

Revitalise Times

Expanding the Scope of Teaching and Learning

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All information in this newsletter was adapted, for the purpose of the REVITALISE program, from the online course Introduction to Scientific Visualization (<http://foxtrot.ncsa.uiuc.edu:8900/public/VISTUT/>) which was derived from Chapter 35, Scientific Visualization, in the *Computer Science and Engineering Handbook* published by [CRC Press](#). This chapter was written by William R. Sherman, Alan B. Craig, M. Pauline Baker, and Colleen Bushell all from NCSA.

Discussion Questions to Ponder:

- What is the difference between a Scientific Visualization and a Scientific Illustration?
- What is the goal of using a Scientific Visualization?
- In what ways could SciViz be used in education?
- Is SciViz applicable to middle and high school classrooms? Why or why not, be prepared to defend your answer ☺! If it is, how is it? Provide examples.
- How does scientific visualization help students meet the learning standards? Think about examples.

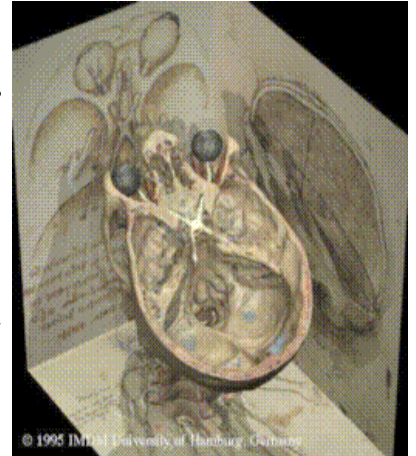
Visualizations Used in Science in the 15th Century!

Visualization didn't begin after the advent of computers. There has always been a need for people to visualize information. At the dawn of human history, humans began spreading pigment on surfaces to convey events that took place, and later to indicate quantities of goods. From that time on, the medium of choice for representing such information has continued to evolve.

In general, visualization efforts required that the creator of the image represent their data by hand. Often this was a painstaking process that involved an artistic ability to mentally envision a pictorial representation of a phenomenon and the manual skills required to transpose the mental image into a suitable medium. The researcher had to be a capable artist and craftsman as

well as a scientist. Usually, the visualizer would render the representation onto paper. However, other media for visualization were used as well.

As the scientific method developed, certain forms of visualization became accepted practices. As a scientist observed a phenomenon, it could be recorded onto an XY plot, representing the relationship between two quantities. A line was often drawn through the data to show the probable continuous pattern. We can now render detailed, data-based visual images by machine to show both quantitative relationships and qualitative overviews. How this process is accomplished, and its value to the scientific method, demand investigation.



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A combination of scientific representations from the fifteenth century and today demonstrates that the craft of visualization has been practiced for many years. (Courtesy of U. Tiede, T. Schiekmann, and K. H. Hohne, University of Hamburg, Germany [Tiede et al. 1996].)

What is SciViz?

Although Visualizations techniques were available to represent scientific data were before the advent of computers, for the purposes of REVITALISE, **scientific visualization** is the use of data-driven computer graphics to aid in the understanding of scientific information. An artist's rendering of a concept is an **illustration**, or more specifically **scientific illustration**.

Is scientific visualization just computer graphics, then? Computer graphics is the medium in which modern visualization is

practiced; however, visualization is more than simply computer graphics. Visualization uses graphics as the tool to represent data and concepts from computer simulations and collected data. Visualization is actually the process of selecting and combining representations and packaging this information in understandable presentations.

Perhaps the field of representing information would be more appropriately labeled **perceptualization**. The goal is, after all, to increase the

information observer's perception of what is taking place in the data.

The use of scientific visualization to represent data is as broad as science itself. It spans the range of scales from the atomic and sub-atomic worlds to the vastness of the universe. It encompasses the study of complicated molecules and the building of complicated machinery. It looks at dynamic systems of living creatures and the dynamics of whole ecosystems. Each of the areas touched by scientific visualization has

representations that are particular to itself. Yet, there is much overlap in the techniques used by visualization developers due to commonality in the underlying mathematical expressions of natural systems.

