Information Graphics

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Chapter 1

Information Graphics

The Washington Metro subway map

Information graphics or **infographics** are graphic visual representations of information, data or knowledge. These graphics present complex information quickly and clearly, such as in signs, maps, journalism, technical writing, and education. With an information graphic, computer scientists, mathematicians, and statisticians develop and communicate concepts using a single symbol to process information.

Overview

Today information graphics surround us in the media, in published works both pedestrian and scientific, in road signs and manuals. They illustrate information that would be unwieldy in text form, and act as a visual shorthand for everyday concepts such as stop and go.

In newspapers, infographics are commonly used to show the weather, as well as maps and site plans for newsworthy events, and graphs for statistical data. Some books are almost entirely made up of information graphics, such as David Macaulay's The Way Things Work. Although they are used heavily in children's books, they are also common in scientific literature, where they illustrate physical systems, especially ones that cannot be photographed (such as cutaway diagrams, astronomical diagrams, and images of microscopic or sub-microscopic systems).

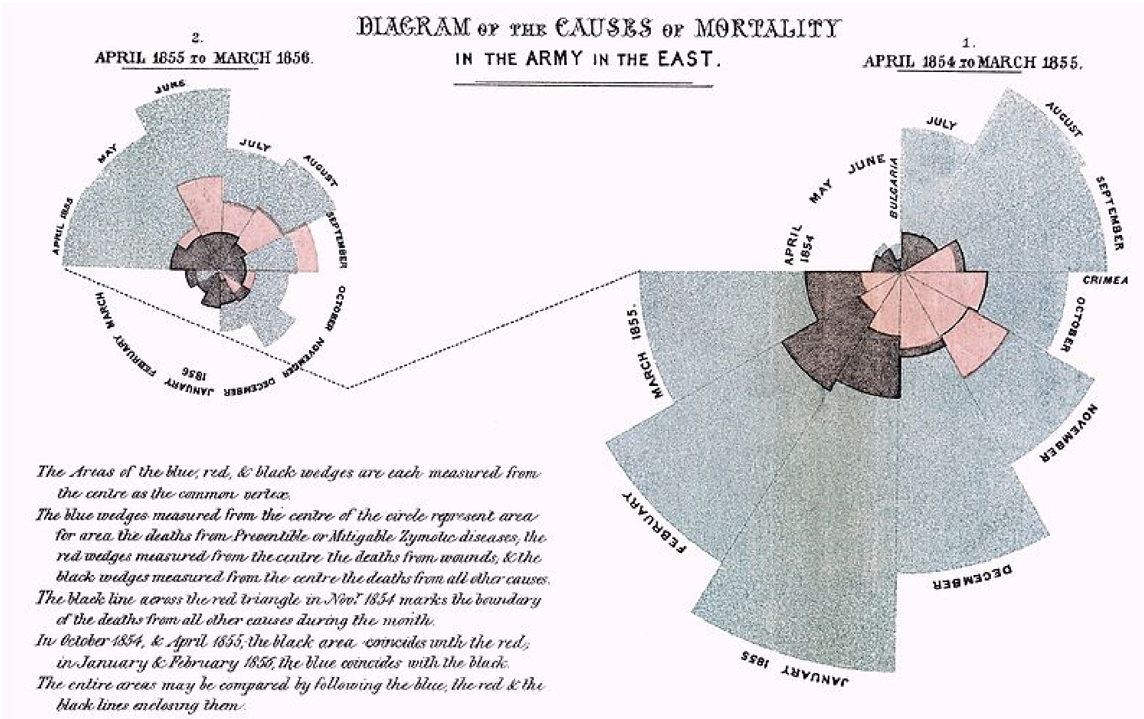
Modern maps, especially route maps for transit systems, use infographic techniques to integrate a variety of information, such as the conceptual layout of the transit network, transfer points, and local landmarks.

Traffic signs and other public signs rely heavily on information graphics, such as stylized human figures (the ubiquitous stick figure), icons and emblems to represent concepts such as yield, caution, and the direction of traffic. Public places such as transit terminals usually have some sort of integrated "signage system" with standardized icons and stylized maps.

Technical manuals make extensive use of diagrams and also common icons to highlight warnings, dangers, and standards certifications.

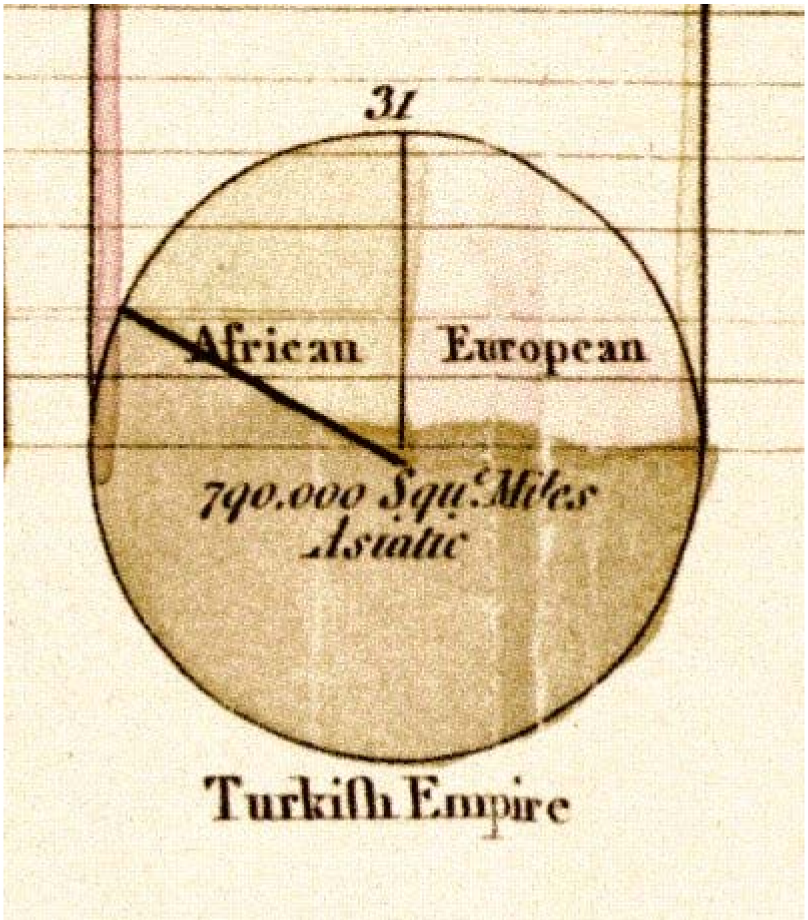
History

Early experiments



Coxcomb chart by Florence Nightingale illustrating causes of mortality during the Crimean War (1857)

In prehistory, early humans created the first information graphics: cave paintings and later maps. Map-making began several millennia before writing, and the map at Çatalhöyük dates from around 7500 BCE. Later icons were used to keep records of cattle and stock. The Indians of Mesoamerica used imagery to depict the journeys of past generations. Illegible on their own, they served as a supportive element to memory and storytelling.



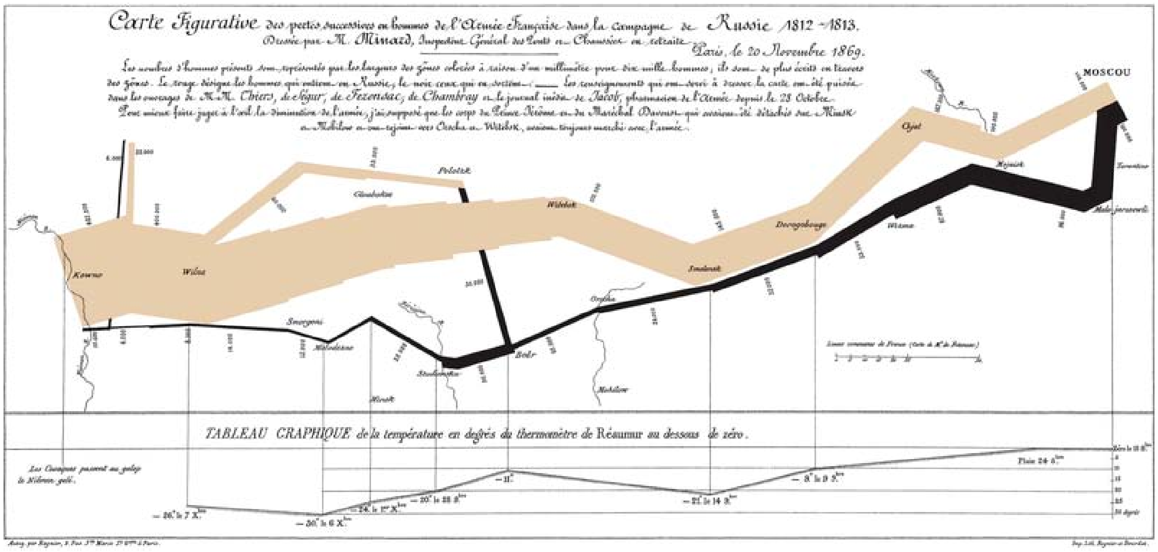
Pie chart from Playfair's *Statistical Breviary* (1801)

In 1626 Christopher Scheiner published the *Rosa Ursina sive Sol* which used a variety of graphics to reveal his astronomical research on the sun. He used a series of images to explain the rotation of the sun over time (by tracking sunspots).

In 1786, William Playfair published the first data graphs in his book *The Commercial and Political Atlas*. The book is filled with statistical graphs, bar charts, line graphs and histograms, that represent the economy of 18th century England. In 1801 Playfair introduced the first area chart and pie chart in *Statistical Breviary*.

In 1857, English nurse Florence Nightingale used information graphics persuading Queen Victoria to improve conditions in military hospitals, principally the Coxcomb chart, a combination of stacked bar and pie charts, depicting the number and causes of deaths during each month of the Crimean War.

1861 saw the release of a seminal information graphic on the subject of Napoleon's disastrous march on Moscow.



Charles Minard's information graphic of Napoleon's invasion of Russia

The creator, Charles Joseph Minard, captured four different changing variables that contributed to the failure, in a single two-dimensional image: the army's direction as they traveled, the location the troops passed through, the size of the army as troops died from hunger and wounds, and the freezing temperatures they experienced.

James Joseph Sylvester introduced the term "graph" in 1878 and published a set of diagrams showing the relationship between chemical bonds and mathematical properties. These were also the first mathematic graphs.

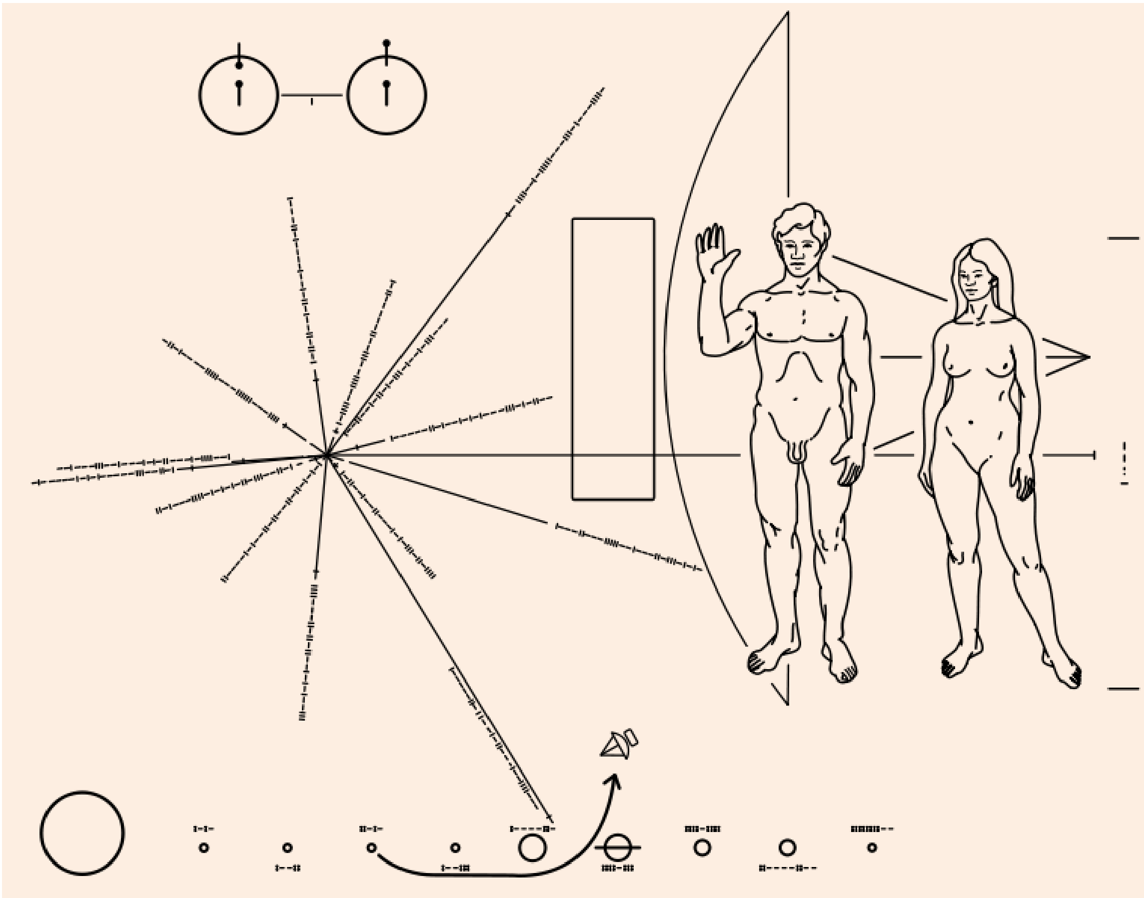
The development of a visual language in the 20th century

In 1936 Otto Neurath introduced a system of pictographs intended to function as an international visual or picture language. Isotype included a set of stylized human figures which were the basis for the ubiquitous modern stick figures.

In 1942 Isidore Isou published the Lettrist manifesto.

In 1958 Stephen Toulmin proposed a graphical argument model that became influential in argumentation theory and its applications.

The 1972 Munich Olympics were the venue for Otl Aicher to introduce a new set of pictograms that proved to be extremely popular, and influenced the ubiquitous modern stick figures used in public signs.



The Pioneer Plaque

Also in 1972 the Pioneer Plaque was launched into space with the Pioneer 10 probe. Inscribed into the plaque was an information graphic intended as a kind of interstellar message in a bottle, designed by Carl Sagan and Frank Drake. The message is unique in that it is intended to be understood by extraterrestrial beings who would share no common language with humans. It depicts a picture of a man and a woman standing in front of a simplified silhouette of the probe in order to give a sense of scale. It also contains a map locating the sun relative to a number of pulsars, and a simplified depiction of the solar system, with the probe's path from earth into outer space shown with an arrow.

2005-Present day. The information graphic trend starts to become popular amongst the larger social media aggregation sites Digg Reddit. The data contained in modern info graphics tends to be research centric and attributed to multiple sources. Information graphics of note are the Infographic Resume of Michael and the more modern UK Government Spending live infographic

With the popularity of the information graphics continuing to grow, see google search trends, many internet marketing companies use this to generate viral content that web users will share freely.

Information graphics subjects

Visual devices

Information graphics are visual devices intended to communicate complex information quickly and clearly. The devices include, according to Doug Newsom (2004), charts, diagrams, graphs, tables, maps and lists. Among the most common devices are horizontal bar charts, vertical column charts, and round or oval pie charts, that can summarize a lot of statistical information. Diagrams can be used to show how a system works, and may be an organizational chart that shows lines of authority, or a systems flowchart that shows sequential movement. Illustrated graphics use images to related data. The snapshots features used every day by *USA Today* are good examples of this technique. Tables are commonly used and may contain lots of numbers. Modern interactive maps and bulleted numbers are also infographic devices.

Elements of information graphics

The basic material of an information graphic is the data, information, or knowledge that the graphic presents. In the case of data, the creator may make use of automated tools such as graphing software to represent the data in the form of lines, boxes, arrows, and various symbols and pictograms. The information graphic might also feature a key which defines the visual elements in plain English. A scale and labels are also common. The elements of an info graphic do not have to be an exact or realistic representation of the data, but can be a simplified version.

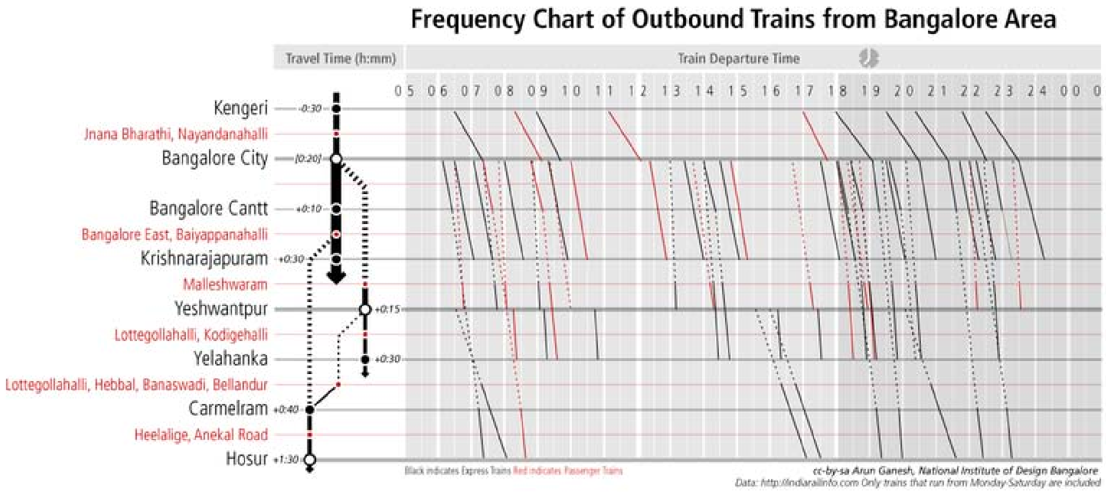
Interpreting information graphics

Many information graphics are specialised forms of depiction that represent their content in sophisticated and often abstract ways. In order to interpret the meaning of these graphics appropriately, the viewer requires a suitable level of graphicacy. In many cases, the required graphicacy involves comprehension skills that are learned rather than innate. At a fundamental level, the skills of decoding individual graphic signs and symbols must be acquired before sense can be made of an information graphic as a whole. However, knowledge of the conventions for distributing and arranging these individual components is also necessary for the building of understanding.

Interpreting with a common visual language

In contrast to the above, many other forms of infographics take advantage of innate visual language that is largely universal. The disciplined use of the color red, for emphasis, on an otherwise muted design, demands attention in a primal way even children understand. Many maps, interfaces, dials and gauges on instruments and machinery use icons that are easy to grasp and speed understanding for safe operation. The use of a rabbit and a turtle icon to represent fast and slow, respectively, is one such successful use by the John Deere company on the throttle of their tractors.

Modern practitioners



Visualization of the frequency of outbound trains from Bangalore, India

A statistician and sculptor, Edward Tufte has written a series of highly regarded books on the subject of information graphics. Tufte also delivers lectures and workshops on a regular basis. He describes the process of incorporating many dimensions of information into a two-dimensional image as 'escaping flatland' (alluding to the 2-dimensional world of the Victorian novella *Flatland*).

The work done by Peter Sullivan for The Sunday Times in the 1970s, 80s and 90s, was one of the key factors in encouraging newspapers to use more graphics. Sullivan is also one of the few authors who have written about information graphics in newspapers. Likewise the staff artists at USA Today, the colorful United States newspaper that debuted in 1982, firmly established the philosophy of using graphics to make information easier to comprehend. The paper received criticism for oversimplifying news and sometimes creating infographics that emphasized entertainment over respect for content and data, sometimes referred to as chartjunk. While some critics deride the graphic qualities of this work, its role in establishing infographics as a practice cannot be ignored.

Nigel Holmes is an established commercial creator of what he calls "explanation graphics". His works deal not only with the visual display of information but also of knowledge – how to do things. He created graphics for *Time* magazine for 16 years, and is the author of several books on the subject.

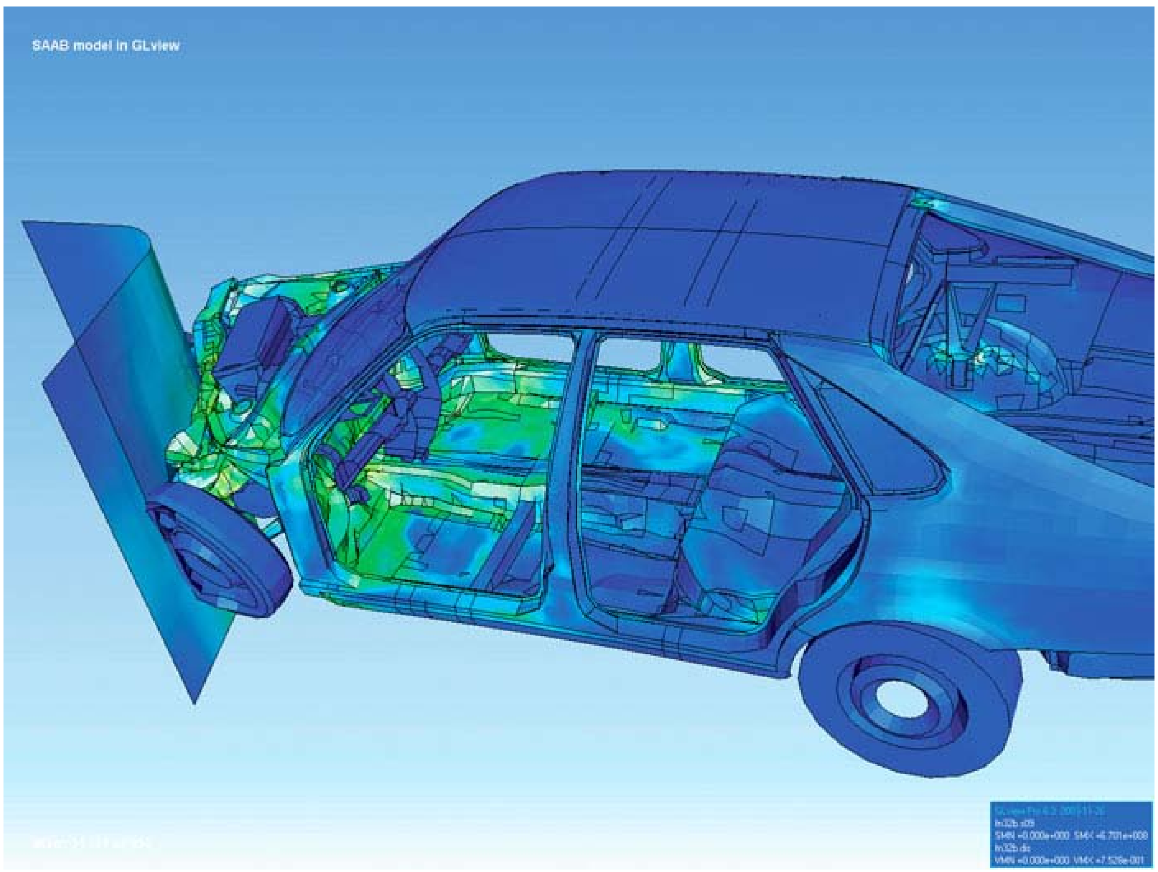
Close and strongly related to the field of information graphics, is information design. Actually, making infographics is a certain discipline within the information design world. Author and founder of the TED, Richard Saul Wurman, is considered the originator of the phrase, "information architect", and many of his books, such as *Information Anxiety*, helped propel the phrase, "information design", from a concept to an actual job category.

While the art form of infographics has its roots in print, by the year 2000, the use of Adobe Flash-based animations on the web has allowed to make mapping solutions and other products famous and addictive by using many key best practices of infographics.

Likewise, their use in television is relatively recent, for in 2002, two Norwegian musicians of Röyksopp issued a music video for their song Remind Me that was completely made from animated infographics. In 2004, a television commercial for the French energy company Areva used similar animated infographics and both of these videos and their high visibility have helped the corporate world recognize the value in using this form of visual language to describe complex information efficiently.

Chapter 2

Visualization (Computer Graphics)



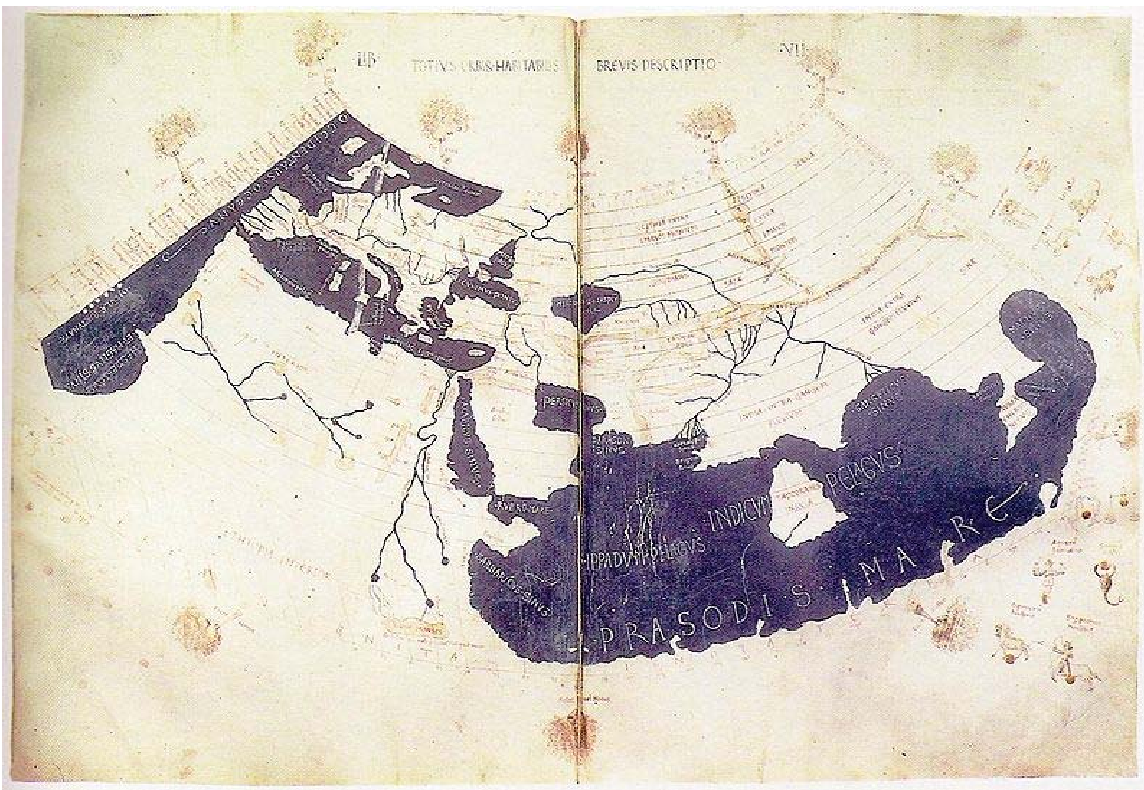
Visualization of how a car deforms in an asymmetrical crash using finite element analysis.

Visualization is any technique for creating images, diagrams, or animations to communicate a message. Visualization through visual imagery has been an effective way to communicate both abstract and concrete ideas since the dawn of man. Examples from history include cave paintings, Egyptian hieroglyphs, Greek geometry, and Leonardo da

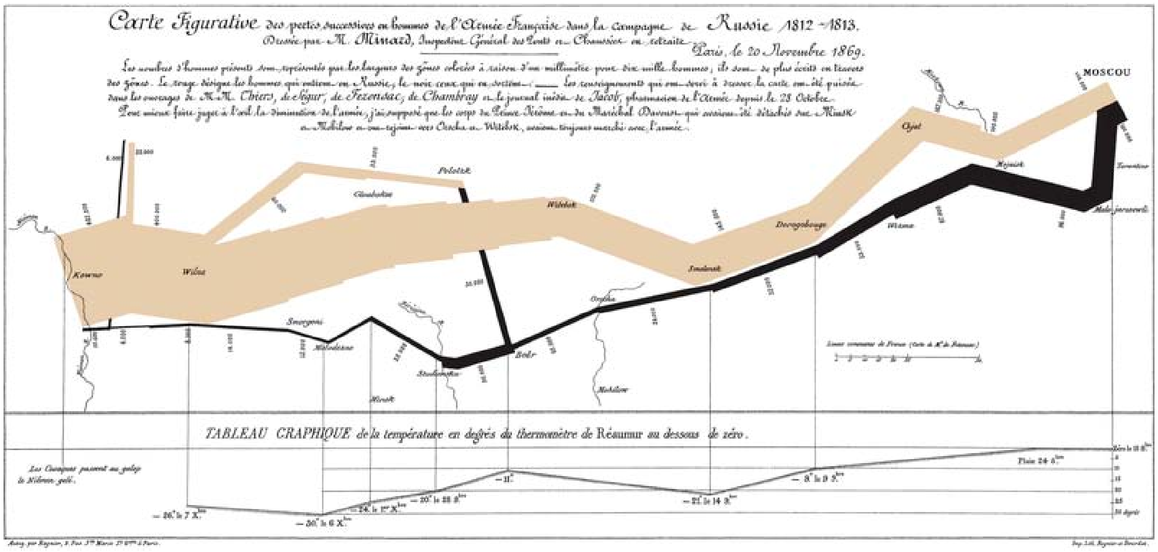
Vinci's revolutionary methods of technical drawing for engineering and scientific purposes.

Visualization today has ever-expanding applications in science, education, engineering (e.g. product visualization), interactive multimedia, medicine, etc. Typical of a visualization application is the field of computer graphics. The invention of computer graphics may be the most important development in visualization since the invention of central perspective in the Renaissance period. The development of animation also helped advance visualization.

Overview



The Ptolemy world map, reconstituted from Ptolemy's *Geographia* (circa 150), indicating the countries of "Serica" and "Sinae" (China) at the extreme right, beyond the island of "Taprobane" (Sri Lanka, oversized) and the "Aurea Chersonesus" (Southeast Asian peninsula).



Charles Minard's information graphic of Napoleon's march

The use of visualization to present information is not a new phenomenon. It has been used in maps, scientific drawings, and data plots for over a thousand years. Examples from cartography include Ptolemy's Geographia (2nd Century AD), a map of China (1137 AD), and Minard's map (1861) of Napoleon's invasion of Russia half a century earlier. Most of the concepts learned in devising these images carry over in a straight forward manner to computer visualization. Edward Tufte has written two critically acclaimed books that explain many of these principles.

Computer graphics has from its beginning been used to study scientific problems. However, in its early days the lack of graphics power often limited its usefulness. The recent emphasis on visualization started in 1987 with the special issue of Computer Graphics on Visualization in Scientific Computing. Since then there have been several conferences and workshops, co-sponsored by the IEEE Computer Society and ACM SIGGRAPH, devoted to the general topic, and special areas in the field, for example volume visualization.

