A Classic Cycle of Visualization

Goal: know that visualization is an iterative process and a proper visualization only obtained after a few iterations through the so-called cycle of visualization.
Computer Scientists

Data

Requirements

Validation

Domain practitioners

Simulation
Measurement
Records and logs ...

Storage
De-noising/filtering
Down-sampling...

Algorithm development
System design
Data analysis
Data processing
Image composition...

Visualization tool

Visual representation,
Presentation
Use cases
New findings...

Algorithm development
System design
Data analysis
Data processing
Image composition...
Visualization is part of an *iterative* process!
One example of how visualization and analysis can help with engineering design...
Expected Effects

Simulation (Data Acquisition)

Data Enhancement

Visual mapping Rendering

Domain expert interpretations

Various Visualizations
Visualization Pipeline

Goal: know the important steps in the process of visualization for data-driven applications. Again, visualization is an iterative process.
Visualization Pipeline Overview

Data acquisition

Data enhancement

Visualization mapping

Rendering (ND->2D)

Data are generated.
What to collect/save?

Data are (pre-) processed.

Data are mapped to visual primitives, e.g. colors, geometry, etc.

Images are generated.
Visualization Pipeline – Step 1

• **Data acquisition**
  – **Real world** (*measured* with equipment, observed)
    • Measurements and observations, e.g., CT/MRI, GIS (MB), seismic data (GB/TB), Hubble Space Telescope (TB)...
  – **Theoretical world** (*computed*)
    • Mathematical and technical models -> e.g., structural mechanics (MB), CFD simulation (GB-TB/steady, TB and peta-scale for time-series)
  – **Artificial world** (*documented/log...*)
    • Data that is designed, e.g. *surveys* (KB), drawing (MB), game industry (GB)
    • Logs, records, and archives (TB)
What do your emails and posts on social media belong to?
Visualization Pipeline – Step 2

• **Data enhancement**
  - **Filtering** (e.g., smoothing), denoising
  - **Handle incomplete data** (due to equipment failure)
  - **Resampling** (e.g., on a different-resolution grid)
    - Reduce data size (needed for big-data processing)
    - Calibrate different data sources
  - **Data interpolation** (e.g., linear, cubic, basis,...)
    - For continuous data only

  - **Analysis** *(may be separated into a different step)*
    - Data derivation (e.g., gradients, limits, curvature, closed sub-sets, structure,...)
    - **Feature/pattern identification, classification, dimensionality reduction**
Visualization Pipeline – Step 3

**Visualization mapping** = map/encode data to something that is renderable

1. Choose proper **geometric** elements
   - Grids (e.g., the original meshes, images, etc.) – *typically come with the data.*
   - Iso-contour/streamlines/surface calculation (create continuity or discontinuity) – *need to be extracted*
   - Glyphs, icons determination – *need to be constructed, map data to the shape, orientation, size, boundary of the glyphs/icons*
   - Graph-layout calculation (determine geometric locations/coordinates)

2. Choose proper **optical attributes** for the geometric elements as above
   - color, illumination, transparency, texture...
Visualization Pipeline – Step 4

• **Rendering** = image generation with Computer Graphics techniques (make it visible!)
  • View point selection (for user interactions)
  • Visibility calculation (given a view point)
  • Illumination (determine pixel colors)
  • Compositing (combine transparent objects,...)

• Animation (a sequence of static images)
Visualization Pipeline Overview

Data acquisition

Data enhancement

Visualization mapping

Rendering (ND->2D)

User interactions

Re-collect the data to refocus or to refine

Changing view point/parameters
Selecting different attributes

When considering the earlier cycle of visualization
Some Useful Principles

Know the content of the application, and characteristics of the data

Understand or translate what the user is looking for (usually difficult)

Visualization mapping, User Interface

Data stakeholders
Domain experts