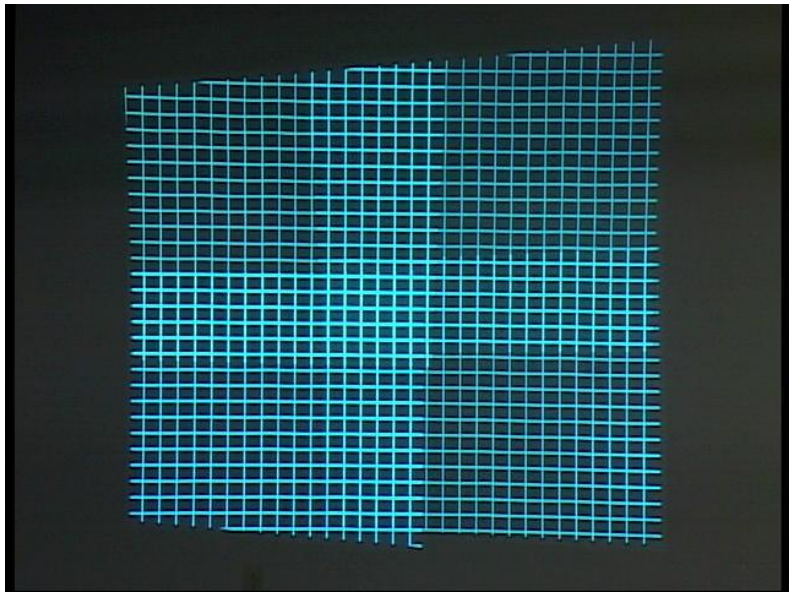
X-Ray Rendering

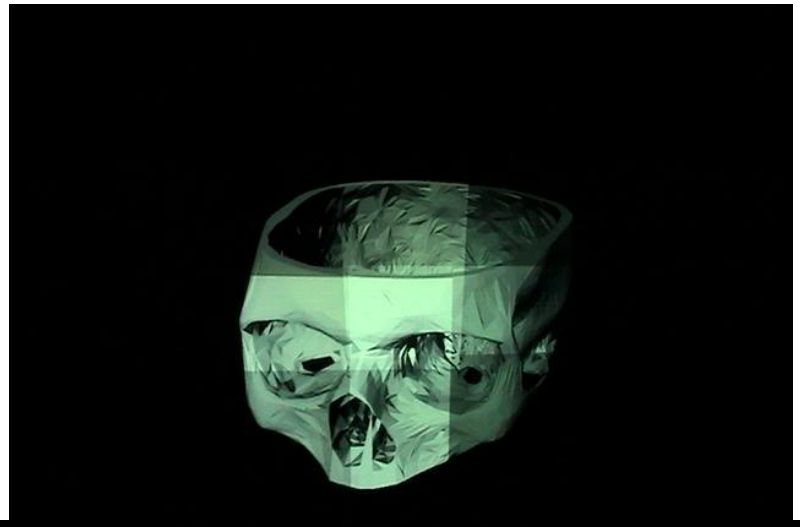


Recall: Module #14

Photometric Correction







But how do we know that the visualization is effective?

Evaluation

- Want to learn what aspects of visualizations or systems “works”
- Want to ensure that methods are improving
- Want to make sure that technique actually helps people and isn’t just “cool”

Evaluation – How?

- How do we evaluate visualizations?
- What do we measure?
- What data do we gather?
- What metrics do we use?
- What evaluation techniques should we use?

Test plan

1. Purpose of the test
2. Problem statement / objectives
3. Participant profile (inclusion/exclusion criteria)
4. Method/technique to be used
5. Test environment
6. Experimenter's role
7. Evaluation measure (qualitative vs. quantitative, subjective vs. objective)
8. Contents of report to be produced

How to Evaluate?

- There are many different forms
  - Qualitative vs. Quantitative
  - Objective vs. Subjective
  - Controlled experiments vs. Interpretive observations