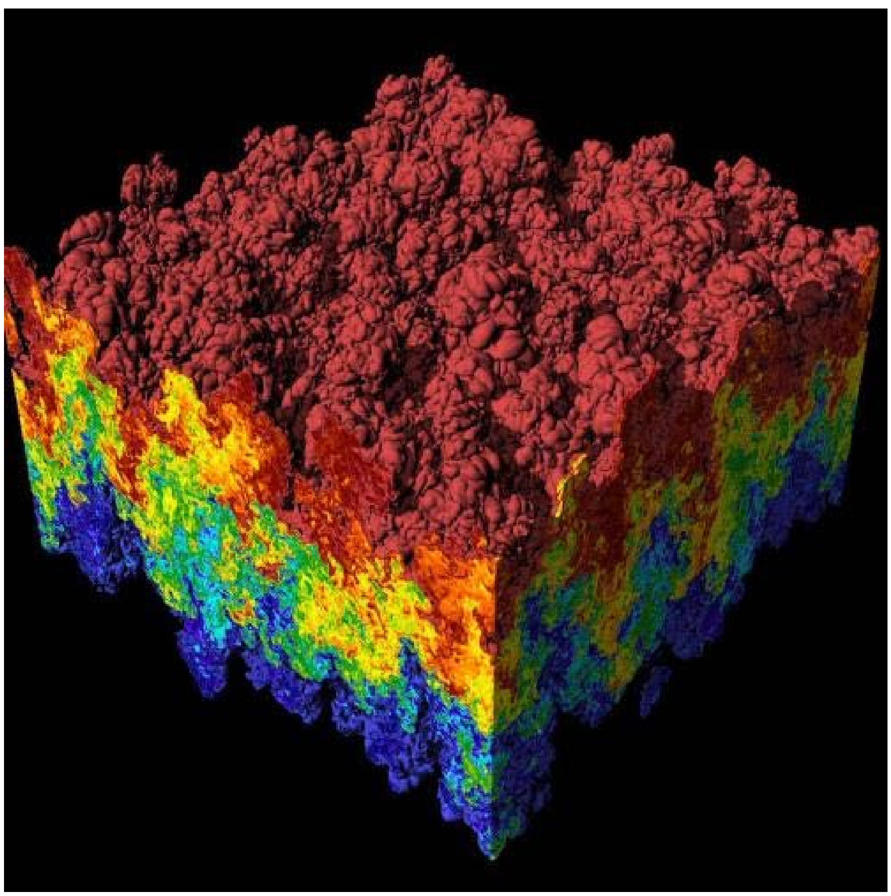
Most people are familiar with the digital animations produced to present meteorological data during weather reports on television, though few can distinguish between those models of reality and the satellite photos that are also shown on such programs. TV also offers scientific visualizations when it shows computer drawn and animated reconstructions of road or airplane accidents. Some of the most popular examples of scientific visualizations are computer-generated images that show real spacecraft in action, out in the void far beyond Earth, or on other planets. Dynamic forms of visualization, such as educational animation or timelines, have the potential to enhance learning about systems that change over time.

Apart from the distinction between interactive visualizations and animation, the most useful categorization is probably between abstract and model-based scientific visualizations. The abstract visualizations show completely conceptual constructs in 2D or 3D. These generated shapes are completely arbitrary. The model-based visualizations either place overlays of data on real or digitally constructed images of reality, or they make a digital construction of a real object directly from the scientific data.

Scientific visualization is usually done with specialized software, though there are a few exceptions, noted below. Some of these specialized programs have been released as Open source software, having very often its origins in universities, within an academic environment where sharing software tools and giving access to the source code is common. There are also many proprietary software packages of scientific visualization tools.

Models and frameworks for building visualizations include the data flow models popularized by systems such as AVS, IRIS Explorer, and VTK toolkit, and data state models in spreadsheet systems such as the Spreadsheet for Visualization and Spreadsheet for Images.

Applications of visualization



A scientific visualization of an extremely large simulation of a Raleigh-Taylor instability caused by two mixing fluids.

As a subject in computer science, **data visualization** or scientific visualization is the use of interactive, sensory representations, typically visual, of abstract data to reinforce cognition, hypothesis building and reasoning.

Scientific visualization

Scientific visualization is the transformation, selection or representation of data from simulations or experiments, with an implicit or explicit geometric structure, to allow the exploration, analysis and understanding of the data. It's a very important part of visualization and maybe the first one, as the visualization of experiments and phenomena is as old as Science itself. Traditional areas of Scientific Visualization are Flow Visualization, medical visualization, astrophysical visualization and chemical visualization. There are several different techniques to visualize scientific data, with isosurface reconstruction and direct volume rendering being the more common.

Educational visualization

Educational visualization is using a simulation normally created on a computer to create an image of something so it can be taught about. This is very useful when teaching about a topic which is difficult to otherwise see, for example, atomic structure, because atoms are far too small to be studied easily without expensive and difficult to use scientific equipment. It can also be used to view past events, such as looking at dinosaurs, or looking at things that are difficult or fragile to look at in reality like the human skeleton, without causing physical or mental harm to a subjective volunteer or cadaver.

Information visualization

Information visualization concentrates on the use of computer-supported tools to explore large amount of abstract data. The term "information visualization" was originally coined by the User Interface Research Group at Xerox PARC and included Dr. Jock Mackinlay. Practical application of information visualization in computer programs involves selecting, transforming and representing abstract data in a form that facilitates human interaction for exploration and understanding. Important aspects of information visualization are dynamics of visual representation and the interactivity. Strong techniques enable the user to modify the visualization in real-time, thus affording unparalleled perception of patterns and structural relations in the abstract data in question.

Knowledge visualization

The use of visual representations to transfer knowledge between at least two persons aims to improve the transfer of knowledge by using computer and non-computer based visualization methods complementarily. Examples of such visual formats are sketches, diagrams, images, objects, interactive visualizations, information visualization applications and imaginary visualizations as in stories. While information visualization concentrates on the use of computer-supported tools to derive new insights, knowledge visualization focuses on transferring insights and creating new knowledge in groups. Beyond the mere transfer of facts, knowledge visualization aims to further transfer insights, experiences, attitudes, values, expectations, perspectives, opinions, and predictions by using various complementary visualizations.

Product Visualization

Product Visualization involves visualization software technology for the viewing and manipulation of 3D models, technical drawing and other related documentation of manufactured components and large assemblies of products. It is a key part of Product Lifecycle Management. Product visualization software typically provides high levels of photorealism so that a product can be viewed before it is actually manufactured. This supports functions ranging from design and styling to sales and marketing. *Technical visualization* is an important aspect of product development. Originally technical drawings were made by hand, but with the rise of advanced computer graphics the drawing board has been replaced by computer-aided design (CAD). CAD-drawings and models have several advantages over hand-made drawings such as the possibility of 3-D modeling, rapid prototyping and simulation

Visual communication

Visual communication is the communication of ideas through the visual display of information. Primarily associated with two dimensional images, it includes: alphanumerics, art, signs, and electronic resources. Recent research in the field has focused on web design and graphically-oriented usability.

Visual analytics

Visual analytics focuses on human interaction with visualization systems as part of a larger process of data analysis. Visual analytics has been defined as "the science of analytical reasoning supported by the interactive visual interface" .

Its focus is on human information discourse (interaction) within massive, dynamically changing information spaces. Visual analytics research concentrates on support for perceptual and cognitive operations that enable users to detect the expected and discover the unexpected in complex information spaces.

Technologies resulting from visual analytics find their application in almost all fields, but are being driven by critical needs (and funding) in biology and national security.

Visualization techniques

The following are examples of some common visualization techniques:

- Constructing isosurfaces
- direct volume rendering

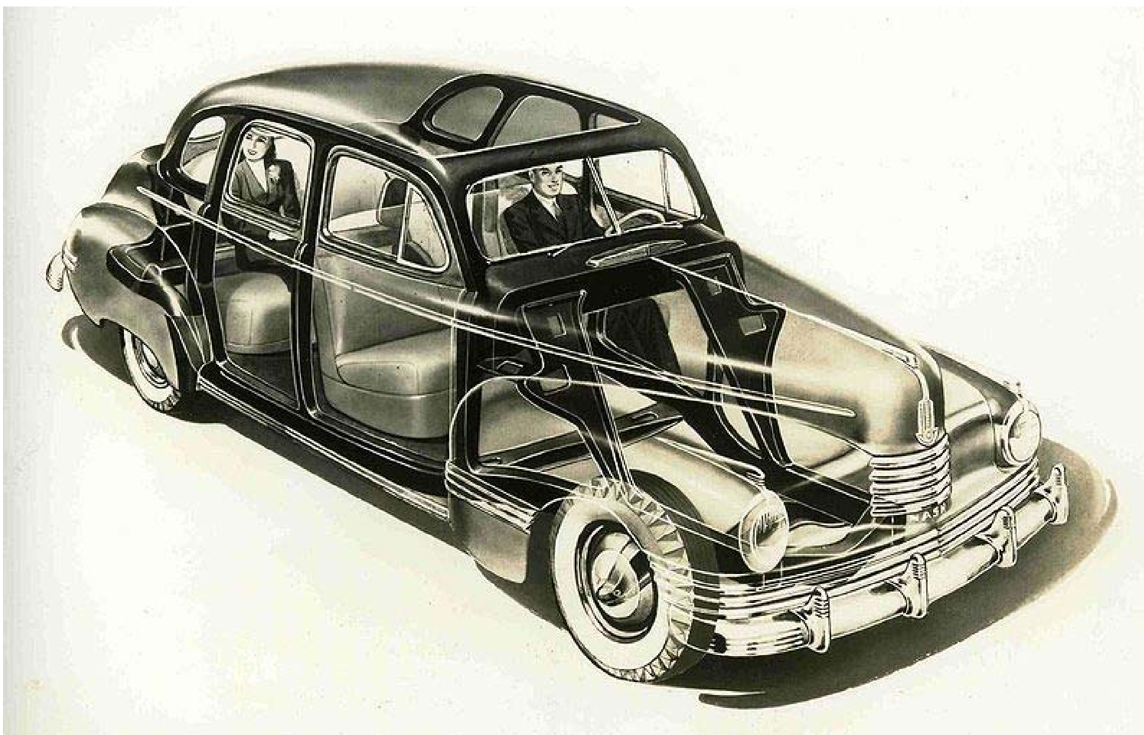
- Streamlines, streaklines, and pathlines
- table, matrix
- charts (pie chart, bar chart, histogram, function graph, scatter plot, etc.)
- graphs (tree diagram, network diagram, flowchart, existential graph, etc.)
- Maps
- parallel coordinates - a visualization technique aimed at multidimensional data
- treemap - a visualization technique aimed at hierarchical data
- Venn diagram
- Timeline
- Euler diagram
- Chernoff face
- Hyperbolic trees
- brushing and linking
- Cluster diagram or dendrogram
- Ordinogram

Related research areas

- Statistics, statistical package, multivariate statistics
- Forecasting, technical analysis
- Data Mining, also known as knowledge-discovery in databases (KDD)
- GeoVisualization, short for Geographic Visualization
- Graph Drawing
- Scientific modeling
- Cave Automatic Virtual Environment
- Morphological Modeling
- Information graphics
- Knowledge management
- Knowledge transfer
- Concept maps
- Morphological analysis
- Formal concept analysis
- Conceptual graphs

Chapter 3

Cutaway Drawing

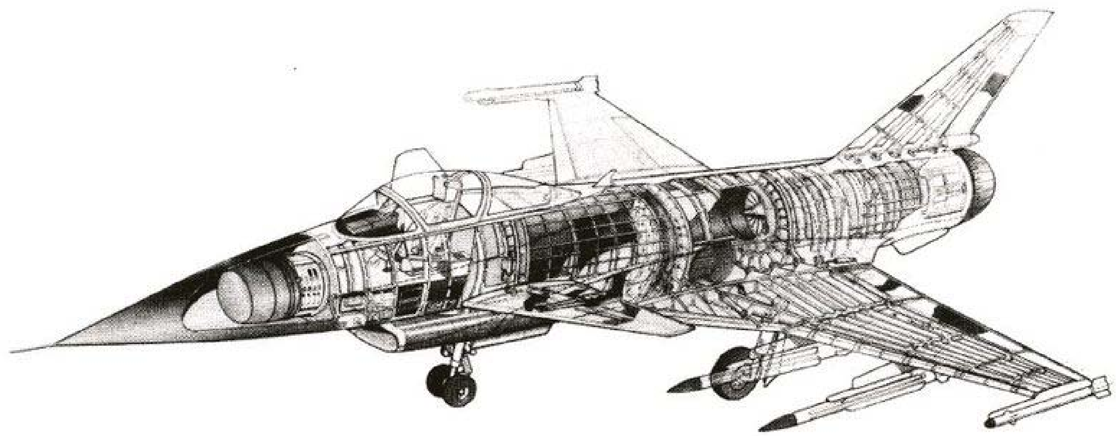


A cutaway drawing of a 1942 Nash Ambassador

A **cutaway drawing**, also called a *cutaway diagram* is a 3D graphics, drawing, diagram and or illustration, in which surface elements a three-dimensional model are selectively removed, to make internal features visible, but without sacrificing the outer context entirely.

Overview

According to Diepstraten et al. (2003) "the purpose of a cutaway drawing is to allow the viewer to have a look into an otherwise solid opaque object. Instead of letting the inner object shine through the surrounding surface, parts of outside object are simply removed. This produces a visual appearance as if someone had cutout a piece of the object or sliced it into parts. Cutaway illustrations avoid ambiguities with respect to spatial ordering, provide a sharp contrast between foreground and background objects, and facilitate a good understanding of spatial ordering".



A Novi Avion cutaway drawing

Though cutaway drawing are not dimensioned manufacturing blueprints, they are meticulously drawn by a handful of devoted artists who either had access to manufacturing details or deduced them by observing the visible evidence of the hidden skeleton (e.g. rivet lines, etc.). The goal of this drawings in studies can be to identify common design patterns for particular vehicle classes. Thus, the accuracy of most of these drawings, while not 100 percent, is certainly high enough for this purpose.

The technique is used extensively in computer-aided design. It has also been incorporated into the user interface of some video games. In The Sims, for instance, users can select through a control panel whether to view the house they are building with no walls, cutaway walls, or full walls.

History

An engraving by Georgius Agricola illustrating the mining practice of fire-setting

The cutaway view and the exploded view were minor graphic inventions of the Renaissance that also clarified pictorial representation. This cutaway view originates in the early fifteenth century notebooks of Marino Taccola (1382 – 1453). In the 16th century cutaway views in definite form were used in Georgius Agricola's (1494-1555) mining book *De Re Metallica* to illustrate underground operations. The 1556 book is a complete and systematic treatise on mining and extractive metallurgy, illustrated with many fine and interesting woodcuts which illustrate every conceivable process to extract ores from the ground and metal from the ore, and more besides. It shows the many watermills used in mining, such as the machine for lifting men and material into and out of a mine shaft.

The term "Cutaway drawing" was already in use in the 19th century but, became popular in the 1930s.

Technique

The location and shape to cut the outside object depends on many different factors, for example:

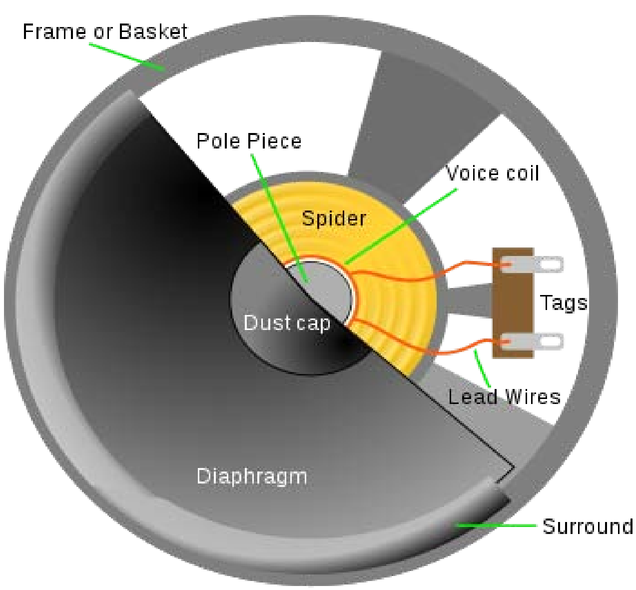
- the sizes and shapes of the inside and outside objects,
- the semantics of the objects,
- personal taste, etc.

These factors, according to Diepstraten et al. (2003), "can seldon be formalized in a simple algorithm, But the properties of cutaway can be distinguish in two classes of cutaways of a drawing":

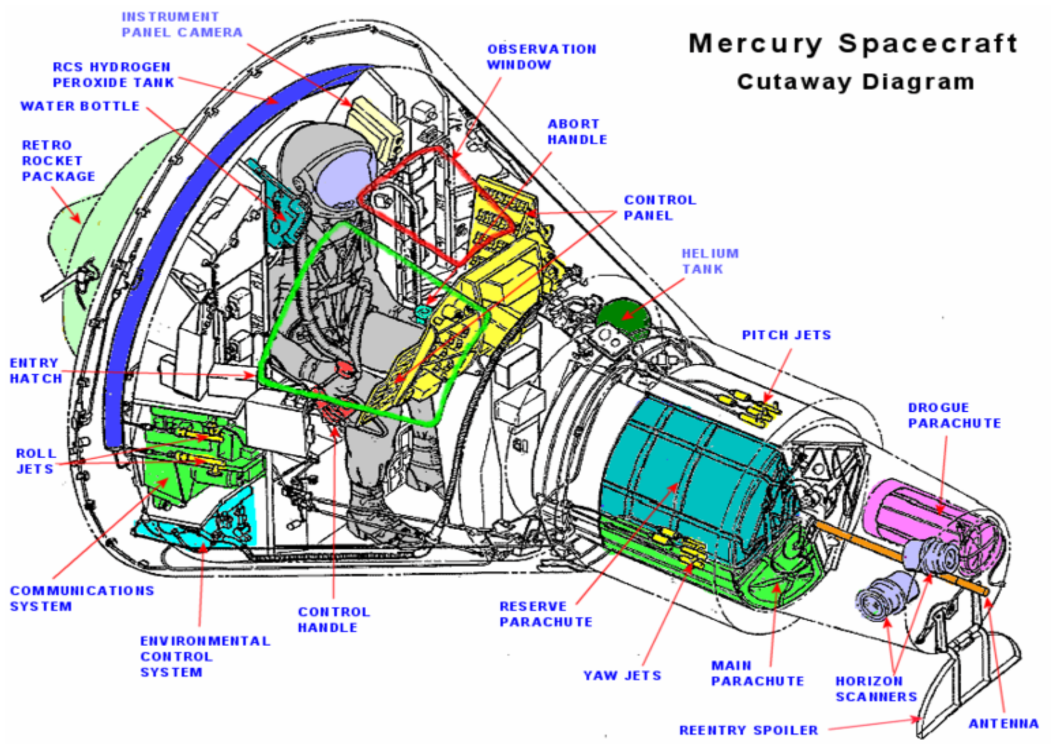
- *cutout* : illustrations were the cutaway is retricted to very simple and regularly shaped of often only a small number of planar slices into the outside object.
- *breakaway* : a cutaway realized by a single hole in the outside object.

Examples

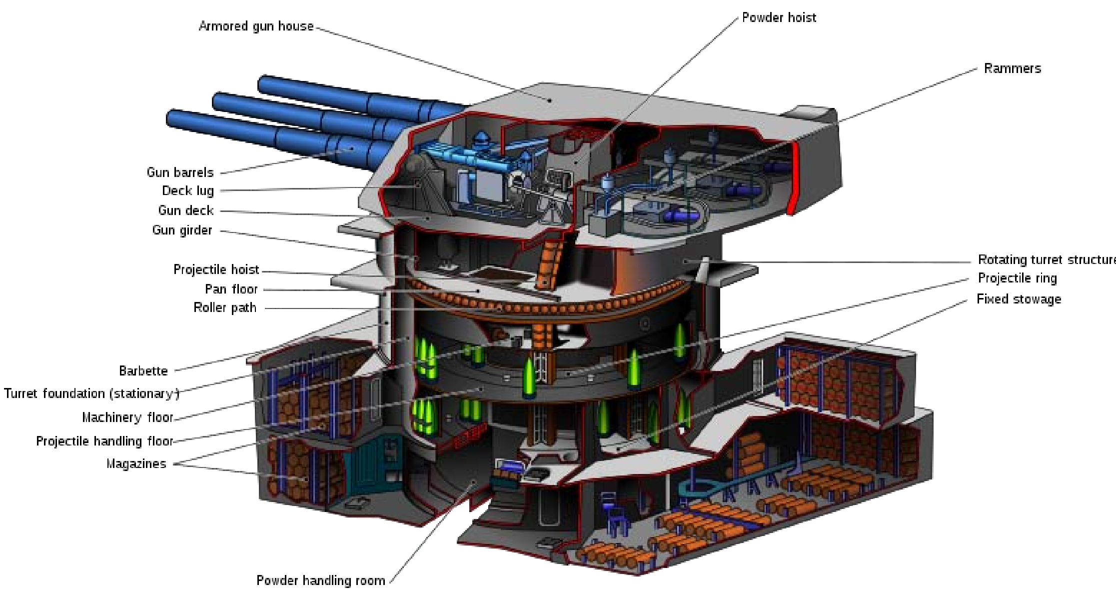
Some more examples of cutaway drawings, from products and systems to architectural building.



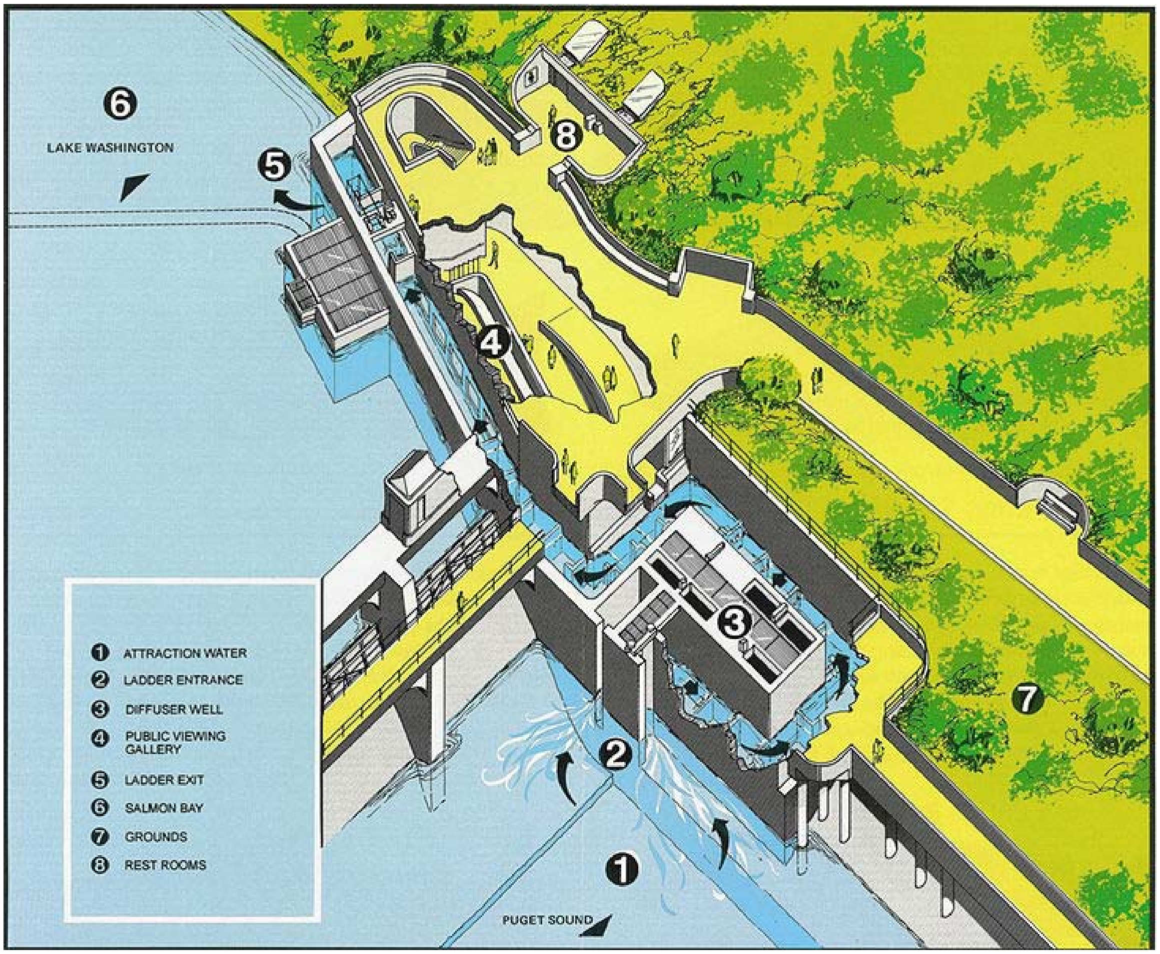
A dynamic loudspeaker



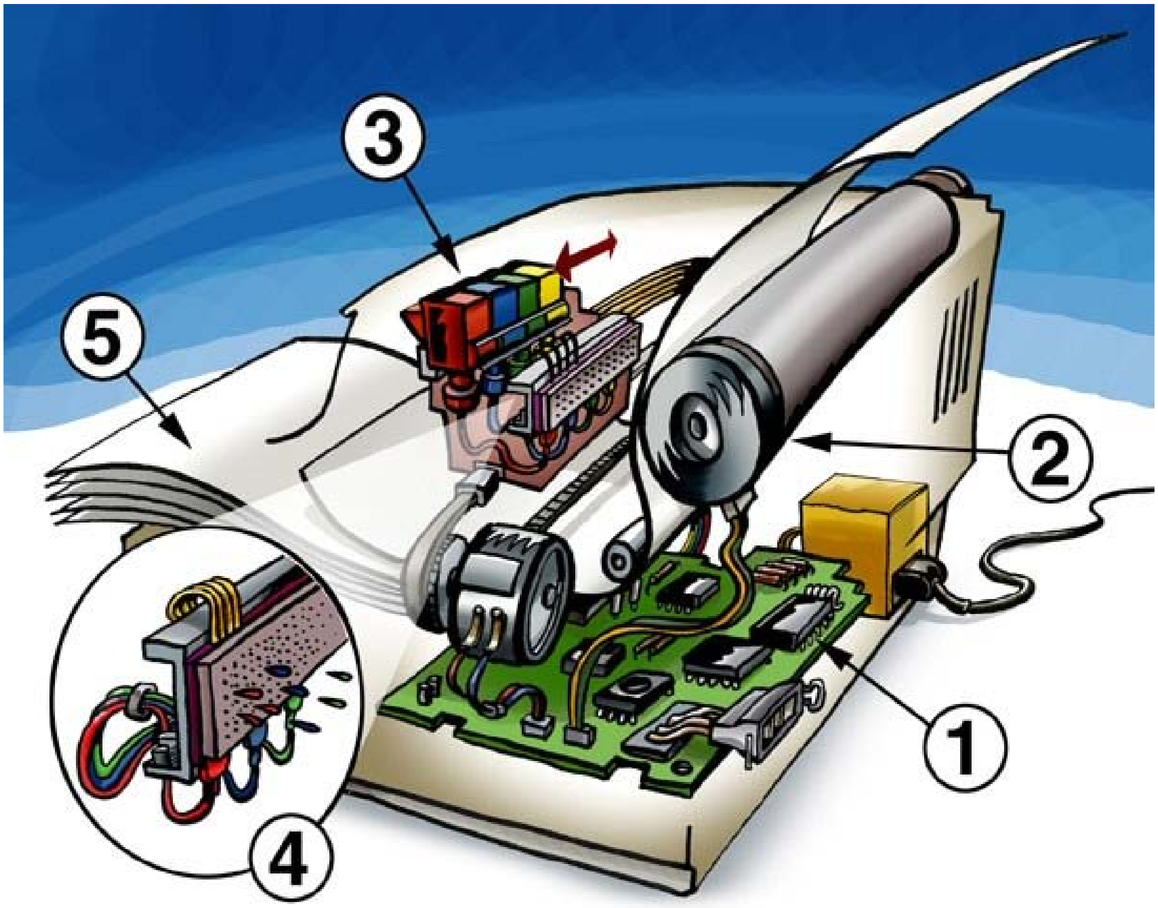
Mercury spacecraft.