The representation of the numeric output of simulations has developed from the simple printing of characters on paper, to vector display and plotter graphics, to three-dimensional (3-D) static images to animated 2-D, then 3-D renderings of a simulation over time.

Underlying Principals of SciViz

Scientific Visualization is a means of communication. Sometimes the communication is between the raw numeric data and the researcher, and sometimes it is between the researcher and a group of people. Either way, for effective communication it is important that both the producer and the audience have a grasp on what happens to the information as it passes from numbers to pictures.

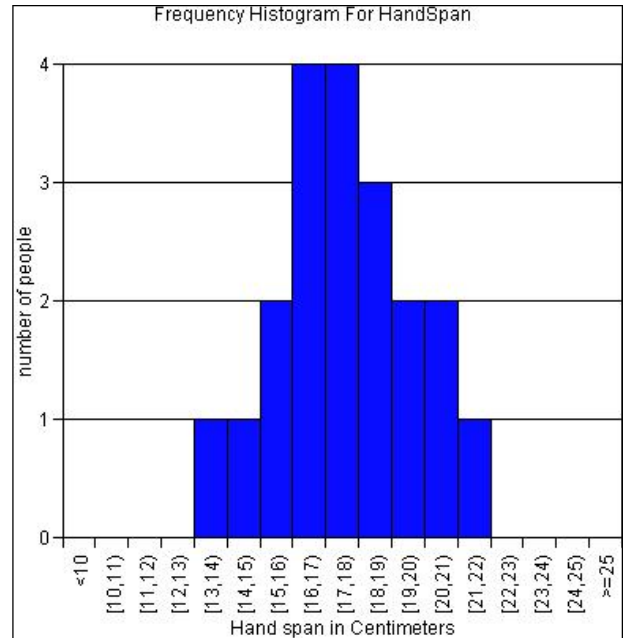
GOALS:

- Readily gain insight into natural process

- Demonstration of a scientific concept
- Uncover patters in data, comparing patterns, discovering new patterns

CONCERNS:

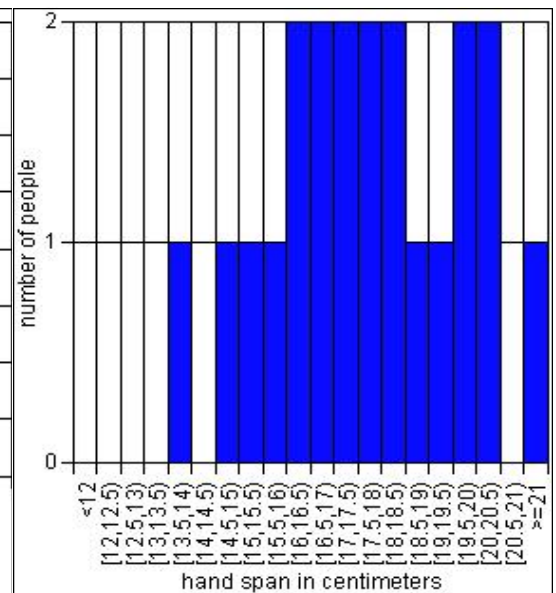
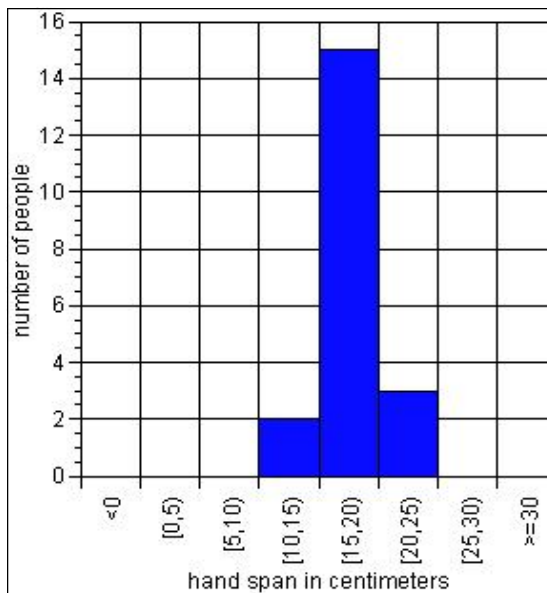
- Transferring from data to images may produce distortion of meaning
- Procedures in producing viz may influence outcome
- Representation choice may hinder understanding
- Accuracy and validity
- Perception of audience



QUESTIONS:

The three histograms all represent the same dataset. Although it could be argued that these histograms are graphical representations and not sciviz's, they do illustrate some of the concerns listed above:

- Why do they each look different?
- Which of the visualization concerns listed in the article need to be addressed? Why?
- What math/science concepts are addressed by this viz?