Controlled Experiment

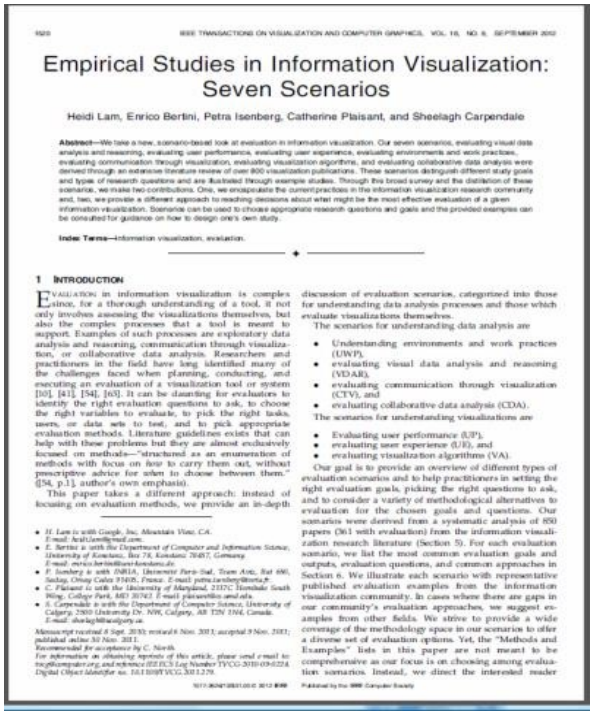
- Good for measuring performance or comparing multiple techniques
- Often quantitative in nature
- What do we measure?
  - Performance, time, errors, …

Subjective Assessment

- Often observational with interview
- Learn people's subjective views on tool
- Was it enjoyable, confusing, fun, difficult, …?
- This kind of personal judgment strongly influence use and adoption, sometimes even overcoming performance deficits

Evaluation Taxonomy

- Lam et al, 2012
- Meta-review: analysis of 850 papers (361 with evaluation)
- Focus on evaluation scenarios



Empirical Studies in Information Visualization: Seven Scenarios

Heidi Lam, Enrico Bertini, Petra Isenberg, Catherine Plaisant, and Sheelagh Carpendale

Abstract—We take a new, scenario-based look at evaluation in information visualization. Our seven scenarios, evaluating visual data analysis and reasoning, evaluating user performance, evaluating user experience, evaluating environments and work practices, evaluating communication through visualization, evaluating visualization algorithms, and evaluating collaborative data analysis were derived through an extensive literature review of over 800 visualization publications. These scenarios distinguish different study goals and types of research questions and are illustrated through example studies. Through this broad survey and the distillation of these scenarios, we make two contributions. One, we encapsulate the current practices in the information visualization research community and, two, we provide a different approach to reaching decisions about what might be the most effective evaluation of a given information visualization. Scenarios can be used to choose appropriate research questions and goals and the provided examples can be consulted for guidance on how to design one's own study.

Index Terms—Information visualization, evaluation.

1 Introduction

Evaluation in information visualization is complex since, for a thorough understanding of a tool, it not only involves assessing the visualizations themselves, but also the complex processes that a tool is meant to support. Examples of such processes are exploratory data analysis and reasoning, communication through visualization, or collaborative data analysis. Researchers and practitioners in the field have long identified many of the challenges faced when planning, conducting, and executing an evaluation of a visualization tool or system [30], [41], [54], [63]. It can be daunting for evaluators to identify the right evaluation questions to ask, to choose the right variables to evaluate, to pick the right tasks, users, or data sets to test, and to pick appropriate evaluation methods. Literature guidelines exists that can help with these problems but they are almost exclusively focused on methods—"structured as an enumeration of methods with focus on *how* to carry them out, without prescriptive advice for *when* to choose between them." ([54, p.1], author's own emphasis).

This paper takes a different approach: instead of focusing on evaluation methods, we provide an in-depth discussion of evaluation scenarios, categorized into those for understanding data analysis processes and those which evaluate visualizations themselves.

The scenarios for understanding data analysis are

- Understanding environments and work practices (UWP),
- evaluating visual data analysis and reasoning (VDAR),
- evaluating communication through visualization (CTV), and
- evaluating collaborative data analysis (CDA).

The scenarios for understanding visualizations are

- Evaluating user performance (UP),
- evaluating user experience (UE), and
- evaluating visualization algorithms (VA).

Our goal is to provide an overview of different types of evaluation scenarios and to help practitioners in setting the right evaluation goals, picking the right questions to ask, and to consider a variety of methodological alternatives to evaluation for the chosen goals and questions. Our scenarios were derived from a systematic analysis of 850 papers (361 with evaluation) from the information visualization research literature (Section 5). For each evaluation scenario, we list the most common evaluation goals and outputs, evaluation questions, and common approaches in Section 6. We illustrate each scenario with representative published evaluation examples from the information visualization community. In cases where there are gaps in our community's evaluation approaches, we suggest examples from other fields. We strive to provide a wide coverage of the methodology space in our scenarios to offer a diverse set of evaluation options. Yet, the "Methods and Examples" lists in this paper are not meant to be comprehensive as our focus is on choosing among evaluation scenarios. Instead, we direct the interested reader

Conclusion

- Validate your visualization system