16"/50 caliber Mark 7 gun



Lake Washington Ship Canal Fish Ladder

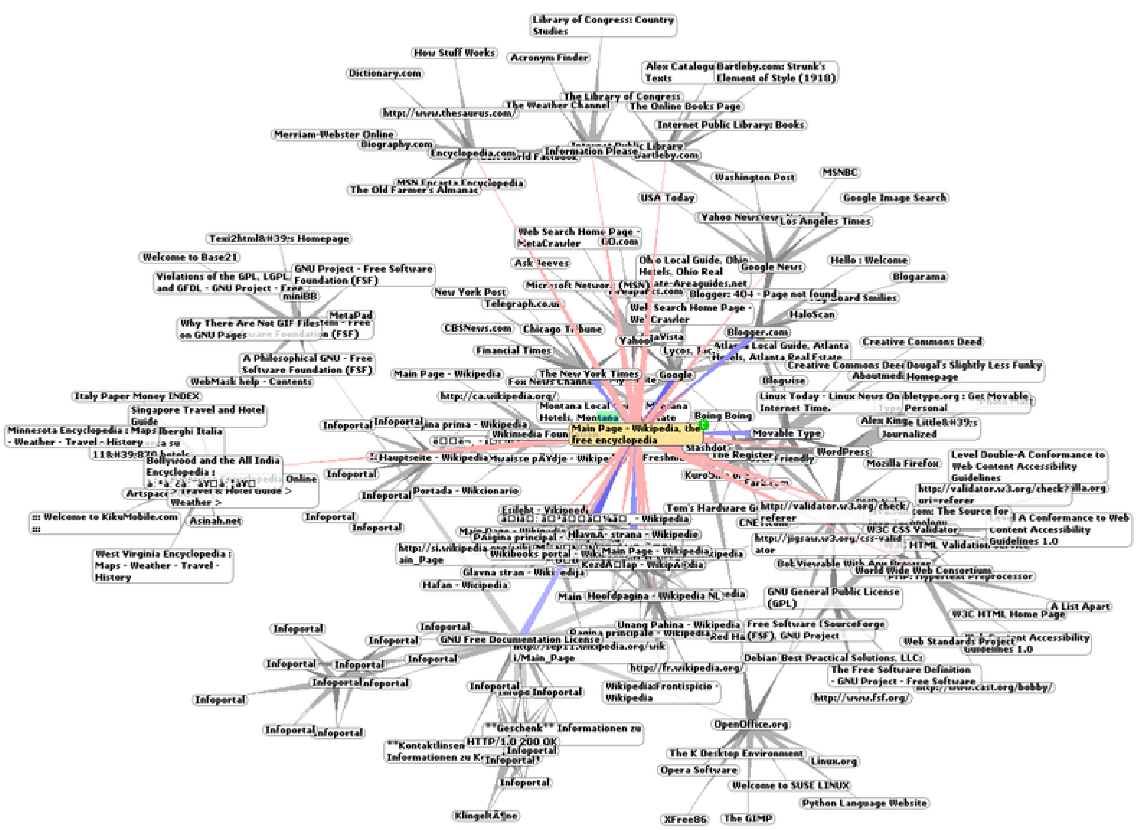


Cutaway of an inkjet printer

Chapter 4

Information Visualization and Labeling (Map Design)

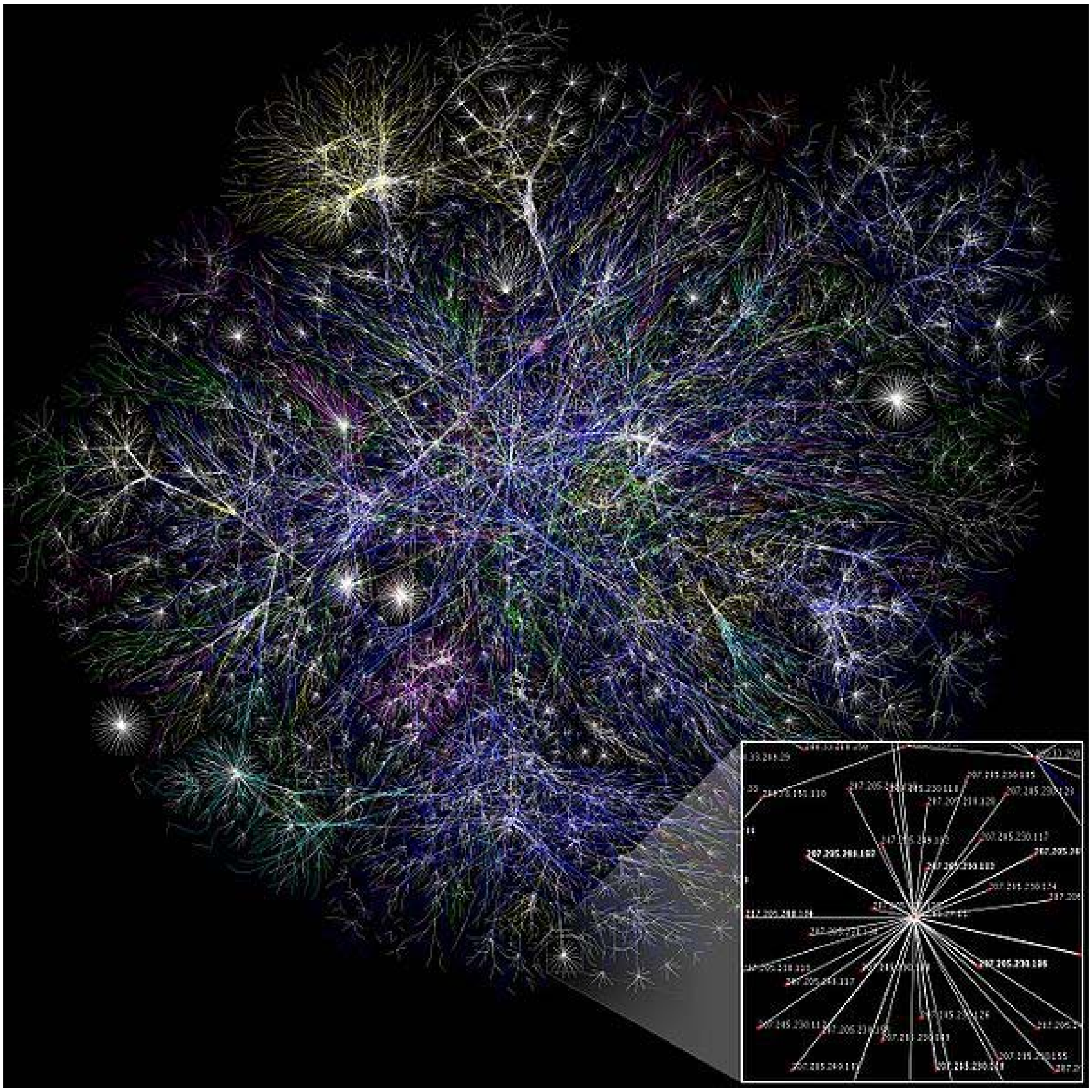
Information visualization



Graphic representation of a minute fraction of the WWW, demonstrating hyperlinks

Information visualization is the interdisciplinary study of "the visual representation of large-scale collections of non-numerical information, such as files and lines of code in software systems, library and bibliographic databases, networks of relations on the internet, and so forth".

Overview



Partial map of the Internet early 2005, each line represents two IP addresses, and some delay between those two, nodes.

The field of information visualization has emerged "from research in human-computer interaction, computer science, graphics, visual design, psychology, and business methods. It is increasingly applied as a critical component in scientific research, digital libraries, data mining, financial data analysis, market studies, manufacturing production control, and drug discovery".

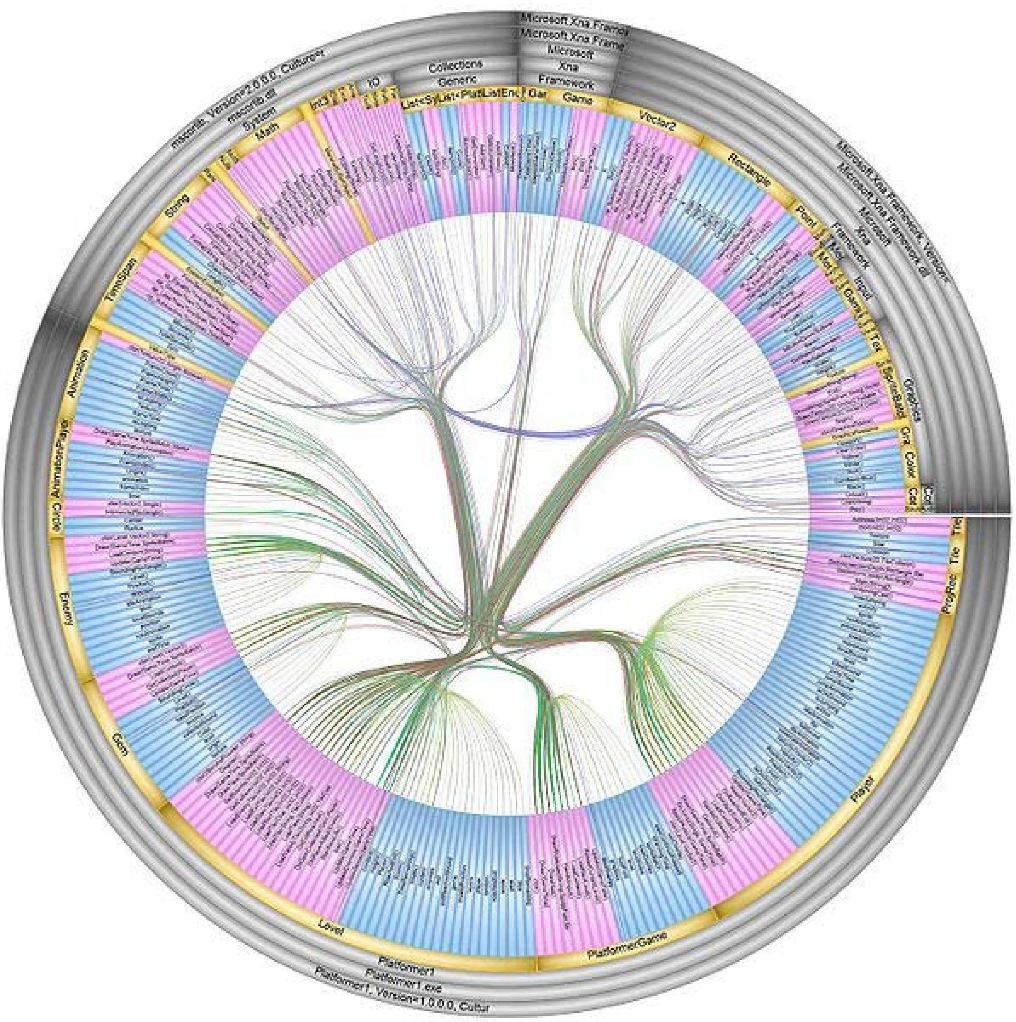
Information visualization presumes that "visual representations and interaction techniques take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once.

Information visualization focused on the creation of approaches for conveying abstract information in intuitive ways."

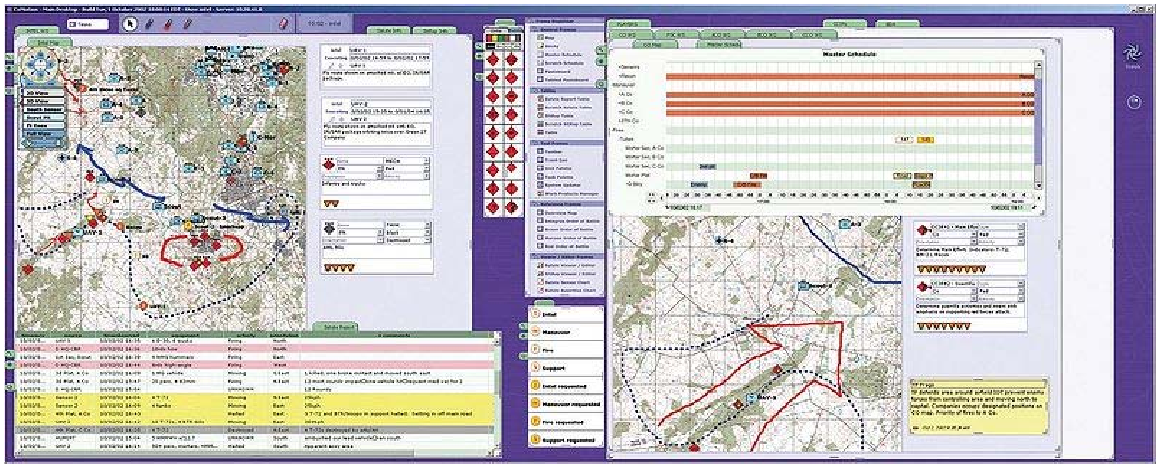
History

The modern study of visualization started with computer graphics, which "has from its beginning been used to study scientific problems. However, in its early days the lack of graphics power often limited its usefulness. The recent emphasis on visualization started in 1987 with the special issue of Computer Graphics on Visualization in Scientific Computing. Since then there have been several conferences and workshops, co-sponsored by the IEEE Computer Society and ACM SIGGRAPH". They have been devoted to the general topics of data visualisation, information visualization and scientific visualisation, and more specific areas such as volume visualization.

Specific methods and techniques



The Solid Software Xplorer (SolidSX) is a software application that gives insight in large (software) systems.



The Command Post of the Future system shows soldiers real-time situational awareness information using a combination of graphical and textual displays. This system is in day-to-day use or has been by soldiers of the US Army's 1st Cavalry Division in Baghdad.

- Cladogram (phylogeny)
- Dendrogram (classification)
- Information visualization reference model
- Graph drawing
- Heatmap
- HyperbolicTree
- Multidimensional scaling
- Problem Solving Environment
- Treemapping
- Southbeach Notation

Applications

Information visualization insights are being applied in areas such as:

- scientific research,
- digital libraries,
- data mining,
- financial data analysis, market studies,
- manufacturing production control,
- and crime mapping.

And also:

- Command Post of the Future
- Informedia Digital Library
- Information graphics
- Starlight Information Visualization System

Experts

Stuart K. Card

Stuart K. Card is an American researcher. He is a Senior Research Fellow at Xerox PARC and one of the pioneers of applying human factors in human–computer interaction. The 1983 book *The Psychology of Human-Computer Interaction*, which he co-wrote with Thomas P. Moran and Allen Newell, became a very influential book in the field, partly for introducing the Goals, Operators, Methods, and Selection rules (GOMS) framework. His currently research is in the field of developing a supporting science of human–information interaction and visual-semantic prototypes to aid sensemaking.

George W. Furnas

George Furnas is a professor and Associate Dean for Academic Strategy at the School of Information of the University of Michigan. Furnas has also worked with Bell Labs where he earned the moniker "Fisheye Furnas" while working with fisheye visualizations. He is a pioneer of Latent semantic analysis, Professor Furnas is also considered a pioneer in the concept of Mosaic of Responsive Adaptive Systems (MoRAS).

James D. Hollan

James D. Hollan directs the Distributed Cognition and Human-Computer Interaction Laboratory at University of California, San Diego. His research explores the cognitive consequences of computationally-based media. The goal is to understand the cognitive and computational characteristics of dynamic interactive representations as the basis for effective system design. His current work focuses on cognitive ethnography, computer-mediated communication, distributed cognition, human-computer interaction, information visualization, multiscale software, and tools for analysis of video data.

More related scientists

- Scott Meyers
- George G. Robertson
- Pierre Rosenstiehl
- Ben Shneiderman
- John Stasko

Organization

Organizations

- International Symposium on Graph Drawing
- Panopticon Software
- University of Maryland Human-Computer Interaction Lab
- Vvi

Labeling (map design)

Cartographic **labeling** is a form of typography and strongly deals with form, style, weight and size of type on a map. Essentially, labeling denotes the correct way to label features (points, arcs, or polygons).

Form

In type, form describes anything from lengths between letters to the case and color of the font. Form works well for both nominal (qualitative) and ordered (quantitative) data.

Italics

Italics describe the sloping of letters setting it apart from non-italicized words (or vice versa). Using italics on a map also slightly decreases the size of the font as it shapely squeezes it around features. When introduced, the idea was to condense the text by italicizing it, thus creating more text on the pages. The slope in the font was created to mimic the flow of cursive handwriting and thus, the angles of italic letters range anywhere from 11 to 30 degree and consequently, serifs are absent.

As a general rule on maps, the smaller the point size of a font, the more condensed and difficult it becomes to read. In an example of labeling a globe, ocean features are generally italicized to give an obvious discernment. In cartographic conventions, natural features are adequate in italics such as the aforementioned hydrographic features.

Case

Case is another way of emphasizing--whether it be uppercase, lowercase or a combination of the two (or even different size points within the same case). In general, uppercase fonts denote a higher emphasis, but according to Bringhurst (1996), an uppercase initial of a word has the seniority; but the lowercase letters have the control. In other words, the strong boldness of a larger letter draws the audience into its viewpoint. The lowercase letters contain the information needed to convey further. When viewing text on maps, it is still crucial to grain the audience's attention as a way of informing them of something other than the map(s). As for design, uppercase is much harder to read than mixed-use. In the globe example, mountain ranges should be in uppercase. When showing a larger scale, such as a region of the United States, it is useful to classify different case sizes. States should be in uppercase, with counties in small uppercase, and cities in lowercase.

Color

Color (value and hue) alterations also allow for a further emphasis on certain features. By changing the color of the font to correspond to the feature it is representing, the two become joined. If the cartographer were to label a river, the extra emphasis would be inherent if the font chosen was blue, to correspond with the blue feature (arc). On the contrary though, this is not always necessarily the case. If the cartographer chose a color of font for an ocean feature (polygon), blue would not be the obvious choice because it would appear to be washed out and thus, no emphasis. In this case, it is useful to label the feature with a more rich, bolder color (such as black font on blue polygon).

Spacing

The spacing of the letters on features also gives a more appealing map-—visually speaking. By enlarging the increments between each letter of a word, the word in turn, becomes more pronounced. In the case for a long arc feature (river), to add more emphasis on the label, the letters would need to be extended or stretched. On the other hand, in some cases, the letters would have to be condensed (shortened increment gaps) to give a more proportional label for a feature.

Style

Serif vs. sans serif

Serifs

The type style affects to overall look of the map and is adequately used to symbolize nominal (qualitative) data within the map. In general, style amounts to the use of serifs versus sans serifs. A serif is, by definition, a cross-line at the end of a stroke along a letter. On a map, the text that is chosen should be consistent. Generally, serif fonts are utilized to give a more regimented block body of text—similar to those used in traditional printing. Serifs are more widely used for historical information or a historical map.

Sans serifs

The serif counterpart is sans serifs (meaning without serifs). Sans serif fonts are the more modern of the two fonts. But choosing one over the other requires that the audience will be able to read the text without strain. Generally, sans serifs are not for large bodies of text in print but instead, are ideal for the internet. On the same facet, sans serifs are optimal for a more-clean appearance in such places like a header, title, or legend. In map design, it’s useful to also use sans serifs for natural features.

Weight

The type weight provides a substantial amount of emphasis of the cartographer’s choosing. Weight is important because it involves the difference between bold and regular contrast. The degree of power that is increased with weight, must be proportional to the size of the letter. If not, a letter can be too intense and thus more difficult to read. Similarly, the spacing between the letters must be extended to provide adequate to read smoothly. Bold text creates direct attention to the eyes of the audience to pronounce certain information from cartographer.

Size

The type size of fonts stresses the importance and emphasis of the intended map. Size is expressed in points through the American point system with 1 point equaling 1/72" of vertical height. Furthermore, points also show the spacing between letters, words and lines. A larger size implies more importance or a greater relative quantity; smaller denotes less importance or less quantity. For design purposes, text using a size of less than 6 point is difficult to read. On the contraire, text that is larger than 26 point is too cumbersome for a standard-size paper format. For titles, a font larger than 10 point generally allows for a good working title. Also, it is important to use at least a 2 point difference between type sizes to allow the audience to see subtle changes.

Placement

With all of the type in order and adequately designed, the final step is the correct placement of labels. Placement describes each feature and its subsequent label(s). For area features, it is important to curve and extend the spaces to properly fill in the areas enough that the audience can discern different areas. As a cartographic convention, labels are usually as horizontal as possible with no upside-down labels. For line features, it is useful to allow the label to conform to the line pattern. Similar to a river (e.g. geographic features), the label should flow around the edges along the line being careful not to have the letters too extended. For point patterns, the minor patterns to follow include keeping labels on/in their respective features (e.g. coastal cities with labels on the land and not ocean). The major pattern for points is the placement along the point itself. The most widely accepted pattern is to start at the center and work outward towards the northeast quadrant from the point. Many studies have been researched to address the correct strategy for the placements. The point feature cartographic label placement (PFCLP) problem offers the solutions when point boxes overlap. Many software features automatically choose label placements for the cartographer, but these are not always a fail-safe option. The use of good judgment and cartographic conventions are important to gain the best placement.

Chapter 5

Patent Visualisation

Patent visualisation is an application of information visualisation. Patents number has been increasing , thus forcing companies to consider intellectual property as a part of their strategy.. So patent visualisation like patent mapping is used to quickly view patents portfolio.

Patent visualisation dedicated software began to appear in 2000 like Aureka from Aurigin now owned by Thomson Reuters. Taking advantage of the innate visual language, software have been developed to convert patents in clear infographics or maps, to allow the analyst to "get insight into the data" and draw conclusions. Also referred as patinformatics, it is the "science of analysing patent information to discover relationsips and trends that would be difficult to see when working with patent documents on a one-and-one basis".

Patents contain two types of information: Structured data like publication number which are processed by data-mining and unstructured text like title, abstract and claims which are used with text mining.

Datamining

The main step in processing structured information lies on data-mining. Data mining has emerged in the late 1980s. Used in computer science and genetic algorithms, data mining is the union of statistics, artificial intelligence and machine learning to assist in the analysis of patents. Patent data mining extracts information from the structured data of the patent document. These structured data are bibliographic fields like location or date or status :

Structured fields

Structured data	Description	Business Intelligence use
Datas	Patent contain different identifying data such as priority, publication data and the issue date • Priority data regroup priority number	Priority application data often propose information such as priority country. Crossing dates and locations fields offer a global vision of

	assigned for the first application, the corresponding date and priority country. • The publication data encompass the publication number given when the patent is published, 18 months after filling and the publication date. • The issue date is the data the patent is granted, usually 3.5 years after filling depending on the patent office.	a technology in time and space.
Assignee	Patent assignees are organizations or individuals, owners of the patent's invention.	The field can offer a ranking of the principal actors of the environment thus allowing seeing potential competitors or partners.
Inventor	Inventors developed the invention	Inventors field combined to the assignee field can create a social network and follow field experts.
Classification	The classification will regroup inventions with similar technologies. The most commonly used is the International Patent Classification IPC. However patent organizations have their own classification for instance the European Patent Office with ECLA.	Grouping patents by thematics offers an overview of the corpus and the potential applications of studied technology.
Status	The legal status is an easy way to access report that lets you view the legal status for all members of a patent family in a single view.	Patent family and legal status searching is very important for litigation and even competitive intelligence.

Advantages

Data mining offers a statistical analysis tool to study filing patterns of competitors, locate the main patent flers within a specific area of technology. This type of approach can be very helpful to monitor competitors environment, moves and innovation trends and gives a macro-view of a technology status in order to evaluates its maturity and complexity.

Text-Mining

Principle

Text-mining is used to search through unstructured full-text patents. This technique is very well known due to the Internet development, its success in bioinformatics and now in the intellectual property environment.

Text mining is based on a statistical approach of words recurrence or occurrence in the patents corpus. An algorithm decomposes the corpus into a text sea, extracts words and expressions from title, summary and claims and gather them by declension. The conjunctions such as "and" or "if" are labeled as non-information bearing words and are stored in the stopword list. These stoplists can be personalized, in order to create an accurate analysis. Next, the algorithm will rank the words by weight, according to their frequency in the patent's corpus and the documents frequency containing this word. It literally fishes the whole Text Sea for words or expressions and counts their occurrence. The score for each word is calculated using this formula :

$$Weight = \frac{Term\ Frequency}{Document\ Frequency} = \frac{Frequency\ of\ theword\ or\ expression\ in\ the\ Text\ Sea}{Number\ of\ documents\ containing\ the\ expression\ or\ word}$$

According to this, a frequently used word in several documents will have less weight or score than a frequently used word in a few patents. Words under a minimum weight are eliminated, only to have left a list of n pertinent words or descriptors. Then each patent is associated to the descriptors found in the selected document. Further, in the process of clusterization, these descriptors are used as subsets, in which the patent are regrouped or they can be used as tags to place the patents in predetermined categories for example keywords from International Patent Classifications.

There are four different full-text parts that can be processed with text-mining :

- Title
- Abstract
- Claim
- Patent Full-Text

Software offer different combinations but using title, abstract and claim is generally the most used, having a good balance between interferences and relevancy.

Advantages

Text-mining approache has numerous advantages. First, it is useful to narrow down a search or quickly evaluate a patent corpus. For instance, if a query has taken irrelevant documents, a multi level clustering hierarchy will identidy them in order to delete them and refine the search. Moreover, this approach offers the possibility to create internal taxonomies specific to a corpus, thus preparing possible mapping.

Visualisations

This art of allying patent analysis and informatic tools offers an overview of the environment through value-added visualisations. As patent contain two types of information, structured and unstructured one, visualisations can be distinguished in two categories. Structured data can be rendered with data mining in macrothematic maps and statistical analysis. Whereas unstructured information extracted by text-mining are represented in a more intuitive way like clouds, cluster maps, 2D keyword map.

Data mining visualisation

Visualisation	**Picture**	**Description**	**Business Intelligence use**
Matrix chart	Picture	Graphic organizer used to summarize a multidimensional data set in a grid	Data comparison
Location map	Picture	Map with overlaid data values on geographic regions	• Spatial patterns • Find innovative countries
Bar chart	Picture	Graph with rectangular bars proportional to the values that they represent, useful for numerical comparisons.	Data evolution
Line graph	Picture	Graph used to summarize how two parameters are related and how they vary.	Data evolution and relationships
Pie chart	Picture	Circular chart divided into sections, to illustrate proportions.	Data comparison

Text mining visualisation

Visualisation	**Description**	**Business Intelligence use**
Tree list	Hierarchy list	• Evaluating the data relevancy • Creating taxonomy • Relationship between concepts
Tag cloud	Full text of concepts. The size of each word is determined by its frequency in the corpus	• Evaluating the data relevancy • More visual than the tree list
2D keyword map	Tomographic map with quantitative representation of relief, usually using contour lines and colors. Distance on the map will be proportional to the difference between patent	• Landscape vision of thematics • Similarity vision with SOM

	themes		• Monitoring competitors

Visualisation for both data-mining and text-mining

Mapping visualisations can be used for both text-mining and data-mining results.

Visualisation	Picture	Description	Business Intelligence use
Tree Map	Picture	Visualization of hierarchical structures. Each data item, or row in the data set, is represented by a rectangle, whose area is proportional to selected parameters.	• Landscape vision of hierarchical thematics • Position of competitors or technology by thematics
Network map	Picture	In a network diagram, entities are connected to each other in the form of a node and link diagram.	• Relationship visions • Monitoring similar competitors or technologies

Uses

What can patent visualisation highlights:

- Competitors
- Partners
- New innovations
- Technologic environment description
- Networks

Chapter 6

Pictogram

A **pictograph** (also called *pictogram* or *pictogramme*) is an ideogram that conveys its meaning through its pictorial resemblance to a physical object. Earliest examples of pictographs include ancient or prehistoric drawings or paintings found on rock walls. Pictographs are also used in writing and graphic systems in which the characters are to considerable extent pictorial in appearance.

Pictography is a form of writing which uses representational, pictorial drawings. It is a basis of cuneiform and, to some extent, hieroglyphic writing, which uses drawings also as phonetic letters or determinative rhymes.

Historical

Early written symbols were based on pictographs (pictures which resemble what they signify) and ideograms (symbols which represent ideas). Ancient Chinese, Sumerian, and Egyptian civilizations began to use such symbols over 5000 years ago, developing them into logographic writing systems around the third millennium BCE. Pictographs are still in use as the main medium of written communication in some non-literate cultures in Africa, The Americas, and Oceania. Pictographs are often used as simple, pictorial, representational symbols by most contemporary cultures.

Native North American pictographs from Agnes Lake, Quetico Provincial Park, Ontario, Canada

Pictographs can often transcend languages in that they can communicate to speakers of a number of tongues and language families equally effectively, even if the languages and cultures are completely different. This is why road signs and similar pictographic material are often applied as global standards expected to be understood by nearly all.

Pictographs can also take the form of diagrams to represent statistical data by pictorial forms, and can be varied in color, size, or number to indicate change.

Pictographs can be considered an art form, and are designated as such in Pre-Columbian art, Native American art, and Painting in the Americas before Colonization. One example of many is the Rock art of the Chumash people, part of the Native American history of California.

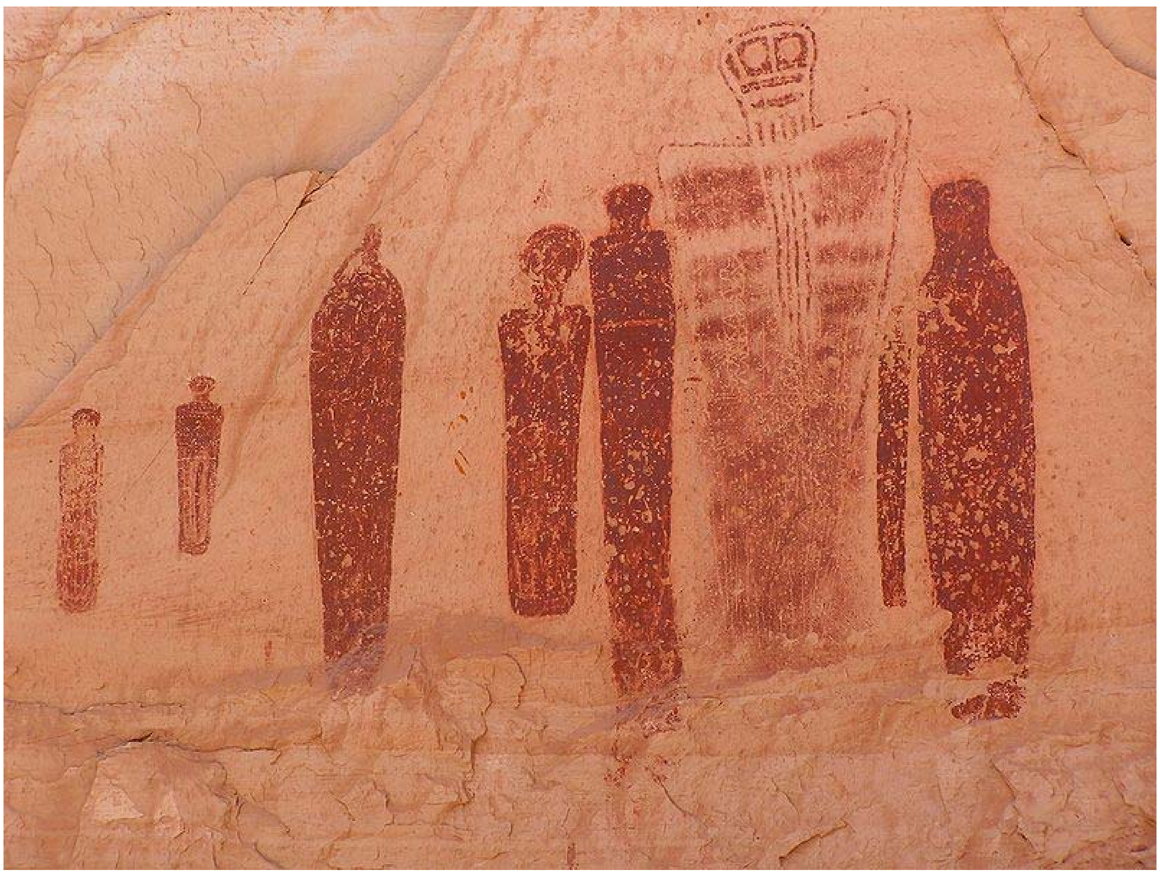
Modern use

Pictographs remain in common use today, serving as pictorial, representational signs, instructions, or statistical diagrams. Because of their graphical nature and fairly realistic style, they are widely used to indicate public toilets, or places such as airports and train stations.

A standard set of pictographs was defined in the international standard *ISO 7001: Public Information Symbols*. Another common set of pictographs are the laundry symbols used on clothing tags and chemical hazard labels.