Analysis Questions:

Biology Questions:

1. Define the term variation in your own words.
2. Describe the pattern of variation in your population.
3. What causes the variation in hand spread that you have observed.
4. Describe a situation in which a larger hand might provide an advantage.
5. Describe a situation in which a smaller hand might provide an advantage.
6. Besides hand size list at least ten other characteristics that vary in human populations. Try to think of some that are internal rather than externally visible.
7. Why is variation an advantage to the population overall?

Scientific Visualization Questions:

1. Why is this called a data driven visualization?
2. What is the effect of the width of the bars?
3. What happens in a frequency histogram if the bin size chosen is too large?
4. What happens in a frequency histogram if the bin size chosen is too small?
5. What effect does sample size have on the bin size that can be chosen?
6. What other types of graphs could be used to visualize this type of data?

Data, Graphs and Questions are available at <http://www2.ncsu.edu/scivis/lessons/variation/varlab2.html>

Representation Techniques

As we saw in the last example, one of the most important elements in creating scientific visualizations is the choice of visual representation, or visual idioms. This section surveys a variety of commonly used visual idioms, each of which are appropriate in different situations. The visual representation is created by combining the elements of form, color, and motion that together show features of the data. This representation can range

from very realistic renderings of real physical objects, to abstract glyphs used to combine many pieces of information into a single idiom.

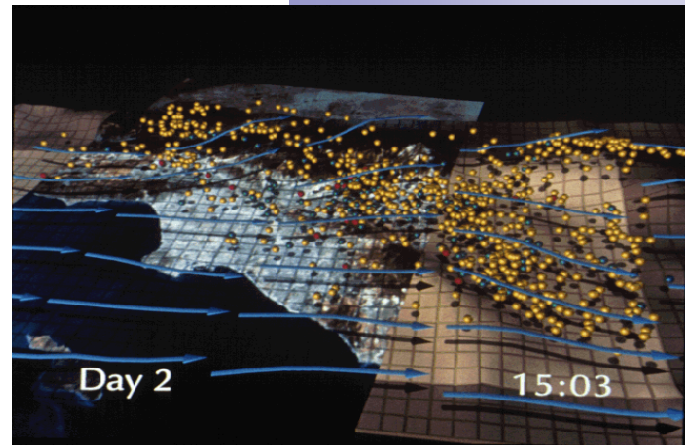
The traditional forms of data display should not be dismissed. Quantitative data can readily be retrieved from such representations as the XY plot, the contour map, and the bar chart.

TECHNIQUES:

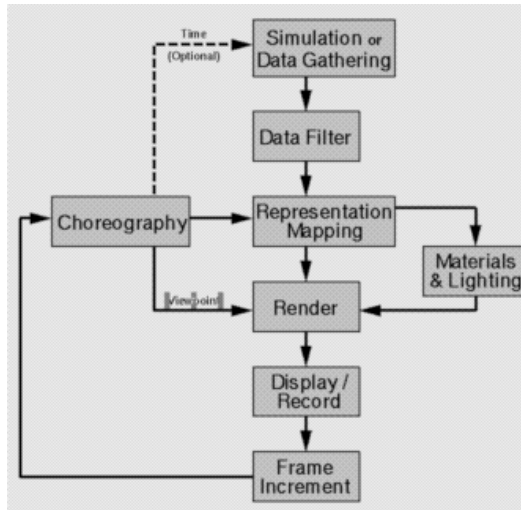
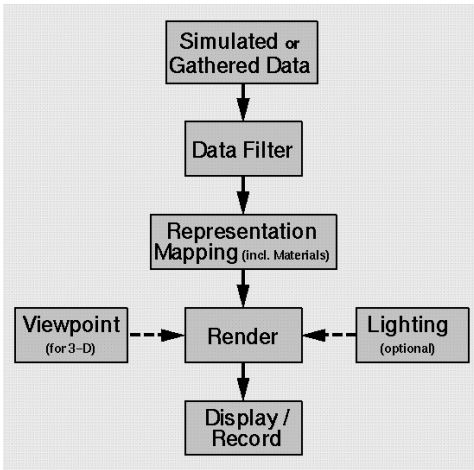
- Realism Continuum

