What is Visualization?

- Is visualization an activity carried out by human beings?
- Is visualization an activity carried out by computer?

**Visualization** is the process of transforming raw data into a displayable image.

**Visualize:**
- “To form a mental image or vision of …”
- “To imagine or remember as if actually seeing.”
Visualization Classification

The purpose of data visualization

➢ To convey information to people quicker

➢ Visualization is a term with many meanings

❖ "Visualization" may mean two things.
  o Use graphical element to display results
  o Use 2 or 3 dimensional graphics to display data.

➢ More possibilities: Interaction, zooming, etc.

Visualization Classification

The purpose of data visualization

➢ To convey information

to people quicker

Data
The purpose of data visualization

- To convey information to people quicker

Cont’d

Visualization Classification

Problem Solving Example

- London cholera epidemic of 1854
- At that time, two hypotheses of causes of cholera:
  - Cholera is related to miasmas concentrated in the swamplike areas of the city
  - Cholera is related to ingestion of contaminated water
- Input Data
  - Locations of deaths due to cholera
  - Locations of water pumps

Dr. Snow’s Cholera Map

Dr. John Snow, medical officer for London, noted that the deaths tended to occur near the Broad Street pump. Closure of the pump coincided with a reduction in cholera.
The purpose of data visualization

- To make our thoughts clear

[Image: The Visible Human Project]

http://www.youtube.com/watch?v=zOPE_q6BGXs&feature=related

Visualization Definition

**Definition of Visualization**: The use of computer-supported, visual representation of data to amplify cognition

**How Visualization Amplifies Cognition**

Different ways that visualizations *could* help amplify cognition:

- By increasing **memory** and processing resources available
- By reducing the amount of time to **search**
- Enhancing the detections of **patterns** and enabling perceptual inference operations
- Aid perceptual **monitoring**
- By encoding information in a **manipulable** medium
Visualization Classification

- Collecting information is no longer a problem, but extracting value from information collections has become progressively more difficult.
- Visualization links the human eye and computer, helping to identify patterns and to extract insights from large amounts of information.
- Visualization technology shows considerable promise from increasing the value of large-scale collections of information.
- Visualization has been used to communicate ideas, to monitor trends implicit in data, and to explore large volumes of data from hypothesis generation.
- Visualization can be classified as information visualization, scientific visualization, and software visualization.

<table>
<thead>
<tr>
<th>Visualization Classification</th>
<th>Information Visualization</th>
<th>Scientific Visualization</th>
<th>Software Visualization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information visualization helps users identify patterns, correlations, or clusters.</td>
<td>Scientific visualization helps understanding physical phenomena in data and visualizing mathematical model plays an essential role</td>
<td>Software visualization helps people understand and use computer software effectively by visualizing the source code data structure, and the changes made to the software</td>
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</tr>
</tbody>
</table>
**Visualization Classification**

**Information Visualization (IV)**

- Visual presentation of abstractions or relationships underlying input data
- Transformation of the symbolic into the geometric
- IV has two goals
  - Communication
    - to communicate a rich **message**
  - Problem solving/ reasoning/ analysis
    - to display large amount of information to facilitate reasoning to uncover **new** facts or relationships
- Limited screen sizes pose a serious challenge for using IV on very large data sets
- Therefore the main task is to pack large information into a simple graphic
  - Highlighting all the required (important) information
- **Creative art?**

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**Visualization Classification**

**Information Visualization (IV)**

- Problem:
  - **HUGE** Datasets: How to understand them?

- Solution
  - Take better advantage of human perceptual system
  - Convert information into a graphical representation.

- Issues
  - How to convert abstract information into graphical form?
  - Do visualizations do a better job than other methods?
Visualization Classification

Information Visualization (IV)

“The use of computer-supported, interactive, visual representations of abstract data to amplify cognition.”

“Tell me and I’ll forget…

Show me and I may remember…

Involve me and I’ll understand.”

Ancient Chinese proverb

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Information Visualization (IV)

- Information visualization helps users identify patterns, correlations, or clusters
  - Structured information
    - Graphical representation to reveal patterns.
    - Integration with various data mining techniques
  - Unstructured Information
    - Need to identify variables and construct visualizable structures. e.g. Maps
Visualization Classification

Goals of Information Visualization

More specifically, visualization should:

- Make large datasets coherent
  (Present huge amounts of information compactly)
- Present information from various viewpoints
- Present information at several levels of detail
  (from overviews to fine structure)
- Support visual comparisons
- Tell stories about the data

Visualization Classification

Scientific Visualization

- Visual modelling of scientific data using computer graphics
- Examples
  - Molecular structural data is hard to understand without visualization
  - Laboratory of Neuro Imaging, UCLA
    - Visualization of brain models
    - http://www.loni.ucla.edu/SVG/
- Focus is
  - On modelling (visually) the input data as close to reality as possible
  - Not on presenting abstractions or relationships from the input data
Visualization Classification

Scientific Visualization

Cont’d

http://www.youtube.com/watch?v=zOPE_q6BGXs&feature=related

Visualization Classification

Scientific Visualization

General Principles

- Maximize comprehension
- Maximize information
- Maximize accuracy
- Minimize clutter
- Maximize interactivity
- Independence of underlying meshing
- Minimize program response time
Software Visualization

Software visualization is the use of the crafts of graphic design and animation with modern human-computer interaction to facilitate both the human understanding and effective use of computer software.