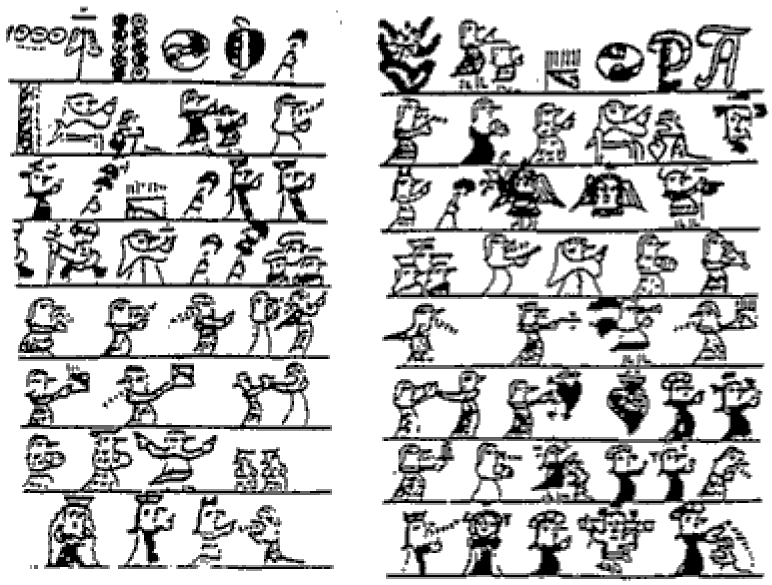
Pictographic writing as a modernist poetic technique is credited to Ezra Pound, though French surrealists accurately credit the Pacific Northwest American Indians of Alaska who introduced writing, via totem poles, to North America.

Contemporary artist Xu Bing created Book from the Ground, a universal language made up of pictogram collected from around the world. A Book from the Ground chat program has been exhibited in museums and galleries internationally.



Native American Pictographs from the Great Gallery, Horseshoe Canyon, Canyonlands National Park

Sample National Park Service pictographs



Pictograph from 1510 telling a story of coming of missionaries to Hispaniola

Water, rabbit, deer pictographs on a replica of an Aztec Stone of the Sun

British Rail passenger safety pictographs at the end of the platform at Meols railway station

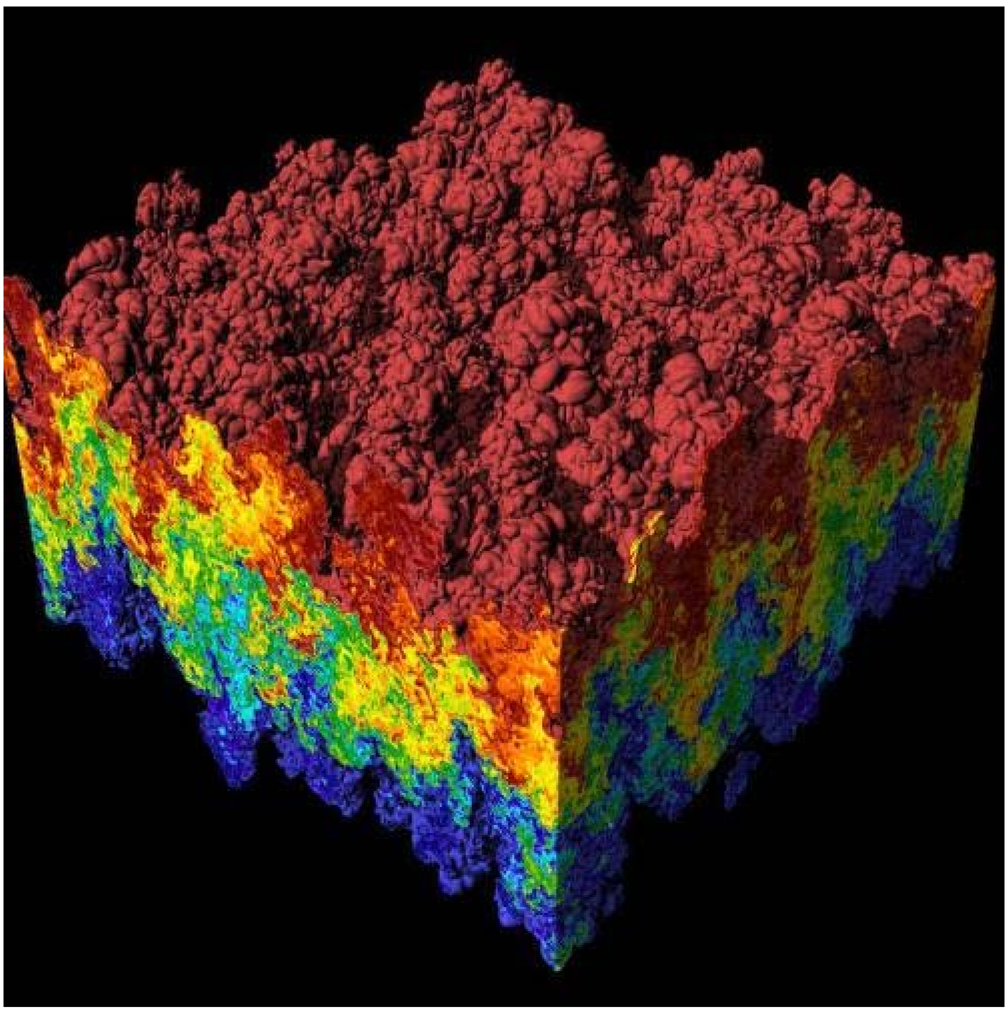
A pictograph warning against swimming because of crocodiles at the Australia Zoo.

The top traffic sign warns people of horses and riders.

A Recycling symbol.

Chapter 7

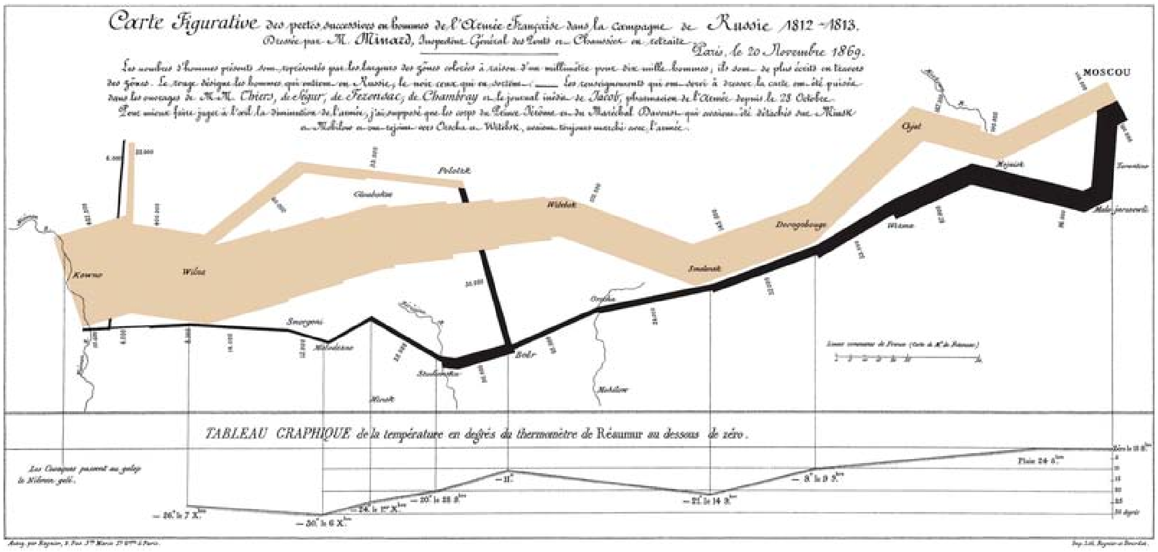
Scientific Visualization



A scientific visualization of an extremely large simulation of a Rayleigh–Taylor instability caused by two mixing fluids.

Scientific visualization (also spelled **scientific visualisation**) is an interdisciplinary branch of science according to Friendly (2008) "primarily concerned with the visualization of three dimensional phenomena (architectural, meteorological, medical, biological, etc.), where the emphasis is on realistic renderings of volumes, surfaces, illumination sources, and so forth, perhaps with a dynamic (time) component".

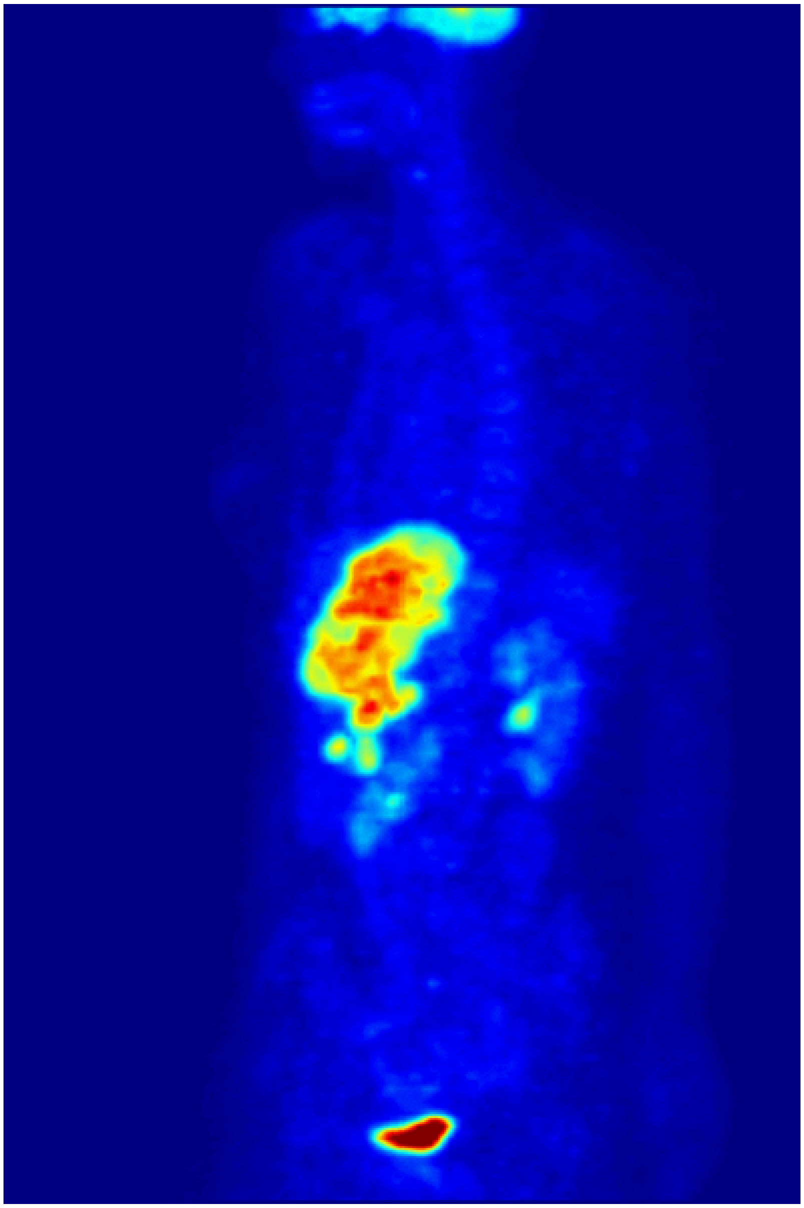
History



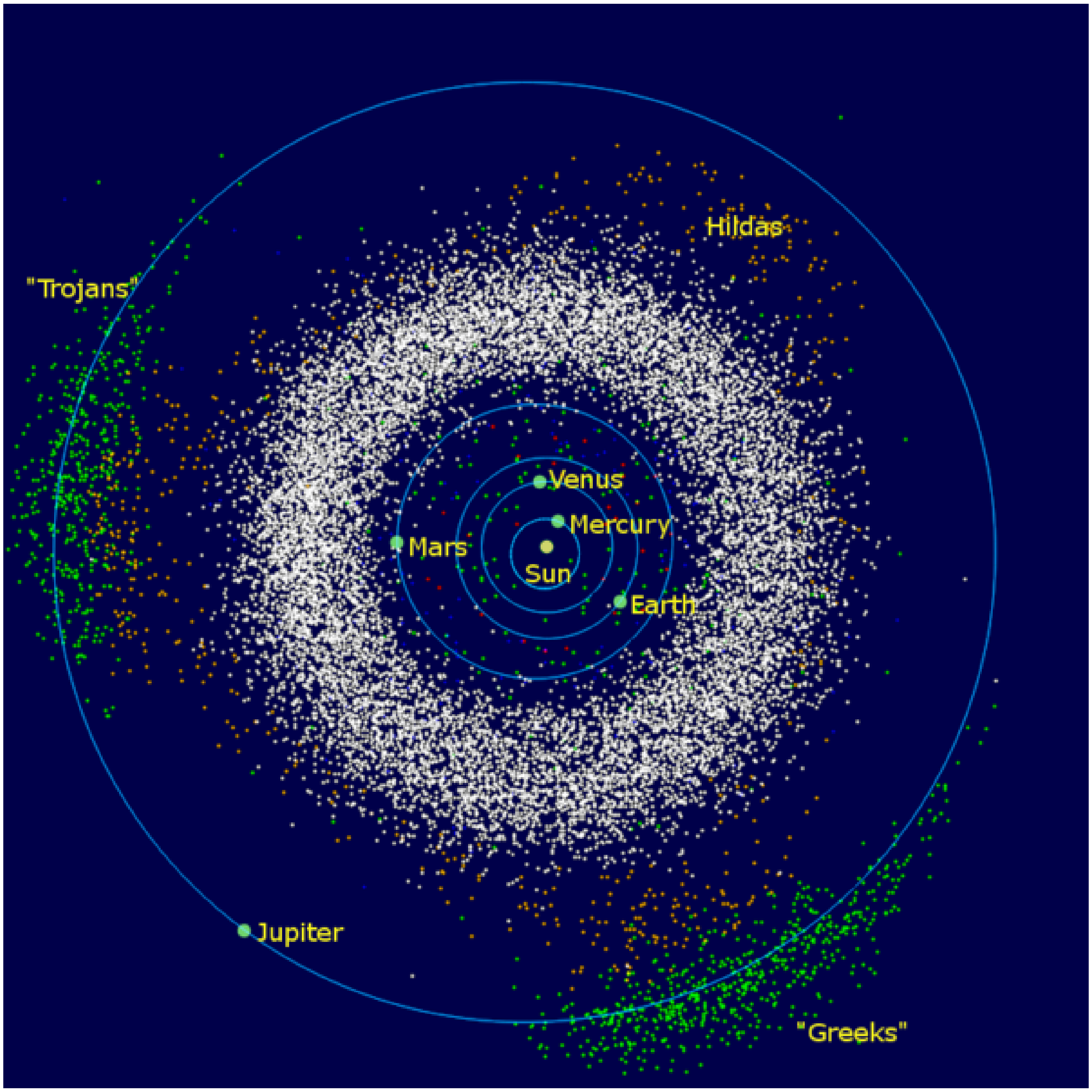
Charles Minard's flow map of Napoleon's March.

One of the earliest examples of three-dimensional scientific visualisation was Maxwell's thermodynamic surface, sculpted in clay in 1874 by James Clerk Maxwell. This prefigured modern scientific visualization techniques which use computer graphics.

Notable early two-dimensional examples include the flow map of Napoleon's March on Moscow produced by Charles Joseph Minard in 1869; the "coxcombs" used by Florence Nightingale in 1857 as part of a campaign to improve sanitary conditions in the British army; and the dot map used by John Snow in 1855 to visualise the Broad Street cholera outbreak.

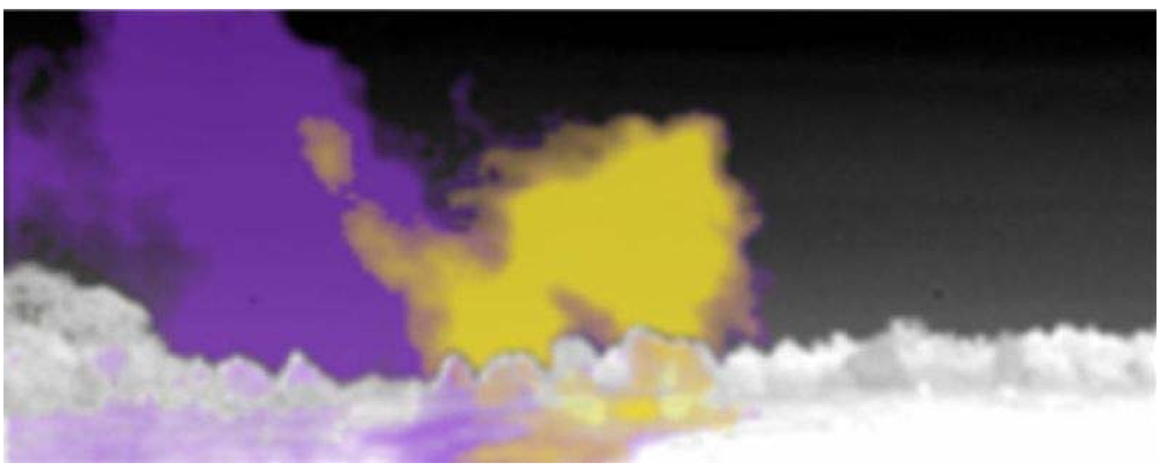


Maximum intensity projection (MIP) of a whole body PET scan.

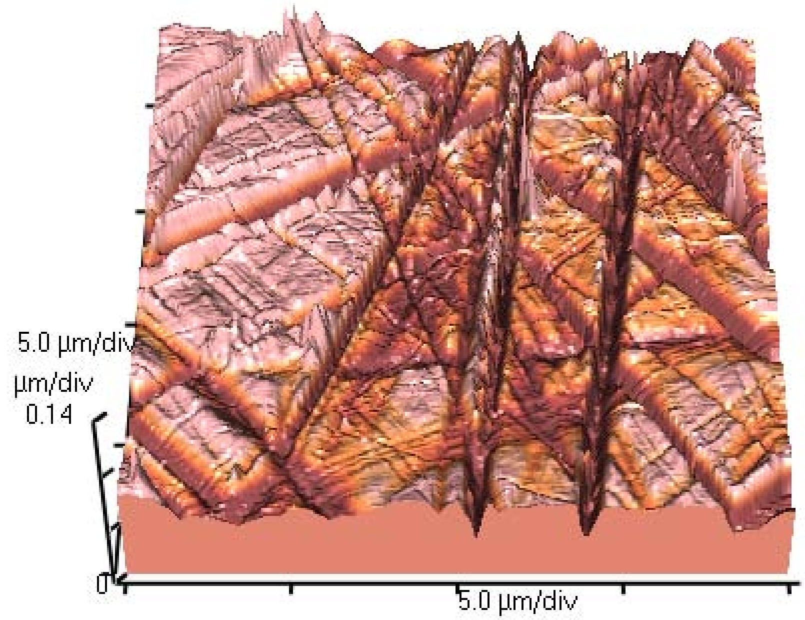


Solar system image of the main asteroid belt and the Trojan asteroids.

Scientific visualization of Fluid Flow: Surface waves in water



Chemical imaging of a simultaneous release of SF_6 and NH_3.



Topographic scan of a glass surface by an Atomic force microscope.

Computer animation

Computer animation is the art, technique and science of creating moving images via the use of computers. Increasingly it is created by means of 3D computer graphics, though 2D computer graphics are still widely used for stylistic, low bandwidth, and faster real-time rendering needs. Sometimes the target of the animation is the computer itself, but sometimes the target is another medium, such as film. It is also referred to as CGI (Computer-generated imagery or computer-generated imaging), especially when used in films.

Computer simulation

Computer simulation is a computer program, or network of computers, that attempts to simulate an abstract model of a particular system. Computer simulations have become a useful part of mathematical modelling of many natural systems in physics, and computational physics, chemistry and biology; human systems in economics, psychology, and social science; and in the process of engineering and new technology, to gain insight into the operation of those systems, or to observe their behavior. The simultaneous visualization and simulation of a system is called visulation.

Computer simulations vary from computer programs that run a few minutes, to network-based groups of computers running for hours, to ongoing simulations that run for months. The scale of events being simulated by computer simulations has far exceeded anything possible (or perhaps even imaginable) using the traditional paper-and-pencil mathematical modeling: over 10 years ago, a desert-battle simulation, of one force invading another, involved the modeling of 66,239 tanks, trucks and other vehicles on simulated terrain around Kuwait, using multiple supercomputers in the DoD High Performance Computer Modernization Program.

Information visualization

Information visualization is the study of "the visual representation of large-scale collections of non-numerical information, such as files and lines of code in software systems, library and bibliographic databases, networks of relations on the internet, and so forth".

Information visualization focused on the creation of approaches for conveying abstract information in intuitive ways. Visual representations and interaction techniques take advantage of the human eye’s broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once.

Interface technology and perception

Interface technology and perception shows how new interfaces and a better understanding of underlying perceptual issues create new opportunities for the scientific visualization community.

Surface rendering

Rendering is the process of generating an image from a model, by means of computer programs. The model is a description of three dimensional objects in a strictly defined language or data structure. It would contain geometry, viewpoint, texture, lighting, and shading information. The image is a digital image or raster graphics image. The term may be by analogy with an "artist's rendering" of a scene. 'Rendering' is also used to describe the process of calculating effects in a video editing file to produce final video output. Important rendering techniques are:

Scanline rendering and rasterisation
: A high-level representation of an image necessarily contains elements in a different domain from pixels. These elements are referred to as primitives. In a schematic drawing, for instance, line segments and curves might be primitives. In a graphical user interface, windows and buttons might be the primitives. In 3D rendering, triangles and polygons in space might be primitives.

Ray casting
: Ray casting is primarily used for realtime simulations, such as those used in 3D computer games and cartoon animations, where detail is not important, or where it is more efficient to manually fake the details in order to obtain better performance in the computational stage. This is usually the case when a large number of frames need to be animated. The resulting surfaces have a characteristic 'flat' appearance when no additional tricks are used, as if objects in the scene were all painted with matte finish.

Radiosity

Radiosity, also known as Global Illumination, is a method which attempts to simulate the way in which directly illuminated surfaces act as indirect light sources that illuminate other surfaces. This produces more realistic shading and seems to better capture the 'ambience' of an indoor scene. A classic example is the way that shadows 'hug' the corners of rooms.

Ray tracing

Ray tracing is an extension of the same technique developed in scanline rendering and ray casting. Like those, it handles complicated objects well, and the objects may be described mathematically. Unlike scanline and casting, ray tracing is almost always a Monte Carlo technique, that is one based on averaging a number of randomly generated samples from a model.

Volume rendering

Volume rendering is a technique used to display a 2D projection of a 3D discretely sampled data set. A typical 3D data set is a group of 2D slice images acquired by a CT or MRI scanner. Usually these are acquired in a regular pattern (e.g., one slice every millimeter) and usually have a regular number of image pixels in a regular pattern. This is an example of a regular volumetric grid, with each volume element, or voxel represented by a single value that is obtained by sampling the immediate area surrounding the voxel.

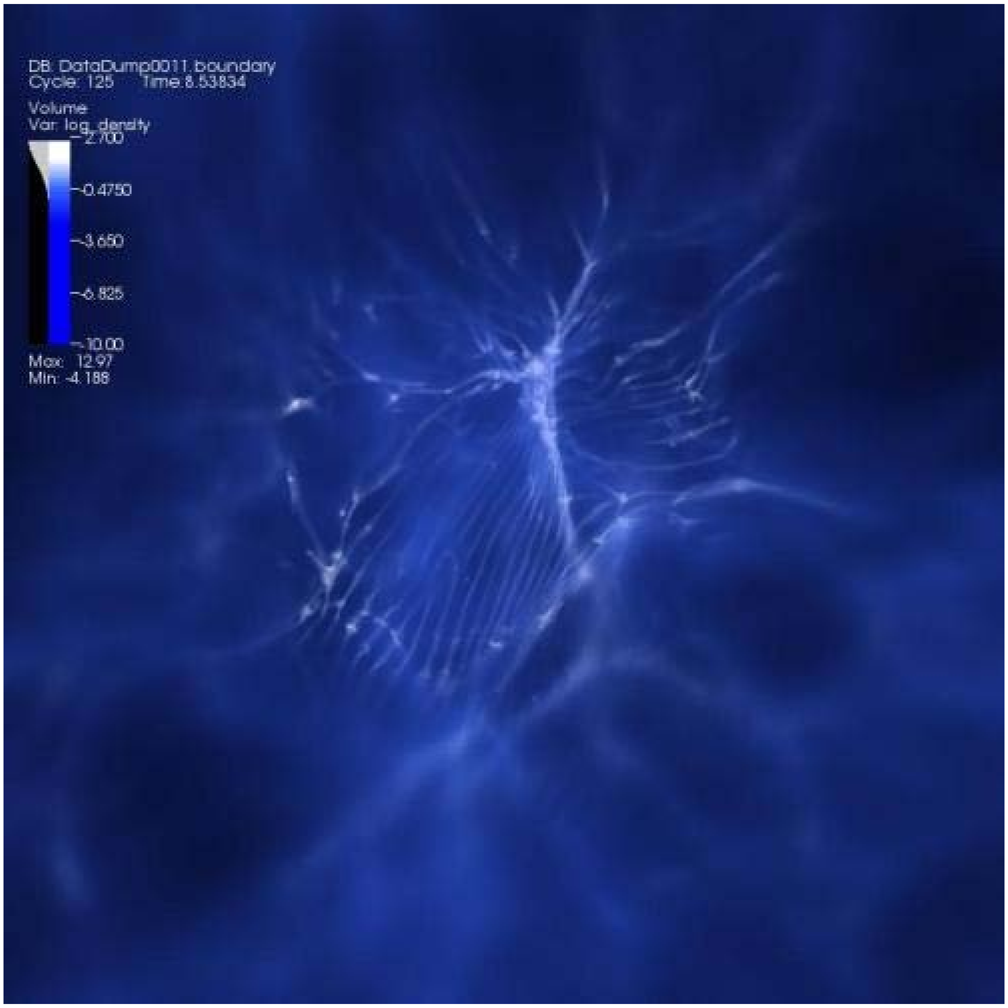
Volume visualization

According to Rosenblum (1994) "volume visualization examines a set of techniques that allows viewing an object without mathematical representing the other surface. Initially used in medical imaging, volume visualization has become an essential technique for many sciences, portraying phenomena become an essential technique such as clouds, water flows, and molecular and biological structure. Many volume visualization algorithms are computationally expensive and demand large data storage. Advances in hardware and software are generalizing volume visualization as well as real time performances".

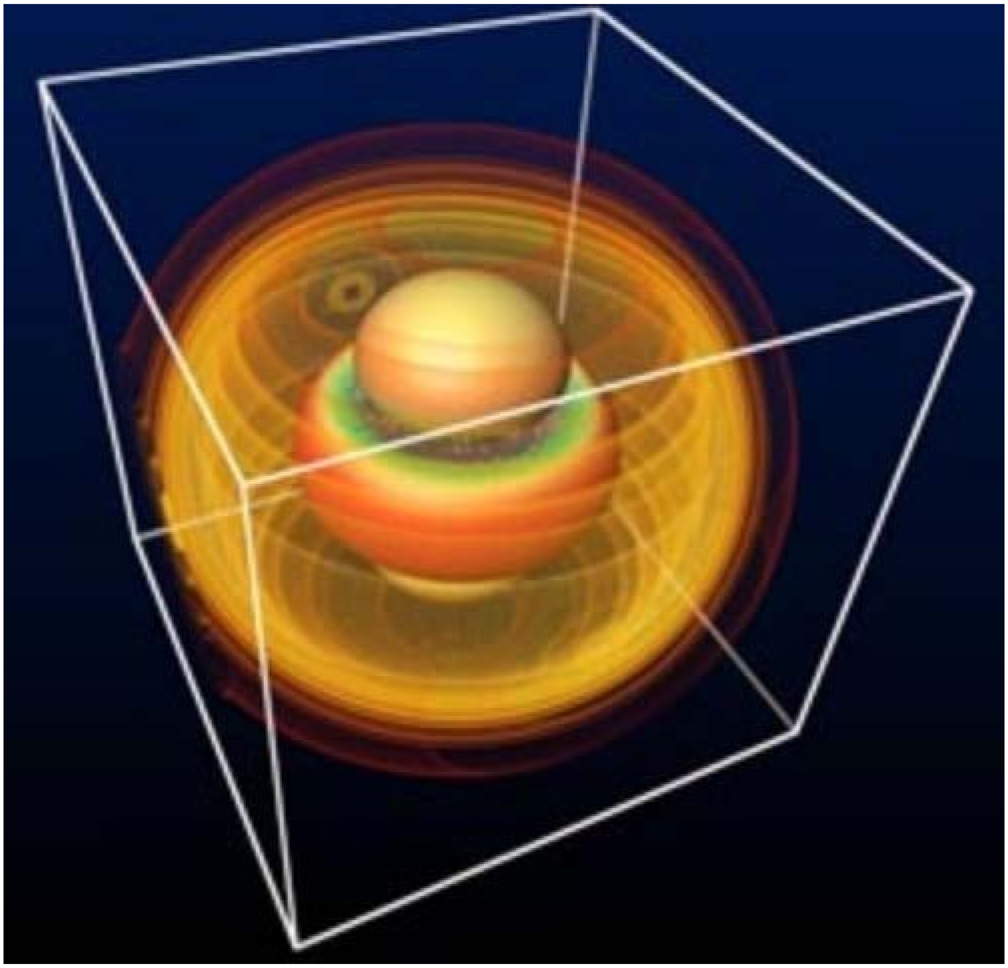
Scientific visualization applications

Here we will give a series of examples how scientific visualization can be applied today.