- Color
- Form
- Motion
- Transparency
- Combining Techniques

Upper level winds pushing the smog out of the LA basin. Winds are off shore, pushing more particles. (NCSA)
(LA Basin topography with overlaid landsat image)



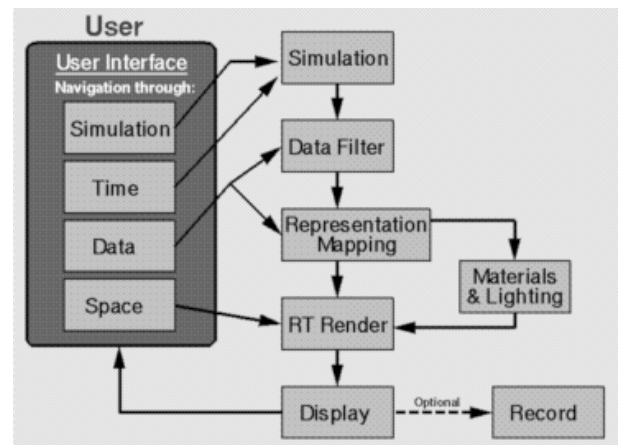
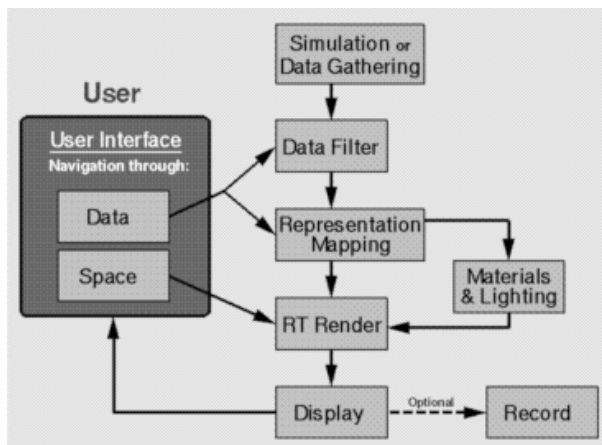
The Visualization Process

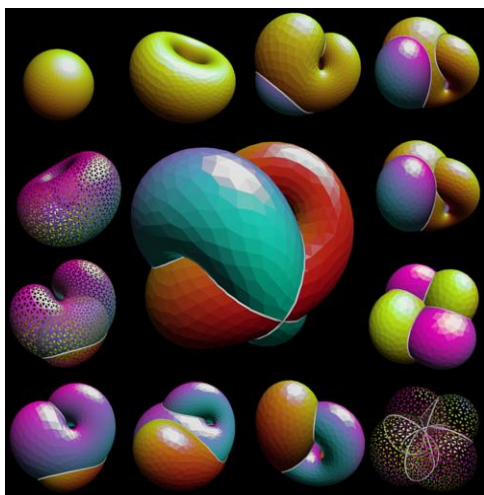


Four types of visualization processes are illustrated:

1. Still Imagery
2. Animation
3. Interaction
4. Interactive Steering (Interaction with user ability to alter the image in realtime)

Question: Which is which?
How can you tell?





The image above is a still image taken from a video created by John Sullivan, George Francis, and Stuart Levy called the Optiverse. This image can be found at <http://new.math.uiuc.edu/optiverse/images.html>

What Does the Scientist Use Today?

With all that is available to the scientist today, what tools are actually used? To be specific, everything. Line graphs, 2-D contours, and 2-D vector plots still provide the basis for closely investigating the results of a simulation. Three-dimensional stills and animations are excellent tools for illustrating concepts. Interactive visualization tools help to find out what's in the dataset and to locate interesting regions that demand close inspection. Animation, while a good tool for presenting the overall contents of a research study, poses problems when it comes to publishing the study.