- Program visualization helps programmers manage complex software
  - Visualizing the source code data structure, and the changes made to the software

- Algorithm animation is used to motivate and support the learning of computational algorithms

Types of Software Visualization

- Software System (Program) Visualization
- (Software) Data Visualization
- Algorithm Visualization
- Visual Programming Languages

- Visualization of Software Structures
- Visualization of Source Code
- Visualization of Trace Execute Data
- Visualization of Version Control Data
Text Visualizations

- Text visualizations are generally provided through text editors
- Examples:
  - Simple: Windows Notepad, SimpleText
  - For experts: vi, emacs
  - With underlying language support: Eclipse, UltraEdit, many HTML editors
  - Free-form text documents: Microsoft Word, other word processors

Advantages
- Provide a uniform way of working with many different underlying notations
- Wide range of editors available to suit any need
- Many incorporate advanced ‘content assist’ capabilities
- Many text editors can be extended to handle new languages or integrate new tools easily

Disadvantages
- Increasing complexity as models get bigger
- Do not handle graph structures and complex interrelationships well
**Visualization Classification**

**Classification based on Data Types**

- 1D Linear
- 2D Map
- 3D World
- Multi-dimensional
- Temporal approaches
- Tree
- Network

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**Visualization Classification**

**Visualization of Linear Data**

- Long lists of items
  - Long lists of menu items
  - Software code listings etc.
  - To display contents of a single document
Visualization Classification

Visualizing Map Data

- GIS are used to visualize map data
  - Google maps or Google Earth
    - http://maps.google.com/
- GIS presents layers of information on a geographic map

Visualization Classification

Visualizing 3D Data

- Complex trees and networks are visualized using 3D graphics
- Largely used in scientific visualization
Visualization Classification

Multi-dimensional data

- Example - Records in a relational database
- Two solutions
  - Plot all possible pairs of variables as 2D scatter plots
    - Simple but not helpful to visualize the data as a whole
  - Parallel coordinates
    - A novel way of plotting multi-dimensional data proposed by Alfred Inselberg

Visualization Classification

Visualizing Temporal Data

LifeLines

- To represent information based on temporal order
- Visualization of computerised medical records
- For a patient
  - Horizontal lines (time lines) represent medical problems, hospitalization and medications
  - Icons on these lines represent events such as tests and physician consultations
- All the patient information is fitted into one screen
**Visualization Classification**

**Visualizing Temporal Data**

Cont’d

**LifeLines**

![LifeLines Image]

**Visualization Classification**

**Visualizing Tree Data**

- Examples: Family Trees and file system directory
- Not only the data but the structure of the data also needs to be displayed
- Data sizes grow rapidly with the increase in height of the tree.
- Windows explorer offers visualization of directory structure in a file system
  - All the items in the file system are not visible without scrolling and expanding nodes

![Tree Data Image]
Visualization Classification

Visualizing Network Data

- Examples: Internet, Web, roads etc.
- Network = nodes + links
- Issues with network visualization are similar to issues with trees
  - Both have data + structure
- Layout design should ensure
  - Minimum link crossings
  - Minimum link lengths
  - Minimum link bends

Visualization Classification

Many possible workflows

<table>
<thead>
<tr>
<th>Data</th>
<th>Prepared data</th>
<th>Focus data</th>
<th>Geometric data</th>
<th>Image data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Analysis</td>
<td>Filtering</td>
<td>Mapping</td>
<td>Rendering</td>
</tr>
<tr>
<td>Matlab</td>
<td>VTK</td>
<td>OSG</td>
<td>Maya</td>
<td></td>
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<td>Paraview</td>
<td>Performer</td>
<td>OpenGL</td>
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<td>Mosaicos</td>
<td>DAFFIE</td>
<td>Display Wall</td>
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Visualization Classification

Evaluating Visualizations

- Graphics are cool!
- Because visualizations use graphics, visualizations are often inappropriately judged by their ‘coolness’ factor
- Evaluation of a visualization should be based on
  - Controlled user experiments
  - Real world user experiments
    - Can the users achieve their intended tasks? (performance)
    - What are the error rates in the user performance tests?
    - What is the time taken for achieving their intended task?
    - What is the time taken for learning to read the graphic?
    - How much information can the user retain for longer periods?

Visualization Classification

Evaluating Visualizations (Cont’d)

- User based evaluations are expensive
- Cheaper alternative is to evaluate visualizations using standard data sets with known patterns or messages
- No visualization is perfect for all contexts and tasks
- Evaluation should uncover the conditions under which a visualization works
Visualization Classification

Evaluating Visualizations

Cont’d

• Scope and Purpose
  – What is the visualization for? What can it visualize?
• Basic Type
• Interaction
  – What interaction mechanisms and metaphors are primarily employed by the visualization?
• Fidelity
  – How well/completely does the visualization reflect the information in the underlying model?
• Consistency
  – How well does the visualization use similar representations for similar concepts?

Thank You