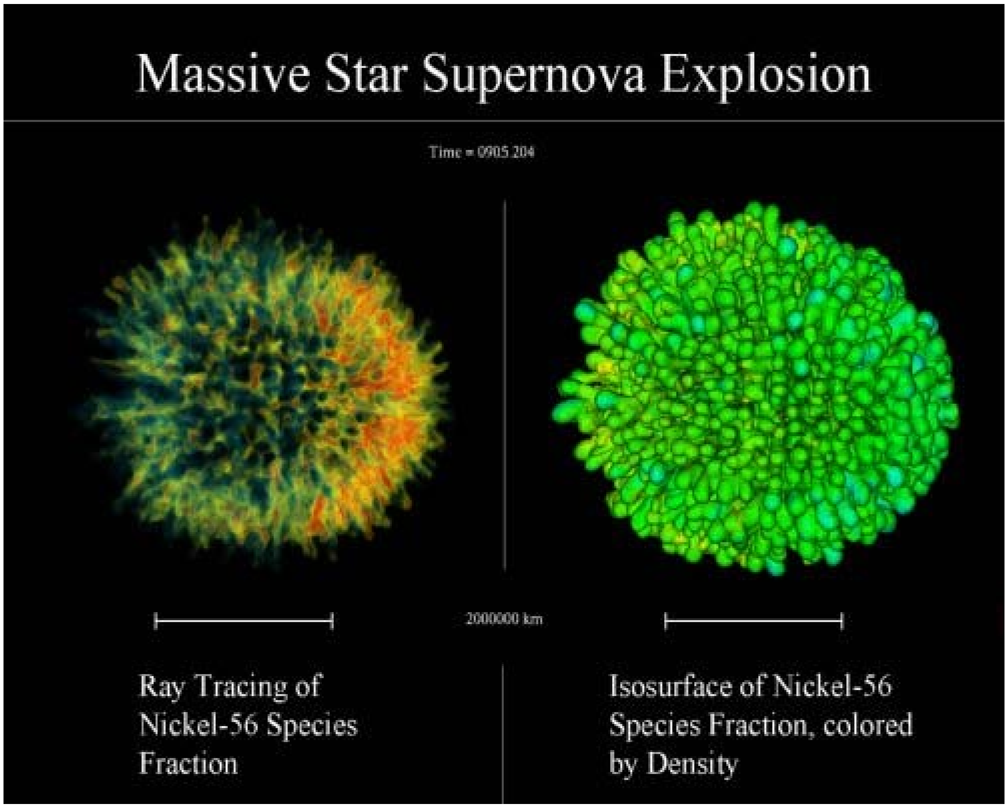
In the natural sciences



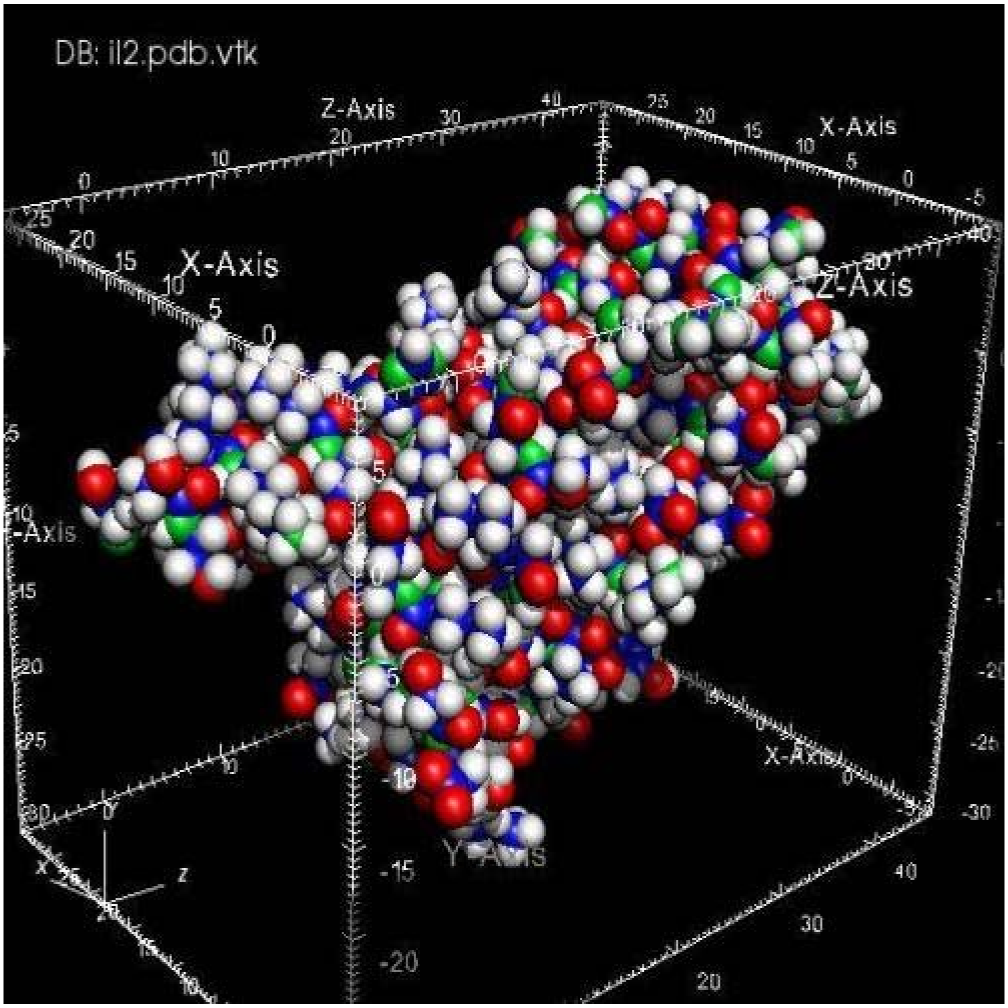
Star formation



Gravity waves



Massive Star Supernovae Explosions



Molecular rendering

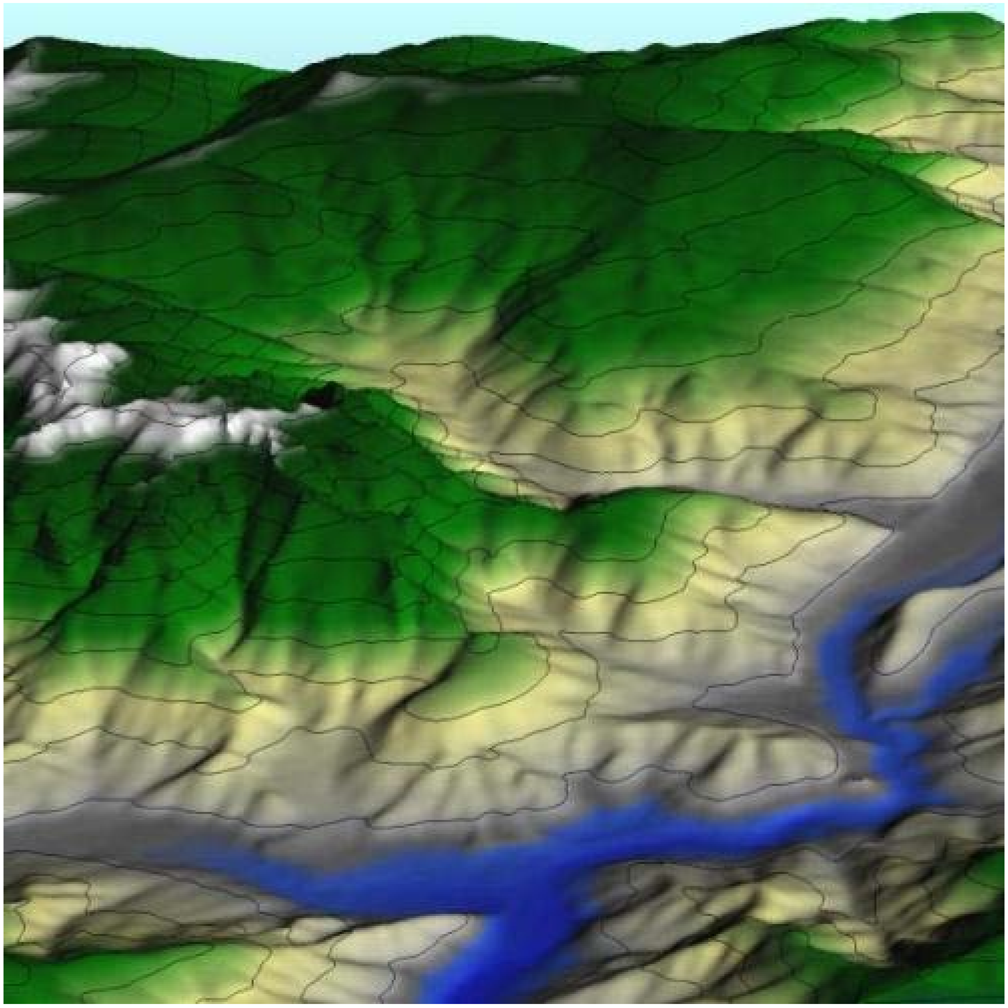
Star formation: The featured plot is a Volume plot of the logarithm of gas/dust density in an Enzo star and galaxy simulation. Regions of high density are white while less dense regions are more blue and also more transparent.

Gravity waves: Researchers used the Globus Toolkit to harness the power of multiple supercomputers to simulate the gravitational effects of black-hole collisions.

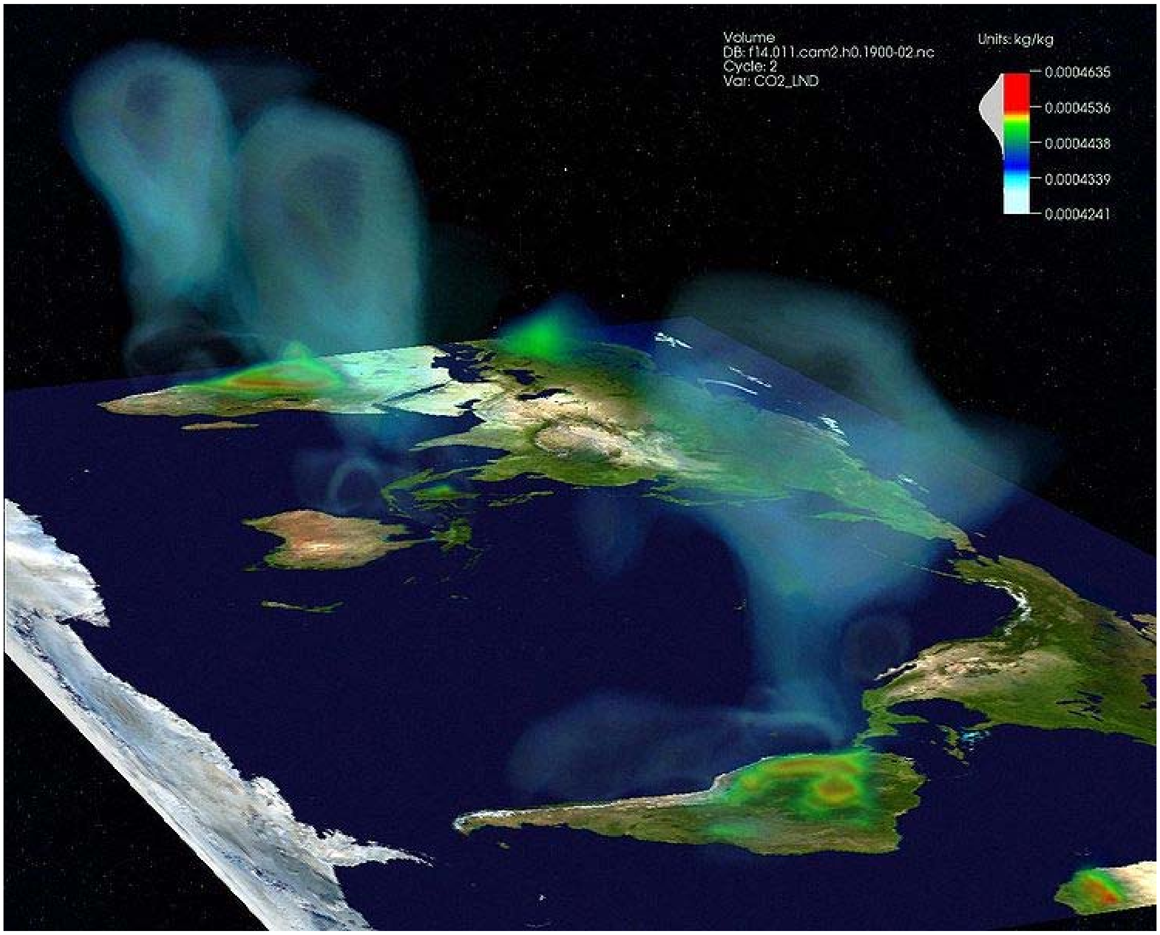
Massive Star Supernovae Explosions: In the image three Dimensional Radiation Hydrodynamics Calculations of Massive Star Supernovae Explosions The DJEHUTY stellar evolution code was used to calculate the explosion of SN 1987A model in three dimensions.

Molecular rendering: VisIt's general plotting capabilities were used to create the molecular rendering shown in the featured visualization. The original data was taken from the Protein Data Bank and turned into a VTK file before rendering.

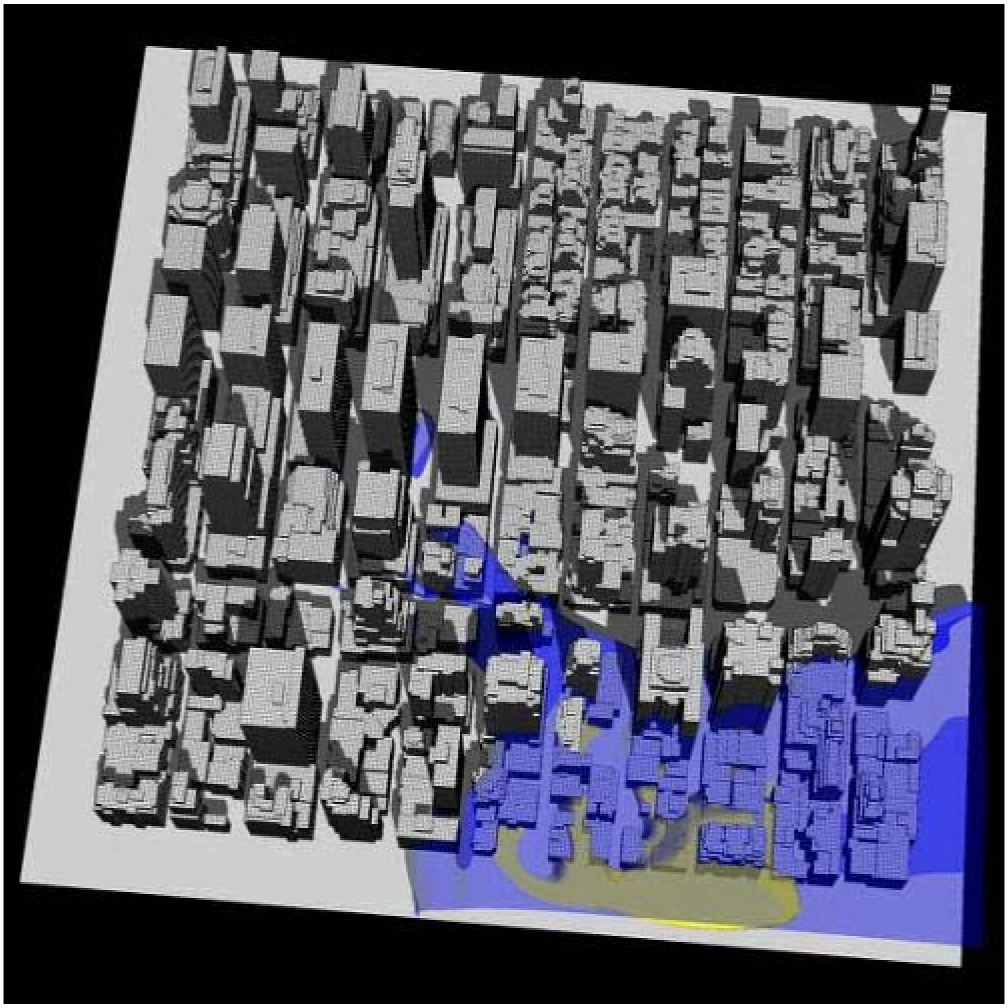
In geography and ecology



Terrain rendering



Climate visualization



Atmospheric Anomaly in Times Square

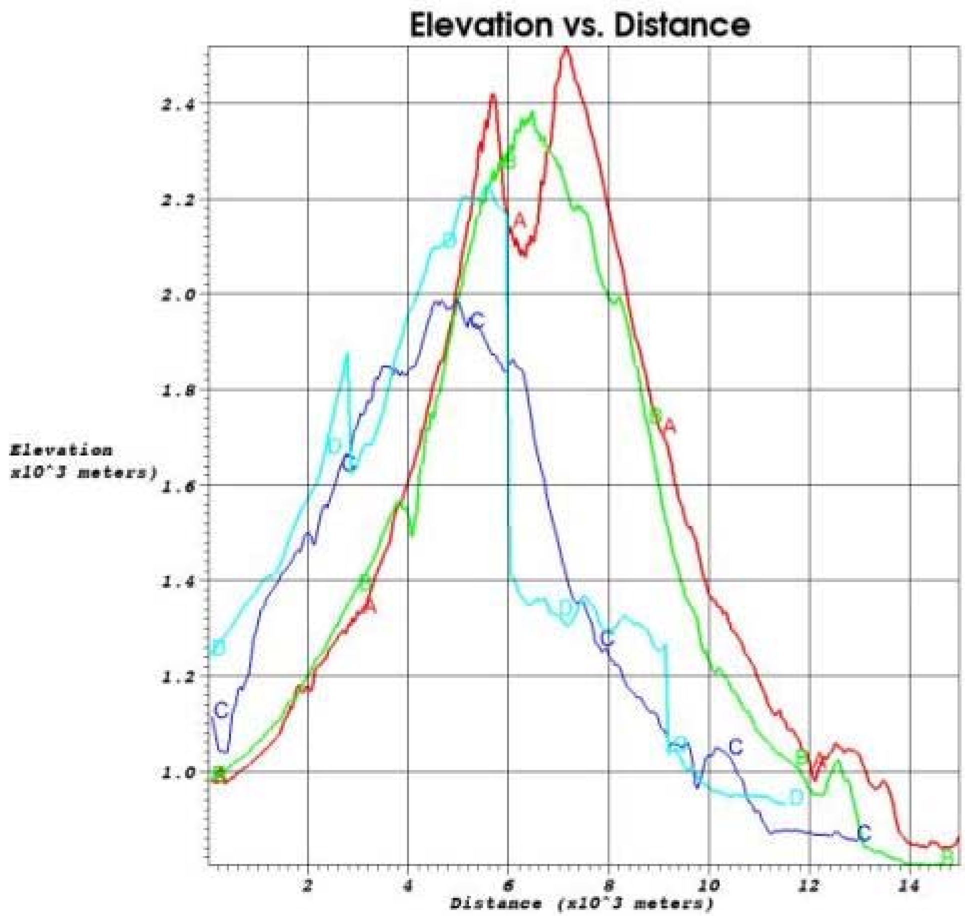
Terrain rendering: VisIt can read several file formats common in the field of Geographic Information Systems (GIS), allowing one to plot raster data such as terrain data in visualizations. The featured image shows a plot of a DEM dataset containing mountainous areas near Dunsmuir, CA. Elevation lines are added to the plot to help delineate changes in elevation.

Tornado Simulation: This image was created from data generated by a tornado simulation calculated on NCSA's IBM p690 computing cluster. High-definition television animations of the storm produced at NCSA were included in an episode of the PBS television series NOVA called "Hunt for the Supertwister." The tornado is shown by spheres that are colored according to pressure; orange and blue tubes represent the rising and falling airflow around the tornado.

Climate visualization: This visualization depicts the carbon dioxide from various sources that are advected individually as tracers in the atmosphere model. Carbon dioxide from the ocean is shown as plumes during February 1900.

Atmospheric Anomaly in Times Square In the image the results from the SAMRAI simulation framework of an atmospheric anomaly in and around Times Square are visualized.

In the formal sciences



Curve plots

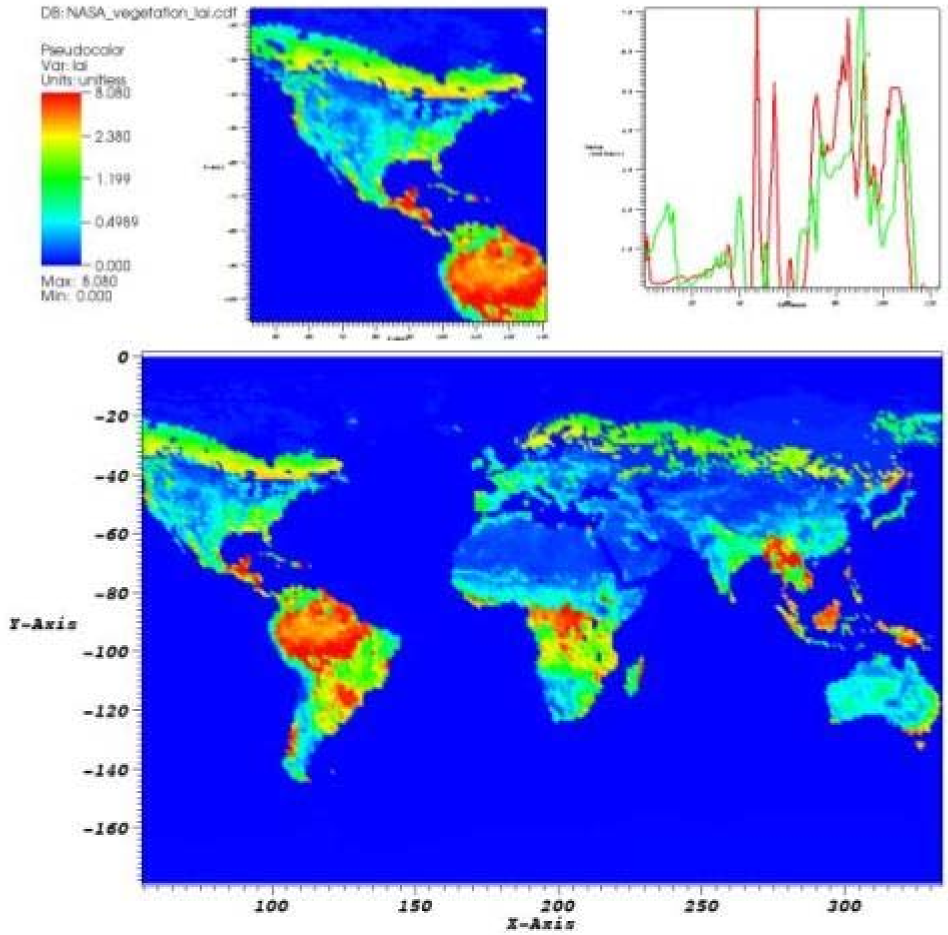
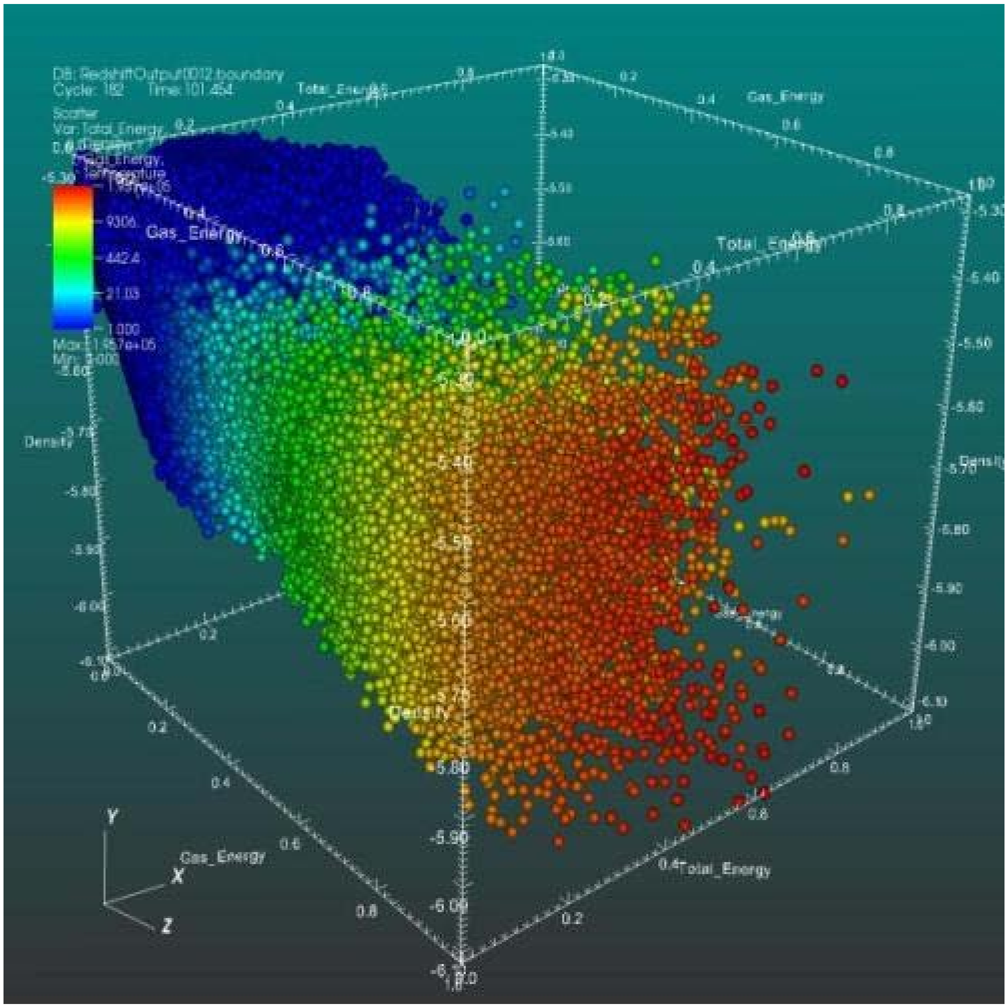


Image annotations



Scatter plot

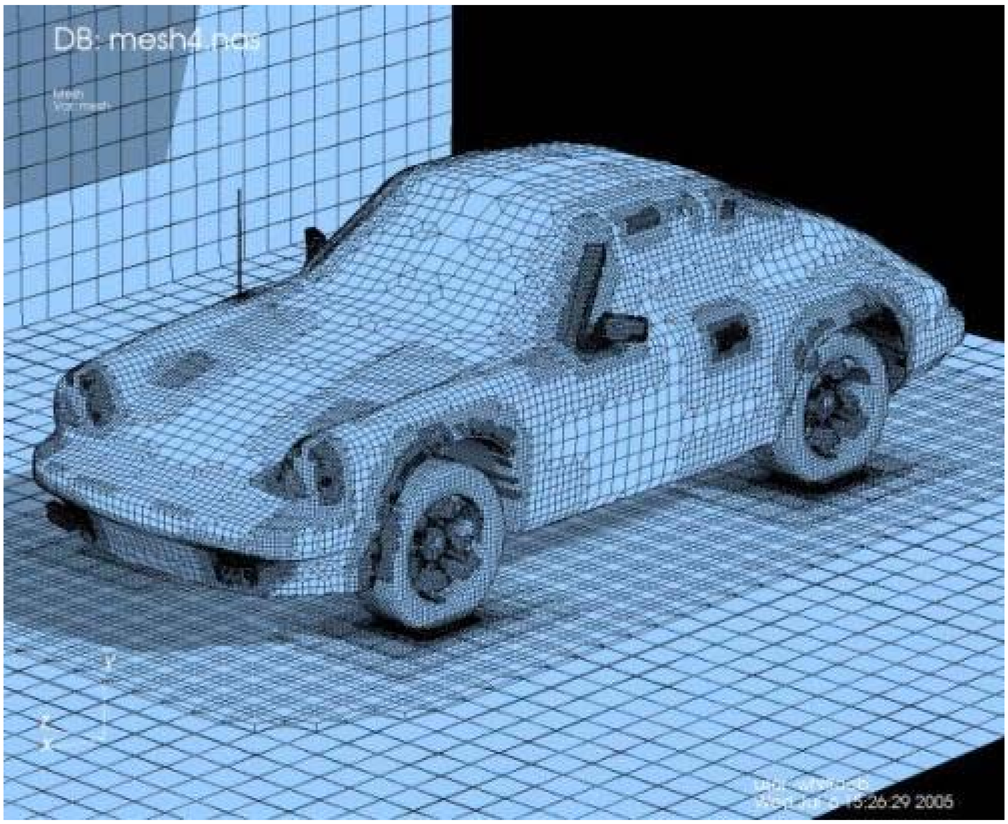
Computer mapping of topographical surfaces: Through computer mapping of topographical surfaces, mathematicians can test theories of how materials will change when stressed. The imaging is part of the work on the NSF-funded Electronic Visualization Laboratory at the University of Illinois at Chicago

Curve plots: VisIt can plot curves from data read from files and it can be used to extract and plot curve data from higher dimensional datasets using lineout operators or queries. The curves in the featured image correspond to elevation data along lines drawn on DEM data and were created with the feature lineout capability. Lineout allows you to interactively draw a line, which specifies a path for data extraction. The resulting data was then plotted as curves.

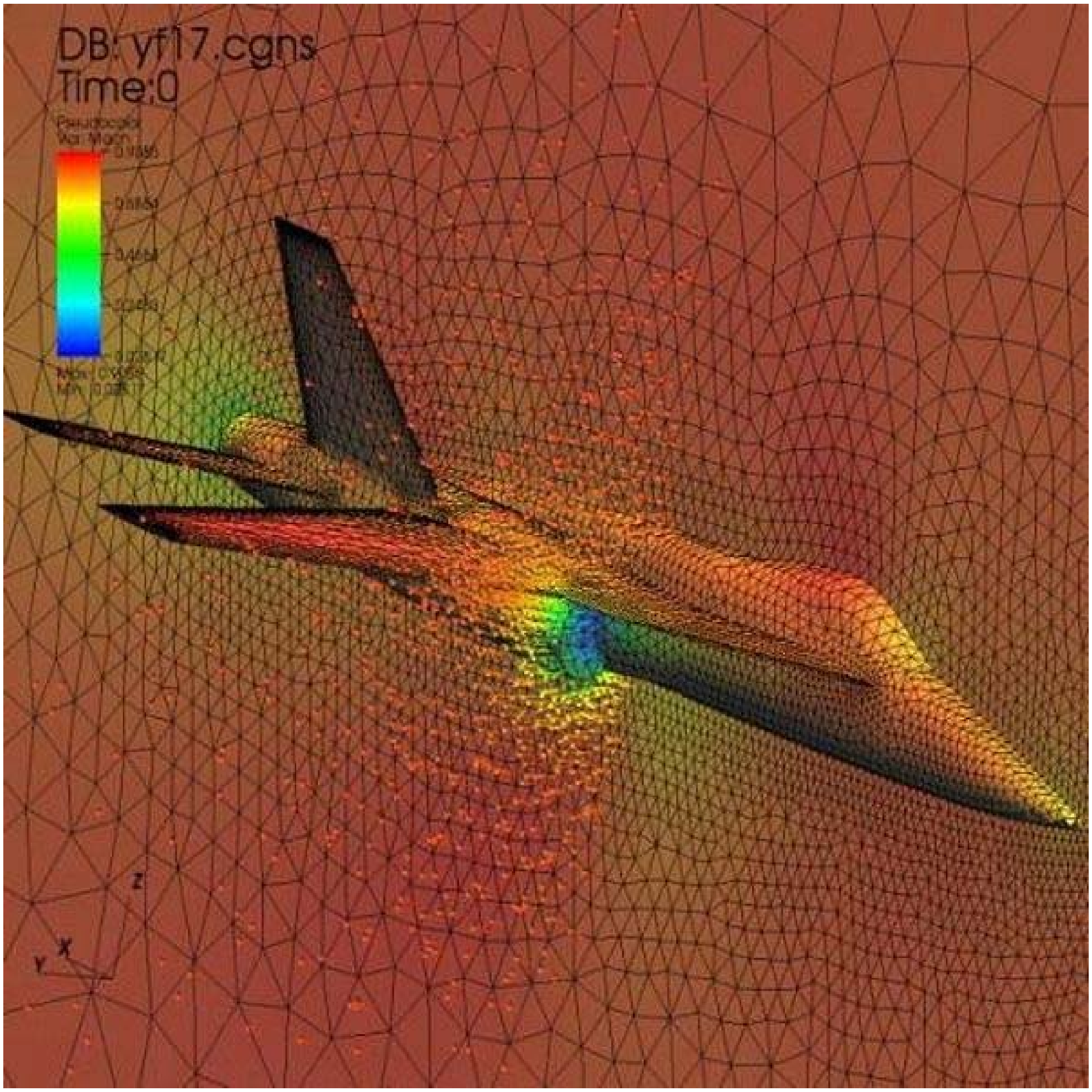
Image annotations: The featured plot shows Leaf Area Index (LAI), a measure of global vegetative matter, from a NetCDF dataset. The primary plot is the large plot at the bottom, which shows the LAI for the whole world. The plots on top are actually annotations that contain images generated earlier. Image annotations can be used to include material that enhances a visualization such as auxiliary plots, images of experimental data, project logos, etc.