Uses for scientific visualization include (but are not limited to):

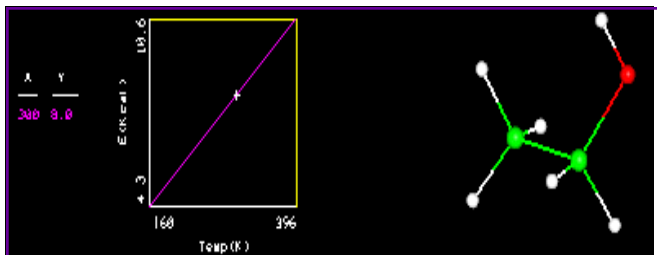
- Residents and physicians from around the world practicing with an interactive video to perform heart surgery using a robotic assisted technique pioneered at East Carolina University
An movie clip of SciViz used in medicine can be accessed at <http://www.osc.edu/~don/CIC/web/Education.mov>
- Professor George Francis from the University of Illinois adapted a computer algorithm to create the image of a mathematical, topological surface that was originally created by a blind mathematician, Bernard Morin, who could only communicate his thoughts and visualizations through formulas. Simulations were run on the image to animate the mathematical transformation which led to applications in math, computer science, and art.

In what other ways not mentioned above might scientists use Scientific Visualization techniques?

In what ways might you use Scientific Visualization techniques?

Where's the Math?

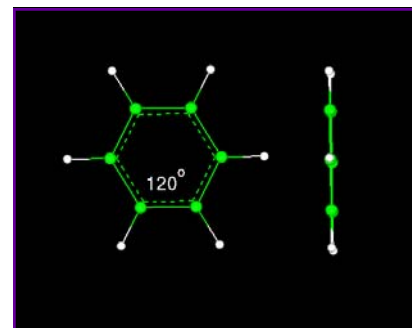
The images and information in this feature are part of MathMol being developed by the NYU/ACF Scientific Visualization Center are available at http://www.nyu.edu/pages/mathmol/quick_tour.html
More activities involving MathMol for K-12 math teachers can be found at <http://www.nyu.edu/pages/mathmol/K12.html>



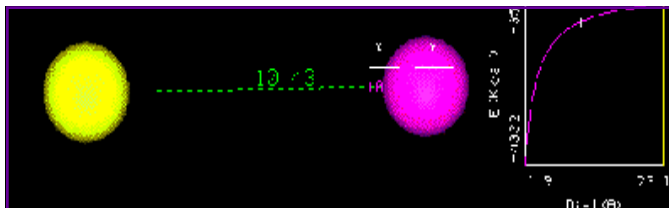
A line is a set of points described by an equation which may be written in the form $y=mx+b$ where the constant m is the slope of the line and b represents its y intercept. As x varies y varies. In the figure above, as the temperature (T) of the system varies, the kinetic energy (E) of the molecule varies. The line describes the equation $E=kT$ where k is the slope of the line.

Figure 1

"I am a math teacher, how does this apply to me"? Consider molecular modeling, many molecular structures have the same shape as familiar space figures. Examine the following images and the captions beneath and determine what 6-12 mathematics classrooms would cover these concepts.



The bond angle formed by 3 consecutive carbon atoms in a benzene ring Figure 3



The set of points which satisfy the equation $y=1/x$ is a hyperbola. As x varies y varies inversely. As x becomes smaller y becomes larger. The relationship between coulombic energy and distance is an inverse relationship. The coulombic energy between the two particles varies with $-1/r$, where r is the distance separating their center of masses.

Figure 2

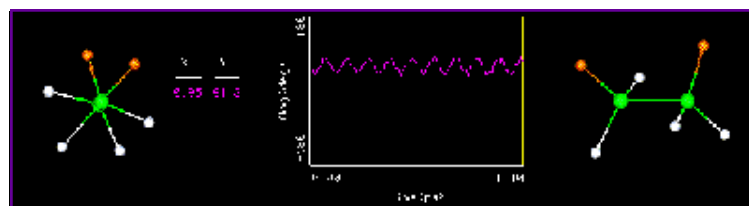


Figure 4 shows that the torsion bond energy of a molecule can be modeled by a periodic function Figure 4