Scatter plot: VisIt's Scatter plot allows to visualize multivariate data of up to four dimensions. The Scatter plot takes multiple scalar variables and uses them for different axes in phase space. The different variables are combined to form coordinates in the phase space and they are displayed using glyphs and colored using another scalar variable.

In the applied sciences



Porsche 911 model



YF-17 aircraft Plot

City rendering

Porsche 911 model (NASTRAN model): The featured plot contains a Mesh plot of a Porsche 911 model imported from a NASTRAN bulk data file. VisIt can read a limited subset of NASTRAN bulk data files, generally enough to import model geometry for visualization.

YF-17 aircraft Plot: The featured image displays plots of a CGNS dataset representing a YF-17 jet aircraft. The dataset consists of an unstructured grid with solution. The image was created by using a pseudocolor plot of the dataset's Mach variable, a Mesh plot of the grid, and Vector plot of a slice through the Velocity field.

City rendering: An ESRI shapefile containing a polygonal description of the building footprints was read in and then the polygons were resampled onto a rectilinear grid, which was extruded into the featured cityscape.

Inbound traffic measured: This image is a visualization study of inbound traffic measured in billions of bytes on the NSFNET T1 backbone for the month of September 1991. The traffic volume range is depicted from purple (zero bytes) to white (100 billion bytes). It represents data collected by Merit Network, Inc.

Scientific visualization experts

Bruce H. McCormick

Bruce H. McCormick (1930 - 2007) was an American computer scientist, who studied Physics from MIT, Cambridge University and Harvard University in the 1950s. In the 1960s he initiated and directed the ILLIAC III Image Processing Computer project and developed the first imaging of blood flow and macular degeneracy in the human retina. In the 1980s he organized and chaired the first Brain Mapping Machine Design Workshop in 1985. Two years later in 1987, he developed and promoted the concept of "scientific visualization" at the National Science Foundation Advisory Panel on Graphics, Image Processing, and Workstations.

Thomas A. DeFanti

Thomas A. DeFanti (born 1948) is an American computer graphics researcher and Director of the Electronic Visualization Laboratory (EVL), who studied mathematics and computer information science, with a PhD in Computer Graphics Research received in 1973. He joined the faculty of the University of Illinois at Chicago, and next he amassed a number of credits. He cofounded the Electronic Visualization Laboratory (EVL), used the EVL hardware and software for the computer animation produced for the Star Wars movie. DeFanti contributed greatly to the growth of the SIGGRAPH organization and conference.

Maxine D. Brown

Maxine D. Brown is an American computer scientist, and associate director of the Electronic Visualization Laboratory (EVL). She also studied mathematics and later computer science in the 1970s. She has a long history of service to the computer graphics and supercomputing communities, and has contributed to many facets of SIGGRAPH.

Clifford A. Pickover

Clifford A. Pickover is an American author, editor, and columnist in the fields of science, mathematics, and science fiction, primary interested in finding new ways to expand creativity by melding art, science, mathematics, and other seemingly disparate areas of human endeavor. In the 1990s he has edited several books, like "Frontiers of Scientific Visualization" (1994) and "Visualizing Biological Information" (1995).

Lawrence Jay Rosenblum

Lawrence J. Rosenblum (born 1949) is an American mathematician, and Program Director for Graphics and Visualization at the National Science Foundation. Rosenblum's research interests include mobile augmented reality (AR), scientific and uncertainty visualization, VR displays, and applications of VR/AR systems. His research group has produced advances in mobile augmented reality (AR), scientific and uncertainty visualization, VR displays, applications of VR/AR systems, and understanding human performance in graphics systems.

Other visualisation experts in this field:

- Donna Cox
- Pat Hanrahan
- Bill Hibbard
- Jim Hoffman
- Chris Lilley (W3C)
- Julian Lombardi
- Dietmar Saupe

Scientific visualization organizations

Important laboratory in the field are:

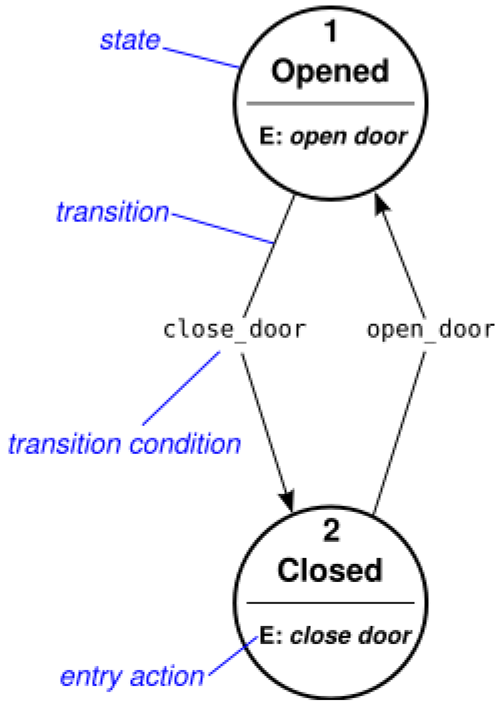
- Electronic Visualization Laboratory
- NASA Goddard Scientific Visualization Studio.

Conferences in this field, ranked by significance in scientific visualization research, are:

- IEEE Visualization
- EuroVis
- SIGGRAPH
- Eurographics
- Graphicon

Chapter 8

State Diagram



A state diagram for a door that can only be opened and closed

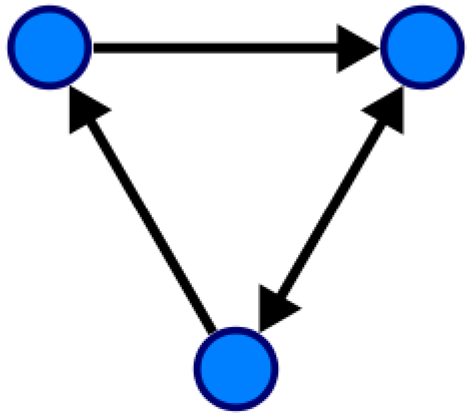
A **state diagram** is a type of diagram used in computer science and related fields to describe the behavior of systems. State diagrams require that the system described is composed of a finite number of states; sometimes, this is indeed the case, while at other times this is a reasonable abstraction. There are many forms of state diagrams, which differ slightly and have different semantics.

Overview

State diagrams are used to give an abstract description of the behavior of a system. This behavior is analyzed and represented in series of events, that could occur in one or more possible states. Hereby "each diagram usually represents objects of a single class and track the different states of its objects through the system".

State diagrams can be used to graphically represent finite state machines. This was introduced by Taylor Booth in his 1967 book "Sequential Machines and Automata Theory". Another possible representation is the State transition table.

Directed graph



A directed graph.

A classic form of a state diagram for a finite state machine is a directed graph with the following elements (Q,Σ,Z,δ,q_0,F):

- **States Q**: a finite set of vertices normally represented by circles and labelled with unique designator symbols or words written inside them;
- **Input symbols Σ**: a finite collection of input symbols or designators;
- **Output symbols Z**: a finite collection of output symbols or designators;

The output function ω represents the mapping of ordered pairs of input symbols and states onto output symbols, denoted mathematically as $\boldsymbol{\omega} : \boldsymbol{\Sigma} \times \mathbf{Q} \rightarrow \mathbf{Z}$.

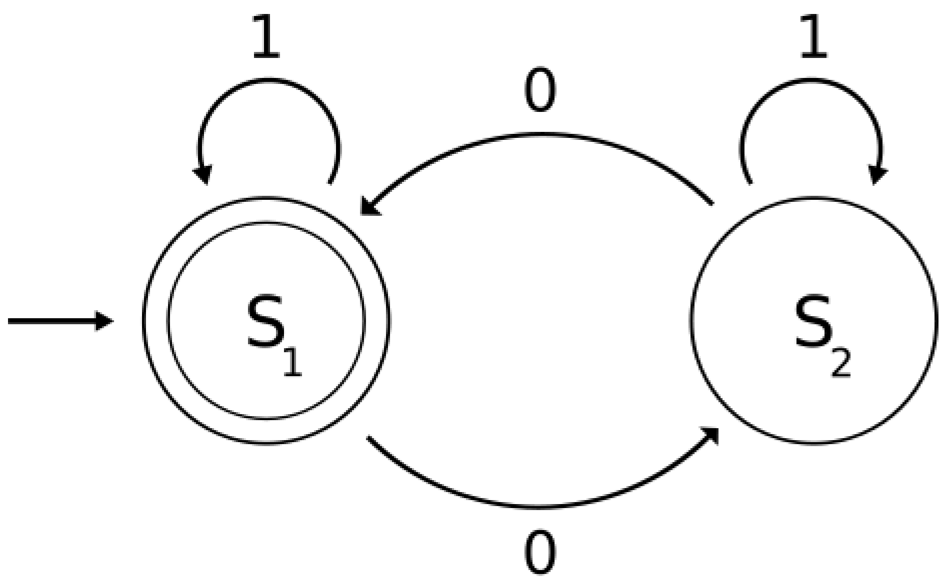
- **Edges δ**: represent the "transitions" between two states as caused by the input (identified by their symbols drawn on the "edges"). An 'edge' is usually drawn as an arrow directed from the present-state toward the next-state. This mapping describes the state transition that is to occur on input of a particular symbol. This is written mathematically as $\boldsymbol{\delta} : \boldsymbol{\Sigma} \times \mathbf{Q} \rightarrow \mathbf{Q}$
- **Start state q_0**: (not shown in the examples below). The start state $q_0 \in Q$ is usually represented by an arrow with no origin pointing to the state. In older texts, the start state is not shown and must be inferred from the text.
- **Accepting state(s) F**: If used, for example for accepting automata, $F \in Q$ is the accepting state. It is usually drawn as a double circle. Sometimes the accept state(s) function as "**F**inal" (halt, trapped) states.

For a deterministic finite state machine (DFA), nondeterministic finite state machine (NFA), generalized nondeterministic finite state machine (GNFA), or Moore machine, the input is denoted on each edge. For a Mealy machine, input and output are signified on each edge, separated with a slash "/": "1/0" denotes the state change upon encountering the symbol "1" causing the symbol "0" to be output. For a Moore machine the state's output is usually written inside the state's circle, also separated from the state's designator with a slash "/". There are also variants that combine these two notations.

For example, if a state has a number of outputs (e.g. "a= motor counter-clockwise=1, b= caution light inactive=0") the diagram should reflect this : e.g. "q5/1,0" designates state q5 with outputs a=1, b=0. This designator will be written inside the state's circle.

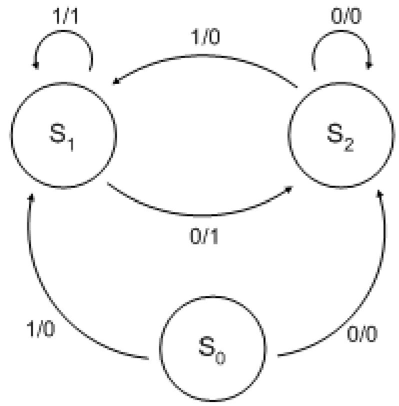
Example: DFA, NFA, GNFA, or Moore machine

S_1 and S_2 are states and S_1 is an **accepting state** or a **final state**. Each edge is labeled with the input. This example shows an acceptor for strings over {0,1} that contain an even number of zeros.



Example: Mealy machine

S_0, S_1, and S_2 are states. Each edge is labeled with "*j* / *k*" where *j* is the input and *k* is the output.

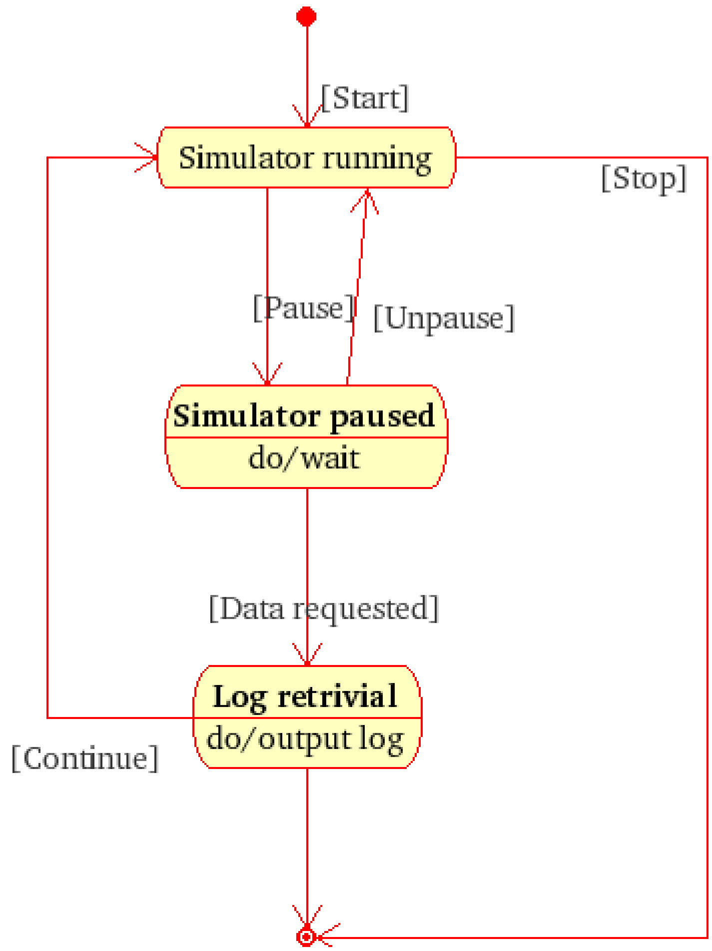


Harel statechart

Harel statecharts are gaining widespread usage since a variant has become part of the Unified Modeling Language (UML). The diagram type allows the modeling of superstates, orthogonal regions, and activities as part of a state.

Classic state diagrams require the creation of distinct nodes for every valid combination of parameters that define the state. This can lead to a very large number of nodes and transitions between nodes for all but the simplest of systems (state and transition explosion). This complexity reduces the readability of the state diagram. With Harel statecharts it is possible to model multiple cross-functional state diagrams within the statechart. Each of these cross-functional state machines can transition internally without affecting the other state machines in the statechart. The current state of each cross-functional state machine in the statechart defines the state of the system. The Harel statechart is equivalent to a state diagram but it improves the readability of the resulting diagram.

UML state diagram



Example UML State diagram.

The **UML state diagram** is essentially a Harel statechart with standardized notation , which can describe many systems, from computer programs to business processes. The following are the basic notational elements that can be used to make up a diagram:

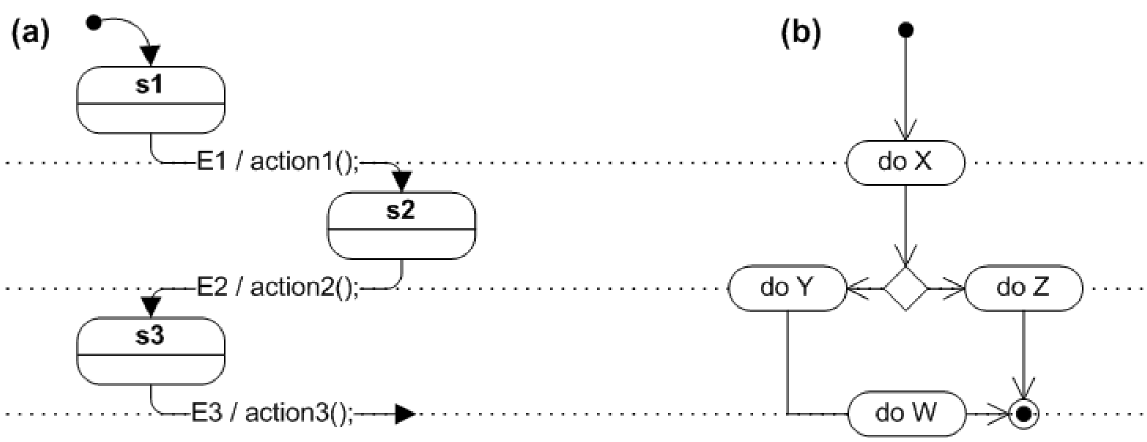
- Filled circle, pointing to the initial state
- Hollow circle containing a smaller filled circle, indicating the final state (if any)
- Rounded rectangle, denoting a state. Top of the rectangle contains a name of the state. Can contain a horizontal line in the middle, below which the activities that are done in that state are indicated
- Arrow, denoting transition. The name of the event (if any) causing this transition labels the arrow body. A guard expression may be added before a "/" and enclosed in square-brackets (***eventName*****[guardExpression]**), denoting that this expression must be true for the transition to take place. If an action is performed during this transition, it is added to the label following a "/" (***eventName*****[guardExpression]/action**).

- Thick horizontal line with either x>1 lines entering and 1 line leaving or 1 line entering and x>1 lines leaving. These denote join/fork, respectively.

State diagrams versus flowcharts

Newcomers to the state machine formalism often confuse **state diagrams** with **flowcharts**. For a long time, the UML specification didn't help in this respect because it used to lump activity graphs in the state machine package (the new UML 2 has finally separated activity diagrams from state machines). Activity diagrams are essentially elaborate flowcharts.

The figure below shows a comparison of a state diagram with a flowchart. A state machine (panel (a)) performs actions in response to explicit events. In contrast, the flowchart (panel (b)) does not need explicit events but rather transitions from node to node in its graph automatically upon completion of activities.



Graphically, compared to state diagrams, flowcharts reverse the sense of vertices and arcs. In a state diagram, the processing is associated with the arcs (transitions), whereas in a flowchart, it is associated with the vertices. A state machine is idle when it sits in a state waiting for an event to occur. A flowchart is busy executing activities when it sits in a node. The figure above attempts to show that reversal of roles by aligning the arcs of the state diagrams with the processing stages of the flowchart.

You can compare a flowchart to an assembly line in manufacturing because the flowchart describes the progression of some task from beginning to end (e.g., transforming source code input into object code output by a compiler). A state machine generally has no notion of such a progression. For example, is not in a more advanced stage when it is **in the "closed" state, compared to being in the "opened" state; it simply reacts differently to the open/close events. A state in a state machine is an efficient way of specifying a particular behavior, rather than a stage of processing.**

The distinction between state machines and flowcharts is especially important because these two concepts represent two diametrically opposed programming paradigms: event-driven programming (state diagrams) and structured programming (flowcharts). You cannot devise effective UML state machines without constantly thinking about the available events. In contrast, events are only a secondary concern (if at all) for flowcharts.

Other extensions

An interesting extension is to allow arcs to flow from any number of states to any number of states. This only makes sense if the system is allowed to be in multiple states at once, which implies that an individual state only describes a condition or other partial aspect of the overall, global state. The resulting formalism is known as a Petri net.

Another extension allows the integration of flowcharts within Harel statecharts. This extension supports the development of software that is both event driven and workflow driven.

Chapter 9

Visual Analytics

Scalable Reasoning Systems: Technology to support knowledge transfer and cooperative inquiry must offer its users the ability to effectively interpret knowledge structures produced by collaborators.

Visual analytics is an outgrowth of the fields information visualization and scientific visualization, that focuses on analytical reasoning facilitated by interactive visual interfaces.

Overview

Visual analytics is "the science of analytical reasoning facilitated by visual interactive interfaces." It can attack certain problems whose size, complexity, and need for closely coupled human and machine analysis may make them otherwise intractable. Visual analytics advances science and technology developments in analytical reasoning, interaction, data transformations and representations for computation and visualization, analytic reporting, and technology transition. As a research agenda, visual analytics brings together several scientific and technical communities from computer science, information visualization, cognitive and perceptual sciences, interactive design, graphic design, and social sciences.

R&D for Visual Analytics.

Visual analytics integrates new computational and theory-based tools with innovative interactive techniques and visual representations to enable human-information discourse. The design of the tools and techniques is based on cognitive, design, and perceptual principles. This science of analytical reasoning provides the reasoning framework upon which one can build both strategic and tactical visual analytics technologies for threat analysis, prevention, and response. Analytical reasoning is central to the analyst's task of applying human judgments to reach conclusions from a combination of evidence and assumptions.

Visual analytics has some overlapping goals and techniques with information visualization and scientific visualization. There is currently no clear consensus on the boundaries between these fields, but broadly speaking the three areas can be distinguished as follows:

- Scientific visualization deals with data that has a natural geometric structure (e.g., MRI data, wind flows).

- Information visualization handles abstract data structures such as trees or graphs.
- Visual analytics is especially concerned with sensemaking and reasoning.

Visual analytics seeks to marry techniques from information visualization with techniques from computational transformation and analysis of data. Information visualization forms part of the direct interface between user and machine, amplifying human cognitive capabilities in six basic ways:

1. by increasing cognitive resources, such as by using a visual resource to expand human working memory,
2. by reducing search, such as by representing a large amount of data in a small space,
3. by enhancing the recognition of patterns, such as when information is organized in space by its time relationships,
4. by supporting the easy perceptual inference of relationships that are otherwise more difficult to induce,
5. by perceptual monitoring of a large number of potential events, and
6. by providing a manipulable medium that, unlike static diagrams, enables the exploration of a space of parameter values.

These capabilities of information visualization, combined with computational data analysis, can be applied to analytic reasoning to support the sense-making process.

Topics

Scope

Visual analytics: research and practice.

Visual analytics is a multidisciplinary field that includes the following focus areas:

- Analytical reasoning techniques that enable users to obtain deep insights that directly support assessment, planning, and decision making
- Data representations and transformations that convert all types of conflicting and dynamic data in ways that support visualization and analysis
- Techniques to support production, presentation, and dissemination of the results of an analysis to communicate information in the appropriate context to a variety of audiences.
- Visual representations and interaction techniques that take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once

Analytical reasoning techniques

Analytical reasoning techniques are the method by which users obtain deep insights that directly support situation assessment, planning, and decision making. Visual analytics must facilitate high-quality human judgment with a limited investment of the analysts' time. Visual analytics tools must enable diverse analytical tasks such as:

- Understanding past and present situations quickly, as well as the trends and events that have produced current conditions
- Identifying possible alternative futures and their warning signs
- Monitoring current events for emergence of warning signs as well as unexpected events
- Determining indicators of the intent of an action or an individual
- Supporting the decision maker in times of crisis.

These tasks will be conducted through a combination of individual and collaborative analysis, often under extreme time pressure. Visual analytics must enable hypothesis-based and scenario-based analytical techniques, providing support for the analyst to reason based on the available evidence.

Data representations

Data representations are structured forms suitable for computer-based transformations. These structures must exist in the original data or be derivable from the data themselves. They must retain the information and knowledge content and the related context within the original data to the greatest degree possible. The structures of underlying data representations are generally neither accessible nor intuitive to the user of the visual analytics tool. They are frequently more complex in nature than the original data and are not necessarily smaller in size than the original data. The structures of the data representations may contain hundreds or thousands of dimensions and be unintelligible to a person, but they must be transformable into lower-dimensional representations for visualization and analysis.

Theories of visualization

Theories of visualization are:

- "Semiology of Graphics" in 1967 written by Jacques Bertin e
- "Languages of Art" from 1977 by Nelson Goodman
- Jock D. Mackinlay's "Automated design of optimal visualization" (APT) from 1986, and
- Leland Wilkinson's "Grammar of Graphics" from 1998,

Visual representations

Visual representations translate data into a visible form that highlights important features, including commonalities and anomalies. These visual representations make it easy for users to perceive salient aspects of their data quickly. Augmenting the cognitive reasoning process with perceptual reasoning through visual representations permits the analytical reasoning process to become faster and more focused.

Process

The input for the data sets used in the visual analytics process are heterogeneous data sources (i.e., the internet, newspapers, books, scientific experiments, expert systems). From these rich sources, the data sets $S = S_1, ..., S_m$ are chosen, whereas each S_i , $i \in (1, ..., m)$ consists of attributes $A_{i1}, ..., A_{ik}$. The goal or output of the process is insight *I*. Insight is either directly obtained from the set of created visualizations *V* or through confirmation of hypotheses *H* as the results of automated analysis methods. This formalization of the visual analytics process is illustrated in the following figure. Arrows represent the transitions from one set to another one.

More formal the visual analytics process is a transformation $F : S \rightarrow I$, whereas *F* is a concatenation of functions $f \in \{D_W, V_X, H_Y, U_Z\}$ defined as follows:

D_W describes the basic data pre-processing functionality with $D_W : S \rightarrow S$ *and* $W \in \{T, C, SL, I\}$ including data transformation functions D_T, data cleaning functions D_C, data selection functions D_{SL} and data integration functions D_I that are needed to make analysis functions applicable to the data set.

$V_W, W \in \{S, H\}$ symbolizes the visualization functions, which are either functions visualizing data $V_S : S \rightarrow V$ or functions visualizing hypotheses $V_H : H \rightarrow V$.

$H_Y, Y \in \{S, V\}$ represents the hypotheses generation process. We distinguish between functions that generate hyphotheses from data $H_S : S \rightarrow H$ and functions that generate hypotheses from visualizations $H_V : V \rightarrow H$.

Moreover, user interactions U_Z, $Z \in \{V, H, CV, CH\}$ are an integral part of the visual analytics process. User interactions can either effect only visualizations $U_V : V \rightarrow V$ (i.e., selecting or zooming), or can effect only hypotheses $U_H : H \rightarrow H$ by generating a new hypotheses from given ones. Furthermore, insight can be concluded from visualizations $U_{CV} : V \rightarrow I$ or from hypotheses $U_{CH} : H \rightarrow I$.

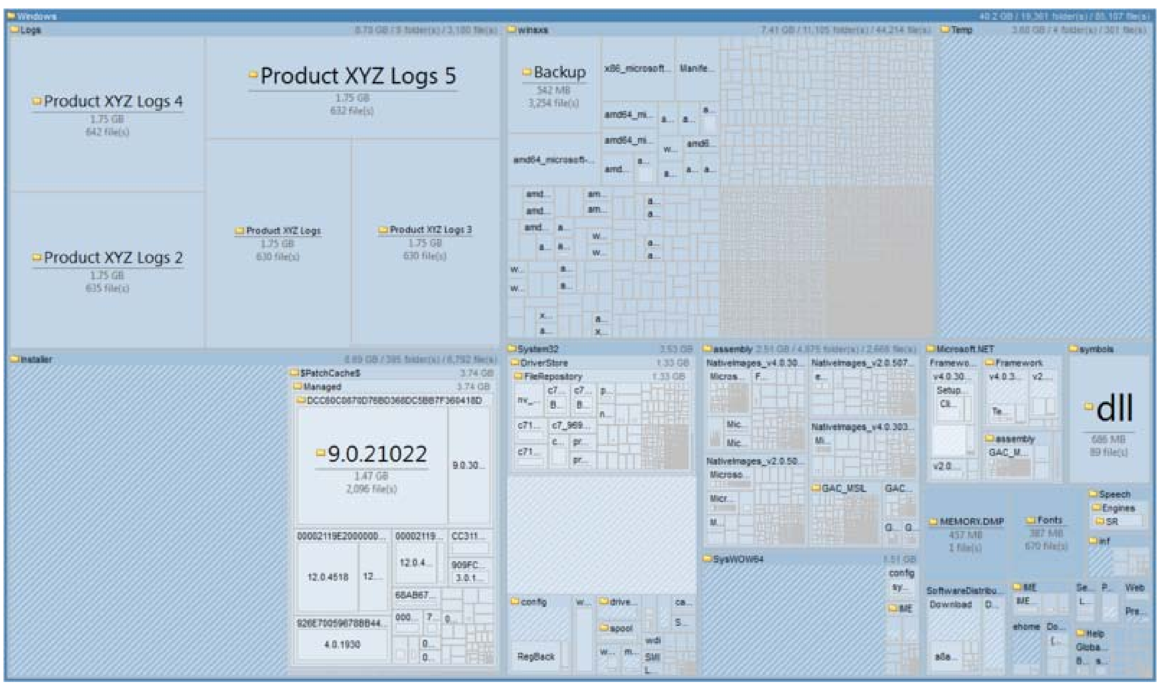
The typical data pre-processing applying data cleaning, data integration and data transformation functions is defined as $D_P = D_T(D_I(D_C(S_1, ..., S_n)))$. After the pre-processing step either automated analysis methods $H_S = \{f_{s1}, ..., f_{sq}\}$ (i.e., statistics, data mining, etc.) or visualization methods $V_S : S \rightarrow V$, $V_S = \{f_{v1}, ..., f_{vs}\}$ are applied to the data, in order to reveal patterns as shown in the figure above.

In general the following paradigm is used to process the data:
Analyse First – Show the Important – Zoom, Filter and Analyse Further – Details on Demand

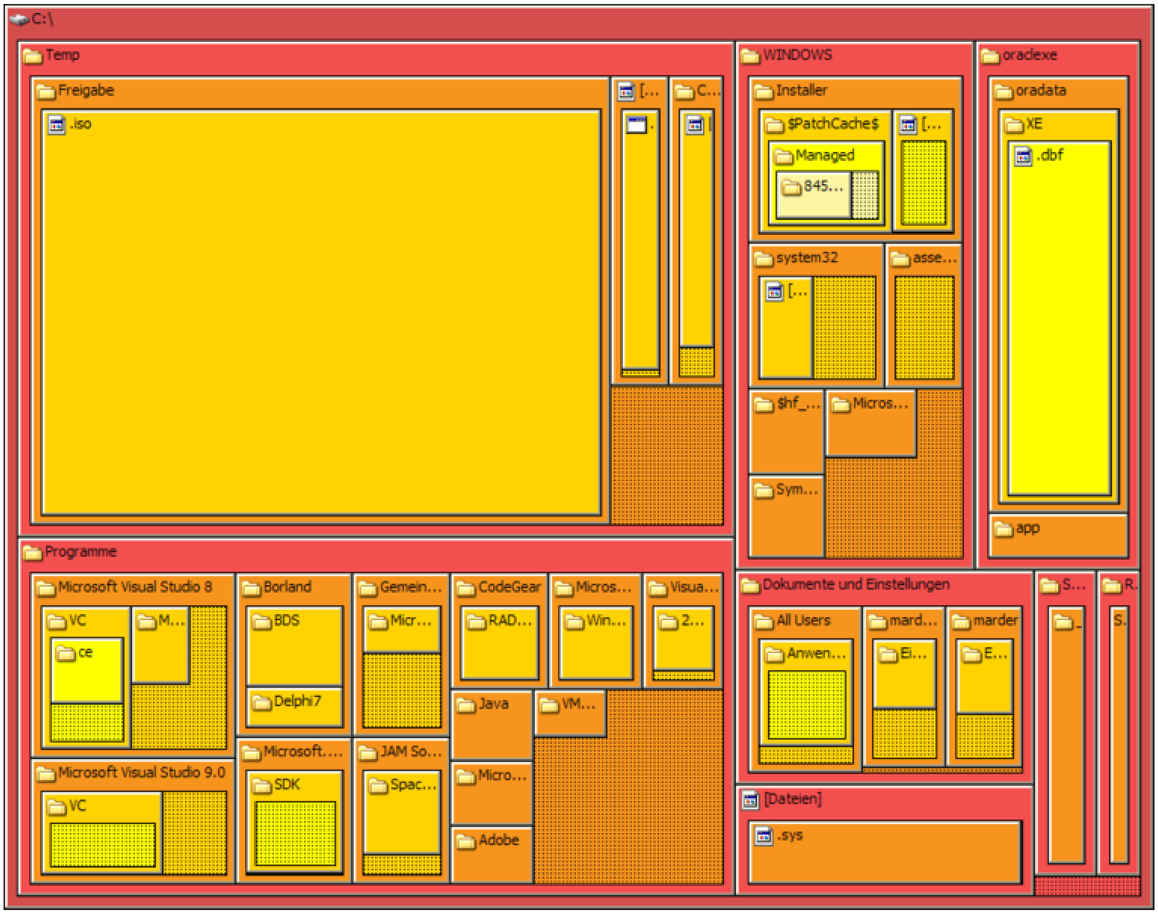
Chapter 10

Treemapping and Visual Learning

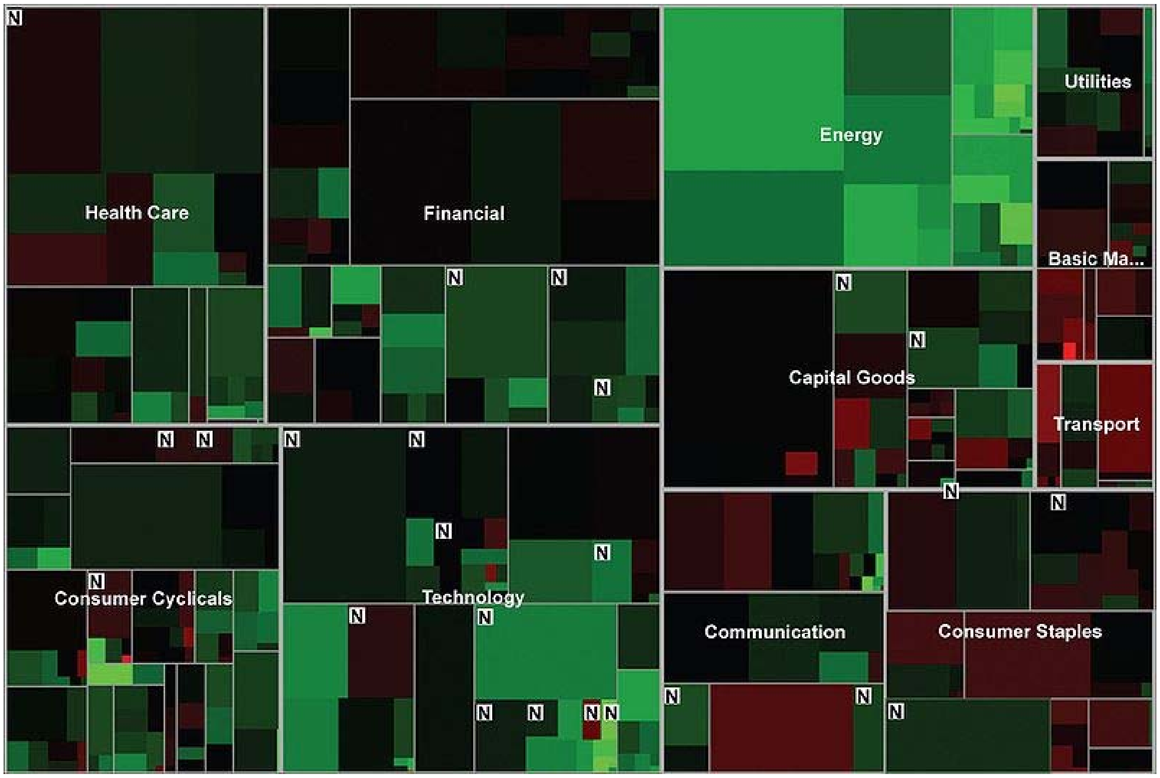
Treemapping



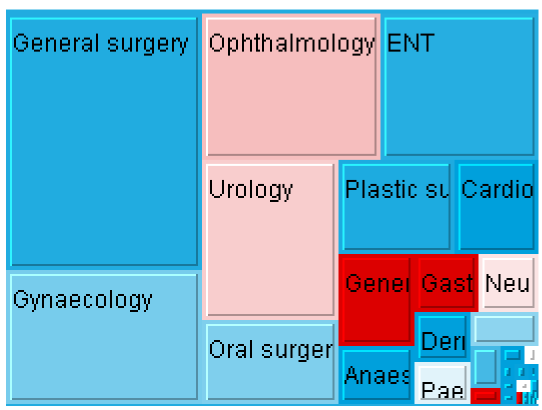
Folder map view in FolderSizes: Shows the distribution of file system objects by size within a limited screen space.



Tree Map in TreeSize: The hierarchical chart visualizes the sizes of each subfolder of a scanned directory



Smart Money magazine's Map of the Market illustrates both high-level overviews and company-level details about stock market activity.



Treemap showing changes in waiting times for patients of English PCTs.

Treemap of soft drink preference in a small group of people. Color and gradients are used to group items, while still identifying individual items.

In information visualization and computing, **treemapping** is a method for displaying hierarchical data by using nested rectangles.

Main idea

Treemaps display hierarchical (tree-structured) data as a set of nested rectangles. Each branch of the tree is given a rectangle, which is then tiled with smaller rectangles representing sub-branches. A leaf node's rectangle has an area proportional to a specified dimension on the data. (In the illustration, this is proportional to a waiting time). Often the leaf nodes are colored to show a separate dimension of the data.

When the color and size dimensions are correlated in some way with the tree structure, one can often easily see patterns that would be difficult to spot in other ways. A second advantage of treemaps is that, by construction, they make efficient use of space. As a result, they can legibly display thousands of items on the screen simultaneously.

The tiling algorithm

To create a treemap, one must define a tiling algorithm, that is, a way to divide a rectangle into sub-rectangles of specified areas. Ideally, a treemap algorithm would create rectangles of aspect ratio close to one, would furthermore preserve some sense of the ordering in the input data, and would change to reflect changes in the underlying data. Unfortunately, these properties have an inverse relationship. As the aspect ratio is optimized, the order of placement becomes less predictable. As the order becomes more stable, the aspect ratio is degraded.

To date, five primary rectangular treemap algorithms have been developed:

Treemap algorithms

algorithm	order	aspect ratios	stability
BinaryTree	partially ordered	high	stable
Ordered	partially ordered	medium	medium stability
Slice And Dice	ordered	very high	stable
Squarified	unordered	lowest	medium stability
Strip	ordered	medium	medium stability
Mixed Treemaps	ordered	lowest	stable

In addition, several algorithms have been proposed that use non-rectangular regions:

- **Voronoi Treemaps** - based on voronoi diagram calculations
- **Jigsaw Treemaps** - based on the geometry of space-filling curves

History

Area-based visualizations have existed for decades. Mosaic plots and Marimekko diagrams both use rectangular tilings to show joint distributions, for example. The main distinguishing feature of a treemap, however, is the recursive construction that allows it to be extended to hierarchical data with any number of levels. This idea was invented by University of Maryland, College Park professor Ben Shneiderman in the early 1990s. Shneiderman and his collaborators then deepened the idea by introducing a variety of interactive techniques for filtering and adjusting treemaps.

These early treemaps all used the simple "slice-and-dice" tiling algorithm. Despite many desirable properties (it is stable, preserves ordering, and is easy to implement), the slice-and-dice method often produces tilings with many long, skinny rectangles. In 1994 Hascoet & Beaudouin-Lafon invented a "squarifying" algorithm that created tilings whose rectangles were closer to square. This algorithm was later popularized by Jarke van Wijk while Martin Wattenberg designed a new "pivot and slice" algorithm. Using this algorithm, Wattenberg created the first web treemap, the SmartMoney Map of the Market, which displayed data on hundreds of companies in the U.S. stock market. Following its launch, treemaps enjoyed a surge of interest, especially in financial contexts.

A third wave of treemap innovation came around 2004, after Marcos Weskamp created the Newsmap, a treemap that displayed news headlines. This example of a non-analytical treemap inspired many imitators, and introduced treemaps to a new, broad audience. In recent years, treemaps have made their way into the mainstream media, including usage by the New York Times.

Visual learning

Visual learning is a teaching and learning style in which ideas, concepts, data and other information are associated with images and techniques. It is one of the three basic types of learning styles in the widely-used Fleming VAK/VARK model that also includes kinesthetic learning and auditory learning.

Theory

First let us place visual learning in it's proper context , learning as a whole .The influential management and systems thinker pioneer Russel Ackoff suggested , the most important contribution of a first rate 21st century education is not content . It is that we acquire the capability to learn and are motivated to do so throughout our lives , we are , by any objective standard , not doing a very good job. In the developed world today , falling global competitiveness is blamed on eduction [Karen Ward HSBC:2011] , our schools , our universities , our tried and tested auditory sequential systems are broken , no longer fit for purpose , a relic of the 19th century [Ackoff] . It is through this lens that we should judge the early pioneers attempts to use psychology to better our society .The great promise of learning styles , we can prepare our population so they are better able to internalize , reflect , boil down , apply and synthesize information from many , many different sources over extended time frames . As a society we can do better , we must do better and we will do better

Although learning styles have "enormous popularity" and both children and adults express personal preferences, there is no evidence that identifying a student's learning style produces better outcomes, and there is significant evidence that the widespread "meshing hypothesis" (that a student will learn best if taught in a method deemed appropriate for the student's learning style) is invalid. Well-designed studies "flatly contradict the popular meshing hypothesis".

The studies flat contradiction fails by confusing practice and theory . The popular meshing hypothesis as implemented by the study designers is much too simplistic in both application and conception . If learning styles are to become a true science of attention proper screening has to be introduced , differentiated materials need to be prepared and communicated in multiple mediums so the learning channels need to overlapped in the correct order . In short a scientific approach .

Visual learning techniques

Creating graphic organizers - Students create graphic organizers such as diagrams, webs, and concept maps by selecting symbols to represent ideas and information. To show the relationships between ideas, students link the symbols and add words to further clarify meaning.

By representing information spatially and with images, students are able to focus on meaning, reorganize and group similar ideas easily, make better use of their visual memory.

In a study entitled *Graphic Organizers: A Review of Scientifically Based Research,* The Institute for the Advancement of Research in Education at AEL evaluated 29 studies and concluded that visual learning improves student performance in the following areas:

- *Critical Thinking*--Graphic organizers link verbal and visual information to help students make connections, understand relationships and recall related details.

Retention
: According to research, students better remember information when it's represented and learned both visually and verbally.

Comprehension
: Students better comprehend new ideas when they are connected to prior knowledge.

Organization
: Students can use diagrams to display large amounts of information in ways that are easy to understand and help reveal relationships and patterns.

Visualising data - When working with data, students build data literacy as they collect and explore information in a dynamic inquiry process, using tables and plots to visually investigate, manipulate and analyze data. As students explore the way data moves through various plot types, such as Venn, stack, pie and axis, they formulate questions and discover meaning from the visual representation.

Tips For Students Who Are Visual Learners

The following are some suggested techniques for students who are visual learners, which can be used to make learning and education more effective.

Study Habits

- Understand the big picture, and have it in front of you as you examine smaller details.
- When trying to learn or memorize a piece of information, close your eyes and try to visualize it. If using flashcards, limit the information on each card so it can be easily recalled in your mind.

- Try to find alternate materials to study from; videos, PowerPoint presentations, maps, etc.

Learning During Lectures

- Avoid visual distractions. Looking out the window or at the person in front of you will not help you learn the material.
- Make illustrations as you take notes. Draw pictures to help you visualize information. Graphs, maps, and images are helpful in retaining information.
- After class, review and organize your notes. This will help you to sort out the information in a way that is meaningful to you and further solidify the material.

Learning From Textbooks

- Preview the chapter by looking through titles, graphs, charts and other visual aids. This will help you obtain the 'big picture' of what you will be learning.
- Use highlighters to emphasize pieces of the material that are especially important. Color-coding is often useful as well.
- Take notes or make illustrations in the margins, or, if it is a textbook you shouldn't be writing in, put them in a separate notebook.

Test Taking

- Think of visual cues used in learning to recall the information for a test. One way to do this is to sit in the same place every time you are in class, then make sure to get the same seat on test day. The visual cues your mind picks up while learning can help you recall information when they are seen again.
- If you find that timed tests are difficult for you or that you feel anxiety when taking tests with a time limit, discuss it with your instructor. Teachers give tests to gather an accurate assessment of the students' progress.

Teaching Visual Learners/ Instructor Course Design

There are some elements of design that can be incorporated into any course that will help ensure learning success:

Simplicity

Distance Education course creators sometimes become victims of the "more is better" concept. This is not the best case when developing a course site. Including everything you have or can find on a topic can overwhelm and confuse students. Improper use of fonts, colors, and graphics can also serve as a distraction and hamper the effectiveness of your course. Another common problem in Blackboard courses is the use of too many buttons or links on the course menu. Keeping the content, menu, color and font variations to a minimum can help keep your site design simple.

Consistency

Consistency can greatly reduce the time initially required to navigate your course site. Consistency across pages can reduce the load on cognitive processing and prevent cognitive overload. If learning to use a course is a quick and painless process, learners are motivated to continue. Consistencies should include: colors, backgrounds, fonts, headings, text layout, folder management, and placement of course materials.

Some inconsistencies, if used correctly and infrequently, such as changing text formats can quickly grab a learner's attention. These might include a highlighted line of text, or an altered color scheme to indicate a change of topic.

Personalizing

Personalizing your course site is also important in order to establish instructor presence, which has been shown to increase student engagement. Some ideas to accomplish this include:

- Add a course banner
- Add a personal picture within "Staff (Faculty) Information"
- Add personal audio clips conveying reinforcement.

Also remember to set proper "availabilities" within your Blackboard's control panel. These course options allow you to customize your course by making only the features you will use "available" to students.

Improvements can be made to enhance the "user friendliness" of your course by creating and managing folders. It's best if folders are arranged and labeled in a logical and consistent sequence. Some common "labels" used for folders - Module - Unit - Week (and number) - Topic - Lesson. Consistency in folder management, labeling and corresponding discussion forums will help students easily navigate throughout your course without aggravation.

Design goals

Remember to keep the following goals in as you create course content.

Design your content:

- to focus attention
- to avoid visual fatigue and cognitive overload
- for scanning
- to educate and not to impress
- for various learning styles
- for consistency

Chapter 11

Map Projection

A **map projection** is any method of representing the surface of a sphere or other three-dimensional body on a plane. Map projections are necessary for creating maps. All map projections distort the surface in some fashion. Depending on the purpose of the map, some distortions are acceptable and others are not; therefore different map projections exist in order to preserve some properties of the sphere-like body at the expense of other properties. There is no limit to the number of possible map projections.

Background

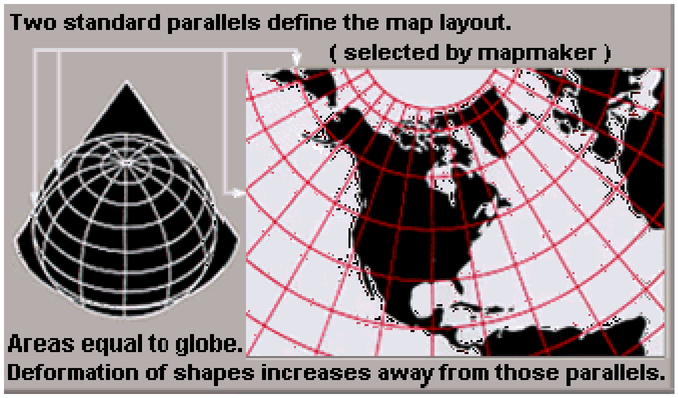
For simplicity, we usually assumes that the surface to be mapped is the surface of a sphere. However, the Earth and other sufficiently large celestial bodies are generally better modeled as oblate spheroids, and small objects such as asteroids may have irregular shapes. These other surfaces can be mapped as well. Therefore, more generally, a map projection is any method of "flattening" into a plane a continuous surface having curvature in all three spatial dimensions.

Projection as used here is not limited to perspective projections, such as those resulting from casting a shadow on a screen, or the rectilinear image produced by a pinhole camera on a flat film plate. Rather, any mathematical function transforming coordinates from the curved surface to the plane is a projection.

Carl Friedrich Gauss's Theorema Egregium proved that a sphere cannot be represented on a plane without distortion. Since any method of representing a sphere's surface on a plane is a map projection, all map projections distort. Every distinct map projection distorts in a distinct way. The study of map projections is the characterization of these distortions.

A map of the earth is a representation of a curved surface on a plane. Therefore a map projection must have been used to create the map, and, conversely, maps could not exist without map projections. Maps can be more useful than globes in many situations: they are more compact and easier to store; they readily accommodate an enormous range of scales; they are viewed easily on computer displays; they can facilitate measuring properties of the terrain being mapped; they can show larger portions of the Earth's surface at once; and they are cheaper to produce and transport. These useful traits of maps motivate the development of map projections.

Metric properties of maps



An Albers projection shows areas accurately, but distorts shapes.

Many properties can be measured on the Earth's surface independently of its geography. Some of these properties are:

- Area
- Shape
- Direction
- Bearing
- Distance
- Scale

Map projections can be constructed to preserve one or more of these properties, though not all of them simultaneously. Each projection preserves or compromises or approximates basic metric properties in different ways. The purpose of the map determines which projection should form the base for the map. Because many purposes exist for maps, many projections have been created to suit those purposes.

Another major concern that drives the choice of a projection is the compatibility of data sets. Data sets are geographic information. As such, their collection depends on the chosen model of the Earth. Different models assign slightly different coordinates to the same location, so it is important that the model be known and that the chosen projection be compatible with that model. On small areas (large scale) data compatibility issues are more important since metric distortions are minimal at this level. In very large areas (small scale), on the other hand, distortion is a more important factor to consider.

Which map is best?

Cartographers have long despaired over publishers' inappropriate use of the Mercator.

A 1943 New York Times editorial states:

The time has come to discard [the Mercator] for something that represents the continents and directions less deceptively... Although its usage... has diminished... it is still highly popular as a wall map apparently in part because, as a rectangular map, it fills a rectangular wall space with more map, and clearly because its familiarity breeds more popularity.

The Peters map controversy motivated the American Cartographic Association (now Cartography and Geographic Information Society) to produce a series of booklets (including *Which Map is Best*) designed to educate the public about map projections and distortion in maps. In 1989 and 1990, after some internal debate, seven North American geographic organizations adopted the following resolution, which rejected all rectangular world maps, a category that includes both the Mercator and the Gall–Peters projections:

WHEREAS, the earth is round with a coordinate system composed entirely of circles, and

WHEREAS, flat world maps are more useful than globe maps, but flattening the globe surface necessarily greatly changes the appearance of Earth's features and coordinate systems, and

WHEREAS, world maps have a powerful and lasting effect on people's impressions of the shapes and sizes of lands and seas, their arrangement, and the nature of the coordinate system, and

WHEREAS, frequently seeing a greatly distorted map tends to make it "look right,"

THEREFORE, we strongly urge book and map publishers, the media and government agencies to cease using rectangular world maps for general purposes or artistic displays. Such maps promote serious, erroneous conceptions by severely distorting large sections of the world, by showing the round Earth as having straight edges and sharp corners, by representing most distances and direct routes incorrectly, and by portraying the circular coordinate system as a squared grid. The most widely displayed rectangular world map is the Mercator (in fact a navigational diagram devised for nautical charts), but other rectangular world maps proposed as replacements for the Mercator also display a greatly distorted image of the spherical Earth.

Construction of a map projection

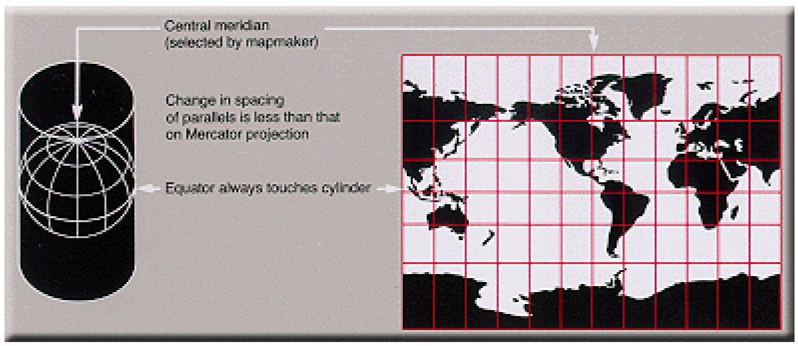
The creation of a map projection involves two steps:

1. Selection of a model for the shape of the Earth or planetary body (usually choosing between a sphere or ellipsoid). Because the Earth's actual shape is irregular, information is lost in this step.

2. Transformation of geographic coordinates (longitude and latitude) to Cartesian (x,y) or polar plane coordinates. Cartesian coordinates normally have a simple relation to eastings and northings defined on a grid superimposed on the projection.

Some of the simplest map projections are literally projections, as obtained by placing a light source at some definite point relative to the globe and projecting its features onto a specified surface. This is **not** the case for most projections which are defined **only** in terms of mathematical formulae that have no direct physical interpretation.

Choosing a projection surface

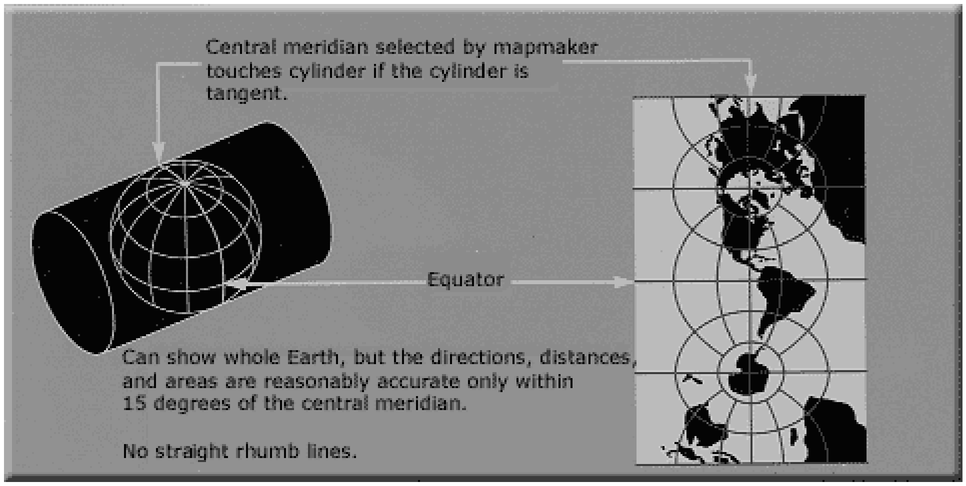


A Miller cylindrical projection maps the globe onto a cylinder.

A surface that can be unfolded or unrolled into a plane or sheet without stretching, tearing or shrinking is called a *developable surface*. The cylinder, cone and of course the plane are all developable surfaces. The sphere and ellipsoid are not developable surfaces. As noted in the introduction, any projection of a sphere (or an ellipsoid) onto a plane will have to distort the image. (To compare, one cannot flatten an orange peel without tearing or warping it.)

One way of describing a projection is first to project from the Earth's surface to a developable surface such as a cylinder or cone, and then to unroll the surface into a plane. While the first step inevitably distorts some properties of the globe, the developable surface can then be unfolded without further distortion.

Aspects of the projection



This transverse Mercator projection is mathematically the same as a standard Mercator, but oriented around a different axis.

Once a choice is made between projecting onto a cylinder, cone, or plane, the **aspect** of the shape must be specified. The aspect describes how the developable surface is placed relative to the globe: it may be *normal* (such that the surface's axis of symmetry coincides with the Earth's axis), *transverse* (at right angles to the Earth's axis) or *oblique* (any angle in between). The developable surface may also be either *tangent* or *secant* to the sphere or ellipsoid. Tangent means the surface touches but does not slice through the globe; secant means the surface does slice through the globe. Insofar as preserving metric properties goes, it is never advantageous to move the developable surface away from contact with the globe, so that possibility is not discussed here.

Scale

A globe is the only way to represent the earth with constant scale throughout the entire map in all directions. A map cannot achieve that property for any area, no matter how small. It can, however, achieve constant scale along specific lines.

Some possible properties are:

- The scale depends on location, but not on direction. This is equivalent to preservation of angles, the defining characteristic of a conformal map.
- Scale is constant along any parallel in the direction of the parallel. This applies for any cylindrical or pseudocylindrical projection in normal aspect.
- Combination of the above: the scale depends on latitude only, not on longitude or direction. This applies for the Mercator projection in normal aspect.
- Scale is constant along all straight lines radiating from a particular geographic location. This is the defining characteristic of an equidistant projection such as the Azimuthal equidistant projection. There are also projections (Maurer, Close) where true distances from *two* points are preserved.

Choosing a model for the shape of the Earth

Projection construction is also affected by how the shape of the Earth is approximated. In the following discussion on projection categories, a sphere is assumed. However, the Earth is not exactly spherical but is closer in shape to an oblate ellipsoid, a shape which bulges around the equator. Selecting a model for a shape of the Earth involves choosing between the advantages and disadvantages of a sphere versus an ellipsoid. Spherical models are useful for small-scale maps such as world atlases and globes, since the error at that scale is not usually noticeable or important enough to justify using the more complicated ellipsoid. The ellipsoidal model is commonly used to construct topographic maps and for other large- and medium-scale maps that need to accurately depict the land surface.

A third model of the shape of the Earth is the geoid, a complex and more accurate representation of the global mean sea level surface that is obtained through a combination of terrestrial and satellite gravity measurements. This model is not used for mapping, because of its complexity, but is used for control purposes in the construction of geographic datums. (In geodesy, plural of "datum" is "datums" rather than "data".) A geoid is used to construct a datum by adding irregularities to the ellipsoid in order to better match the Earth's actual shape. It takes into account the large-scale features in the Earth's gravity field associated with mantle convection patterns, and the gravity signatures of very large geomorphic features such as mountain ranges, plateaus and plains. Historically, datums have been based on ellipsoids that best represent the geoid within the region that the datum is intended to map. Each ellipsoid has a distinct major and minor axis. Different controls (modifications) are added to the ellipsoid in order to construct the datum, which is specialized for a specific geographic region (such as the North American Datum). A few modern datums, such as WGS84 which is used in the Global Positioning System, are optimized to represent the entire earth as well as possible with a single ellipsoid, at the expense of accuracy in smaller regions.

Classification

A fundamental projection classification is based on the type of projection surface onto which the globe is conceptually projected. The projections are described in terms of placing a gigantic surface in contact with the earth, followed by an implied scaling operation. These surfaces are cylindrical (e.g. Mercator), conic (e.g., Albers), or azimuthal or plane (e.g. stereographic). Many mathematical projections, however, do not neatly fit into any of these three conceptual projection methods. Hence other peer categories have been described in the literature, such as pseudoconic, pseudocylindrical, pseudoazimuthal, retroazimuthal, and polyconic.

Another way to classify projections is according to properties of the model they preserve. Some of the more common categories are:

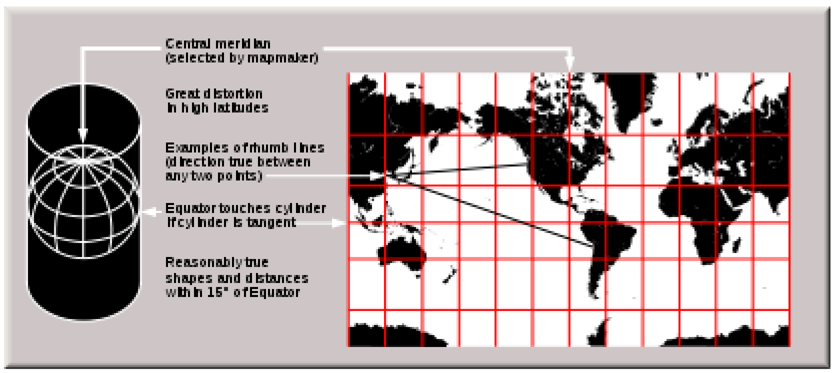
- Preserving direction (*azimuthal*), a trait possible only from one or two points to every other point

- Preserving shape locally (*conformal* or *orthomorphic*)
- Preserving area (*equal-area* or *equiareal* or *equivalent* or *authalic*)
- Preserving distance (*equidistant*), a trait possible only between one or two points and every other point
- Preserving shortest route, a trait preserved only by the gnomonic projection

NOTE: Because the sphere is not a developable surface, it is impossible to construct a map projection that is both equal-area and conformal.

Projections by surface

Cylindrical



The Mercator projection shows courses of constant bearing as straight lines.

The term "normal cylindrical projection" is used to refer to any projection in which meridians are mapped to equally spaced vertical lines and circles of latitude (parallels) are mapped to horizontal lines.

The mapping of meridians to vertical lines can be visualized by imagining a cylinder (of which the axis coincides with the Earth's axis of rotation) wrapped around the Earth and then projecting onto the cylinder, and subsequently unfolding the cylinder.

By the geometry of their construction, cylindrical projections stretch distances east-west. The amount of stretch is the same at any chosen latitude on all cylindrical projections, and is given by the secant of the latitude as a multiple of the equator's scale. The various cylindrical projections are distinguished from each other solely by their north-south stretching (where latitude is given by φ):

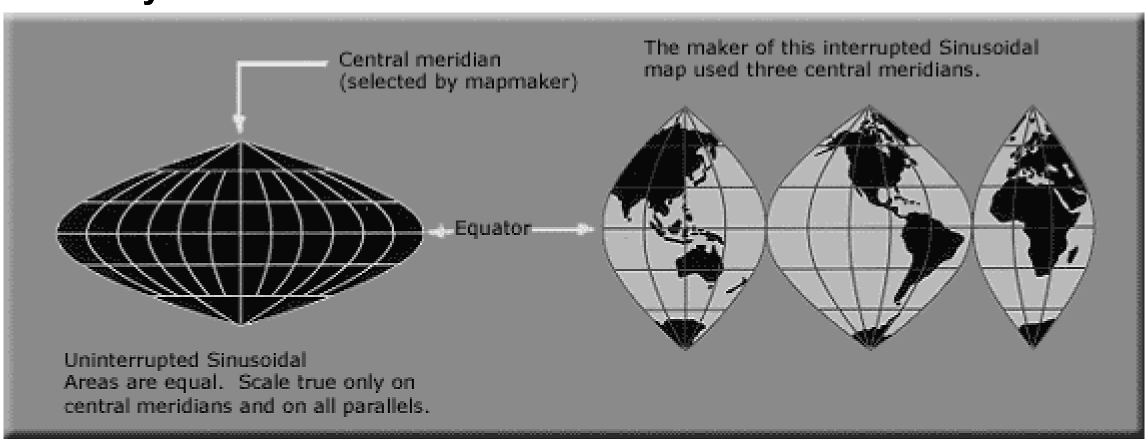
- North-south stretching is equal to the east-west stretching (secant φ): The east-west scale matches the north-south scale: conformal cylindrical or Mercator; this distorts areas excessively in high latitudes.
- North-south stretching growing rapidly with latitude, even faster than east-west stretching (secant² φ: The cylindric perspective (= central cylindrical) projection; unsuitable because distortion is even worse than in the Mercator projection.

- North-south stretching grows with latitude, but less quickly than the east-west stretching: such as the Miller cylindrical projection (secant[4φ/5]).
- North-south distances neither stretched nor compressed (1): equidistant cylindrical or plate carrée.
- North-south compression precisely the reciprocal of east-west stretching (cosine φ): equal-area cylindrical (with many named specializations such as Gall–Peters or Gall orthographic, Behrmann, and Lambert cylindrical equal-area). This divides north-south distances by a factor equal to the secant of the latitude, preserving area but heavily distorting shapes.

In the first case (Mercator), the east-west scale always equals the north-south scale. In the second case (central cylindrical), the north-south scale exceeds the east-west scale everywhere away from the equator. Each remaining case has a pair of identical latitudes of opposite sign (or else the equator) at which the east-west scale matches the north-south-scale.

Normal cylindrical projections map the whole Earth as a finite rectangle, except in the first two cases, where the rectangle stretches infinitely tall while retaining constant width.

Pseudocylindrical



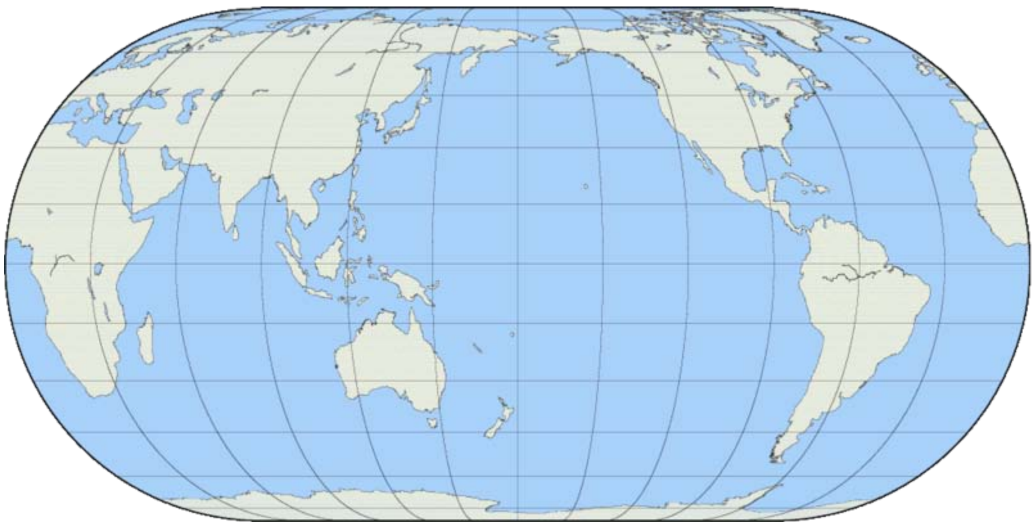
A sinusoidal projection shows relative sizes accurately, but grossly distorts shapes. Distortion can be reduced by "interrupting" the map.

Pseudocylindrical projections represent the *central* meridian and each parallel as a single straight line segment, but not the other meridians. Each pseudocylindrical projection represents a point on the Earth along the straight line representing its parallel, at a distance which is a function of its difference in longitude from the central meridian.

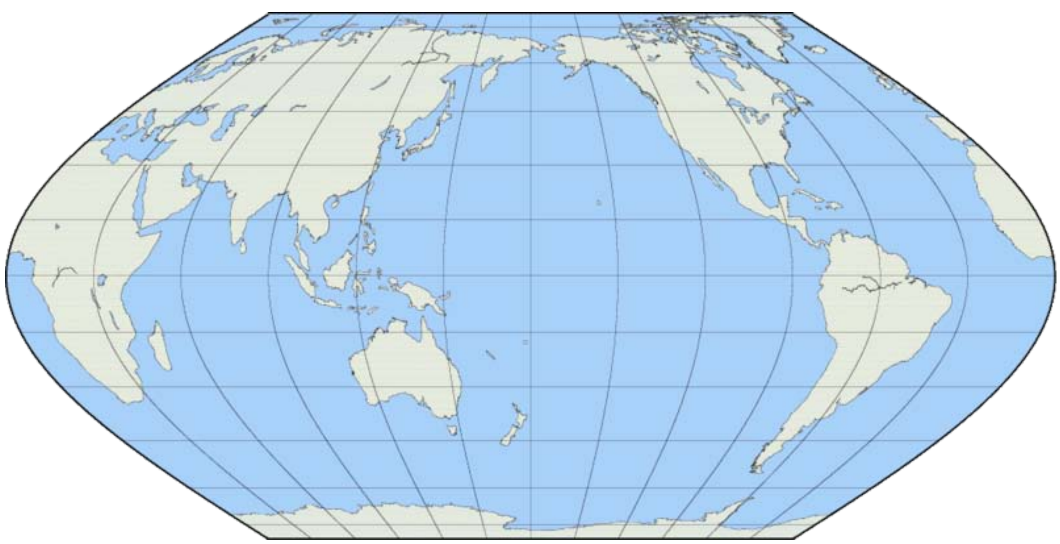
- Sinusoidal: the north-south scale and the east-west scale are the same throughout the map, creating an equal-area map. On the map, as in reality, the length of each parallel is proportional to the cosine of the latitude. Thus the shape of the map for the whole earth is the region between two symmetric rotated cosine curves.

The true distance between two points on the same meridian corresponds to the distance on the map between the two parallels, which is smaller than the distance between the two points on the map. The true distance between two points on the same parallel – and the true area of shapes on the map – are not distorted. The meridians drawn on the map help the user to realize the shape distortion and mentally compensate for it.

- Collignon projection, which in its most common forms represents each meridian as 2 straight line segments, one from each pole to the equator.
- Mollweide
- Goode homolosine
- Eckert IV



- Eckert VI



- Kavrayskiy VII
- Tobler hyperelliptical

Hybrid

The HEALPix projection combines an equal-area cylindrical projection in equatorial regions with the Collignon projection in polar areas.

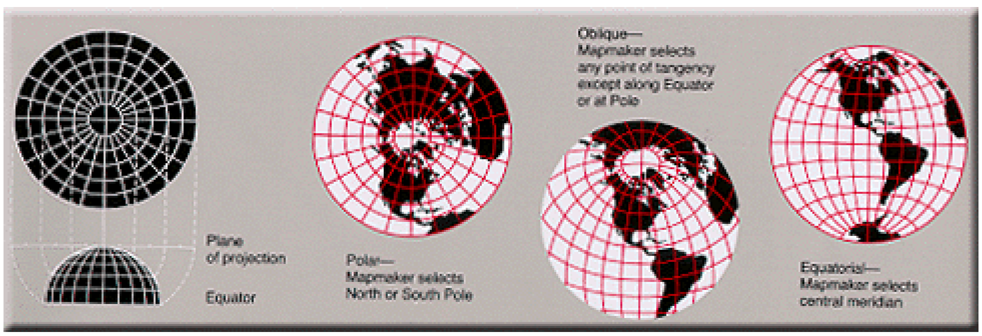
Conical

- Equidistant conic
- Lambert conformal conic
- Albers conic

Pseudoconical

- Bonne
- Werner cordiform designates a pole and a meridian; distances from the pole are preserved, as are distances from the meridian (which is straight) along the parallels
- Continuous American polyconic

Azimuthal (projections onto a plane)



An azimuthal projection shows distances and directions accurately from the center point, but distorts shapes and sizes elsewhere.

Azimuthal projections have the property that directions from a central point are preserved (and hence, great circles through the central point are represented by straight lines on the map). Usually these projections also have radial symmetry in the scales and hence in the distortions: map distances from the central point are computed by a function $r(d)$ of the true distance d, independent of the angle; correspondingly, circles with the central point as center are mapped into circles which have as center the central point on the map.

The mapping of radial lines can be visualized by imagining a plane tangent to the Earth, with the central point as tangent point.

The radial scale is $r'(d)$ and the transverse scale $r(d)/(R \sin(d/R))$ where R is the radius of the Earth.

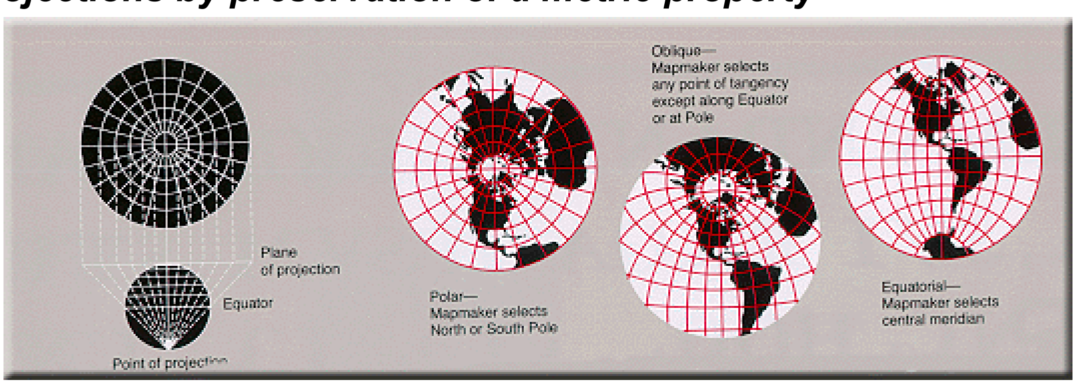
Some azimuthal projections are true perspective projections; that is, they can be constructed mechanically, projecting the surface of the Earth by extending lines from a point of perspective (along an infinite line through the tangent point and the tangent point's antipode) onto the plane:

- The gnomonic projection displays great circles as straight lines. Can be constructed by using a point of perspective at the center of the Earth. $r(d) = c \tan(d/R)$; a hemisphere already requires an infinite map,
- The General Perspective Projection can be constructed by using a point of perspective outside the earth. Photographs of Earth (such as those from the International Space Station) give this perspective.
- The orthographic projection maps each point on the earth to the closest point on the plane. Can be constructed from a point of perspective an infinite distance from the tangent point; $r(d) = c \sin(d/R)$. Can display up to a hemisphere on a finite circle. Photographs of Earth from far enough away, such as the Moon, give this perspective.
- The azimuthal conformal projection, also known as the stereographic projection, can be constructed by using the tangent point's antipode as the point of perspective. $r(d) = c \tan(d/2R)$; the scale is $c/(2R \cos^2(d/2R))$. Can display nearly the entire sphere on a finite circle. The full sphere requires an infinite map.

Other azimuthal projections are not true perspective projections:

- Azimuthal equidistant: $r(d) = cd$; it is used by amateur radio operators to know the direction to point their antennas toward a point and see the distance to it. Distance from the tangent point on the map is proportional to surface distance on the earth
- Lambert azimuthal equal-area. Distance from the tangent point on the map is proportional to straight-line distance through the earth: $r(d) = c \sin(d/2R)$
- Logarithmic azimuthal is constructed so that each point's distance from the center of the map is the logarithm of its distance from the tangent point on the Earth. Works well with cognitive maps. $r(d) = c \ln(d/d_0)$; locations closer than at a distance equal to the constant d_0 are not shown (, figure 6-5)

Projections by preservation of a metric property



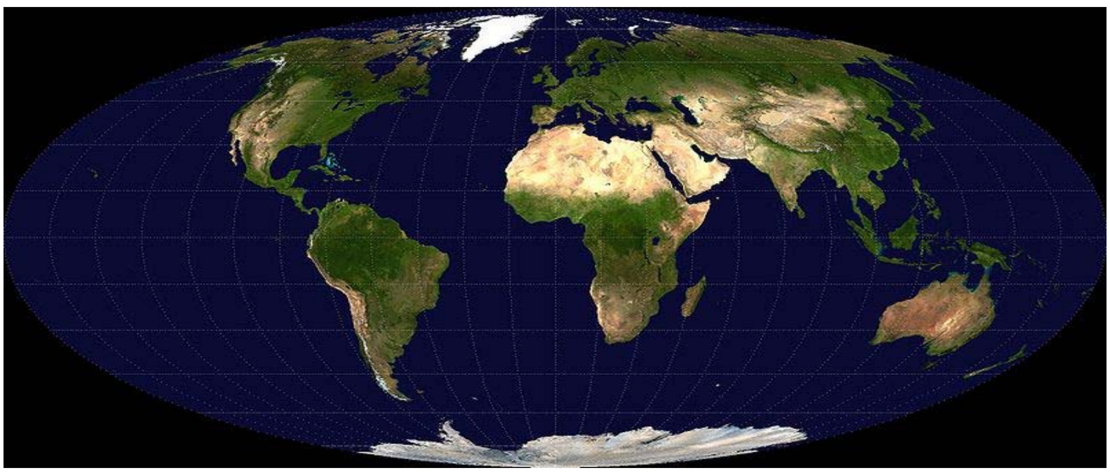
A stereographic projection is conformal and perspective but not equal area or equidistant.

Conformal

Conformal map projections preserve angles locally. These are some conformal projections:

- Mercator - rhumb lines are represented by straight segments
- Stereographic - shape of circles is conserved
- Roussilhe
- Lambert conformal conic
- Quincuncial map
- Adams hemisphere-in-a-square projection
- Guyou hemisphere-in-a-square projection

Equal-area



The equal-area Mollweide projection

These are some projections that preserve area:

- Gall orthographic (also known as Gall–Peters, or Peters, projection)
- Albers conic
- Lambert azimuthal equal-area
- Lambert cylindrical equal-area
- Mollweide
- Hammer
- Briesemeister
- Sinusoidal
- Werner
- Bonne
- Bottomley
- Goode's homolosine
- Hobo-Dyer

- Collignon
- Tobler hyperelliptical
- Snyder’s equal-area polyhedral projection, used for geodesic grids.

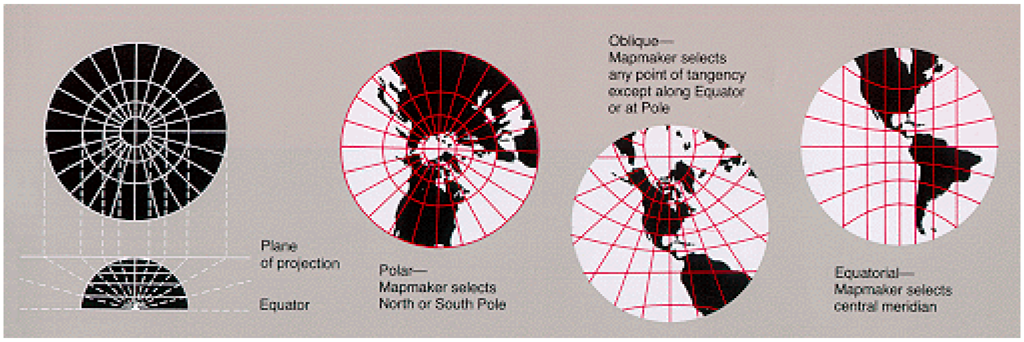
Equidistant

A two-point equidistant projection of Asia

These are some projections that preserve distance from some standard point or line:

- Equirectangular - distances along meridians are conserved
- Plate carrée - an Equirectangular projection centered at the equator
- Azimuthal equidistant - distances along great circles radiating from centre are conserved
- Equidistant conic
- Sinusoidal - distances along parallels are conserved
- Werner cordiform distances from the North Pole are correct as are the curved distance on parallels
- Soldner
- Two-point equidistant: two "control points" are arbitrarily chosen by the map maker. Distance from any point on the map to each control point is proportional to surface distance on the earth.

Gnomonic



The Gnomonic projection is thought to be the oldest map projection, developed by Thales in the 6th century BC

Great circles are displayed as straight lines:

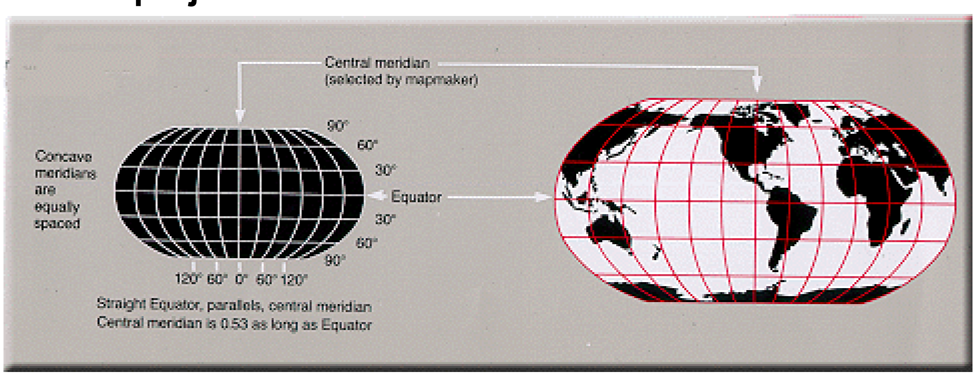
- Gnomonic projection

Retroazimuthal

Direction to a fixed location B (the bearing at the starting location A of the shortest route) corresponds to the direction on the map from A to B:

- Littrow - the only conformal retroazimuthal projection
- Hammer retroazimuthal - also preserves distance from the central point
- Craig retroazimuthal *aka* Mecca or Qibla - also has vertical meridians

Compromise projections



The Robinson projection was adopted by National Geographic Magazine in 1988 but abandoned by them in about 1997 for the Winkel Tripel.

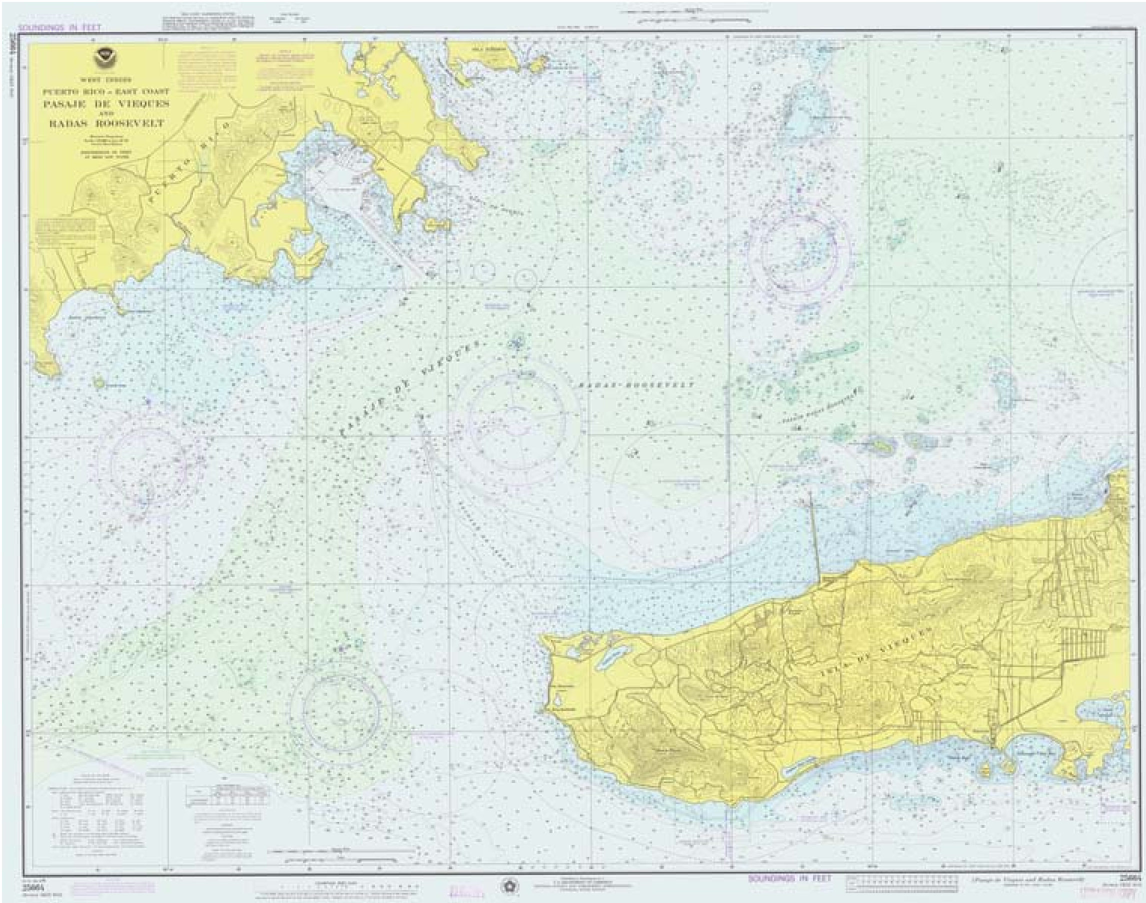
Compromise projections give up the idea of perfectly preserving metric properties, seeking instead to strike a balance between distortions, or to simply make things "look right". Most of these types of projections distort shape in the polar regions more than at the equator. These are some compromise projections:

- Robinson
- van der Grinten
- Miller cylindrical
- Winkel Tripel
- Buckminster Fuller's Dymaxion
- B.J.S. Cahill's Butterfly Map
- Kavrayskiy VII
- Wagner VI
- Chamberlin trimetric
- Oronce Fine's cordiform

Chapter 12

Nautical Chart

A **nautical chart** is a graphic representation of a maritime area and adjacent coastal regions. Depending on the scale of the chart, it may show depths of water and heights of land (topographic map), natural features of the seabed, details of the coastline, navigational hazards, locations of natural and man-made aids to navigation, information on tides and currents, local details of the Earth's magnetic field, and man-made structures such as harbours, buildings, and bridges. Nautical charts are essential tools for marine navigation; many countries require vessels, especially commercial ships, to carry them. Nautical charting may take the form of charts printed on paper or computerised electronic navigational charts. Recent technologies have made available paper charts which are printed "on demand" with cartographic data that has been downloaded to the commercial printing company as recently as the night before printing. With each daily download, critical data such as Local Notice to Mariners is added to the on-demand chart files so that these charts will be 100% up to date at the time of printing.



A 1976 United States NOAA chart of part of Puerto Rico

Sources and publication of nautical charts

Nautical charts are based on hydrographic surveys. As surveying is laborious and time-consuming, hydrographic data for many areas of sea may be dated and not always reliable. Depths are measured in a variety of ways. Historically the sounding line was used. In modern times, echo sounding is used for measuring the seabed in the open sea. When measuring the safe depth of water over an entire obstruction, such as a shipwreck, the minimum depth is checked by sweeping the area with a length of horizontal wire. This ensures that difficult to find projections, such as masts, do not present a danger to vessels navigating over the obstruction.

Nautical charts are issued by the national hydrographic offices in many countries. These charts are considered "official" in contrast to those made by commercial publishers. Many hydrographic offices provide regular, sometimes weekly, manual updates of their charts through their sales agents. Individual hydrographic offices produce national chart series and international chart series. Coordinated by the International Hydrographic Organization, the international chart series is a worldwide system of charts ("INT" chart series), which is being developed with the goal of unifying as many chart systems as possible.

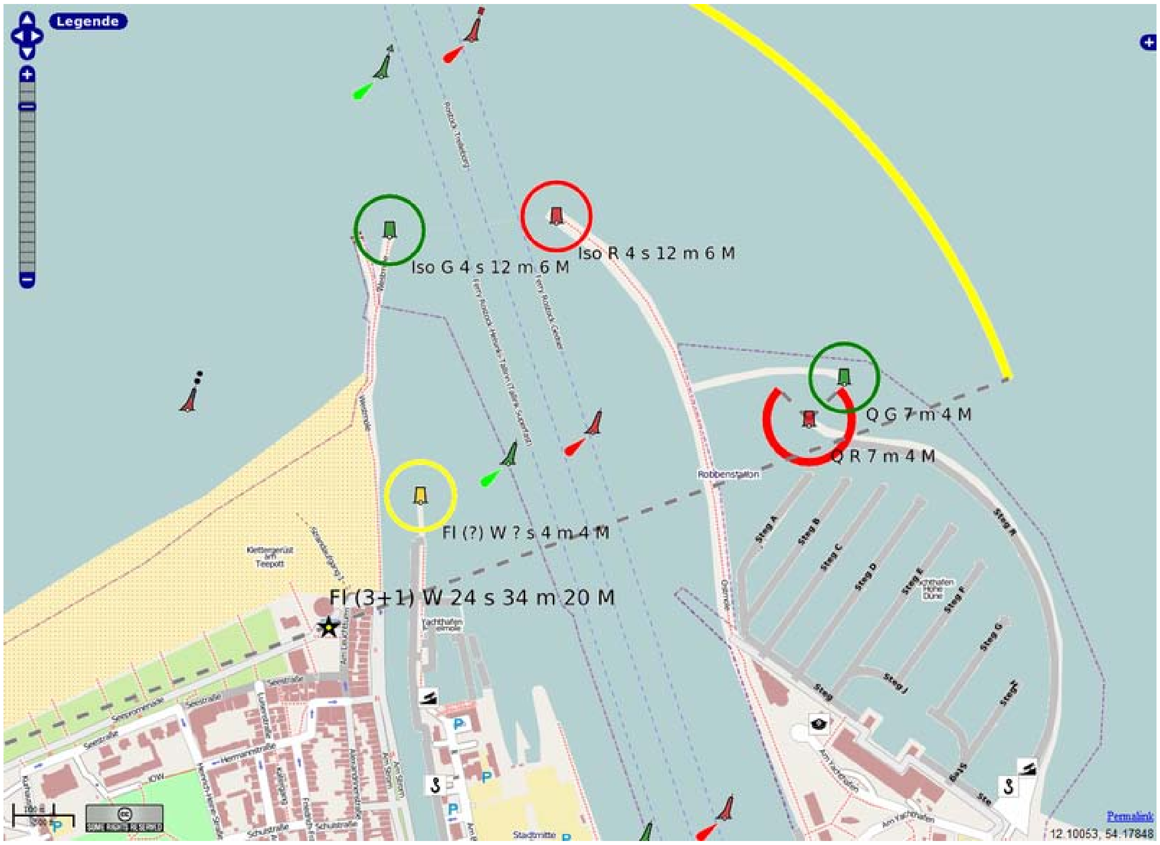
There are also commercially published charts, some of which may carry additional information of particular interest, e.g. for yacht skippers.

Free nautical charts

TeamSurv creates charts using crowd sourced data. Boats log GPS and depth sounder information (plus compass heading and sea surface temperature when available) as they go about their nortmal activities, and upload the data to the server where the data undergoes quality checks and is corrected for tide height, speed of sound and other factors before being used to create a chart. Data can be collected using a hardware logger or through a number of software packages, and is open to all. Processed data can be viewed at the teamsurv.eu web site, overlaid on top of Google Maps.

BlooSee is a worldwide ocean mapping site, a mobile app, and a social network for sea lovers, offering free NOAA/United States and Brazil charts. BlooSee leverages the power of the community to complement official nautical chart data with content generated by sailors, surfers, divers, kayakers, fisherman, NGO's, merchants, and other ocean communities. BlooSee's charts and data are layered over the satellite imagery of Google Maps/Google Earth.

Marine GeoGarage is the first nautical chart web portal in the Cloud. The website allows to freely view seamless georeferenced nautical raster chart layers issued from different Hydrographic Services (NOAA US, Linz NZ , DNH Brazil) upon Google Maps imagery. Additional free features are available for the user (voyage planning, waypoint and route monitoring with transfer to GPS, bearing and distance calculations).



OpenSeaMap - the free nautical chart

The US National Oceanic and Atmospheric Administration is now offering complete detailed nautical charts for free download for home printing for the entire US coast. The charts are continuously updated. This should improve the safety at sea, while reducing costs for mariners. Note, however, that these print-at-home charts will typically not offer the detail that "full size" NOAA charts do.

Chart correction

The nature of a waterway depicted by a chart may change, and artificial aids to navigation may be altered at short notice. Therefore, old or uncorrected charts should never be used for navigation. Every producer of nautical charts also provides a system to inform mariners of changes that affect the chart. In the United States, chart corrections and notifications of new editions are provided by various governmental agencies by way of Notice to Mariners, Local Notice to Mariners, Summary of Corrections, and Broadcast Notice to Mariners. In the U.S., NOAA also has a printing partner who prints the "POD" (print on demand) NOAA charts, and they contain the very latest corrections and notifications at the time of printing. Radio broadcasts give advance notice of urgent corrections.

A good way to keep track of corrections is with a *Chart and Publication Correction Record Card* system. Using this system, the navigator does not immediately update every chart in the portfolio when a new *Notice to Mariners* arrives, instead creating a card for every chart and noting the correction on this card. When the time comes to use the chart, he pulls the chart and chart's card, and makes the indicated corrections on the chart. This system ensures that every chart is properly corrected prior to use. A prudent mariner should obtain a new chart if he or she has not kept track of corrections and his chart is more than several months old.

Various Digital Notices to Mariners systems are available on the market such as Voyager, ChartCo to correct British Admiralty charts as well as NOAA charts. These systems provides only vessels relevant corrections via e-mail or web downloads reducing time needed to sort our correction for each chart. Also, tracings to assist corrections are provided at the same time.

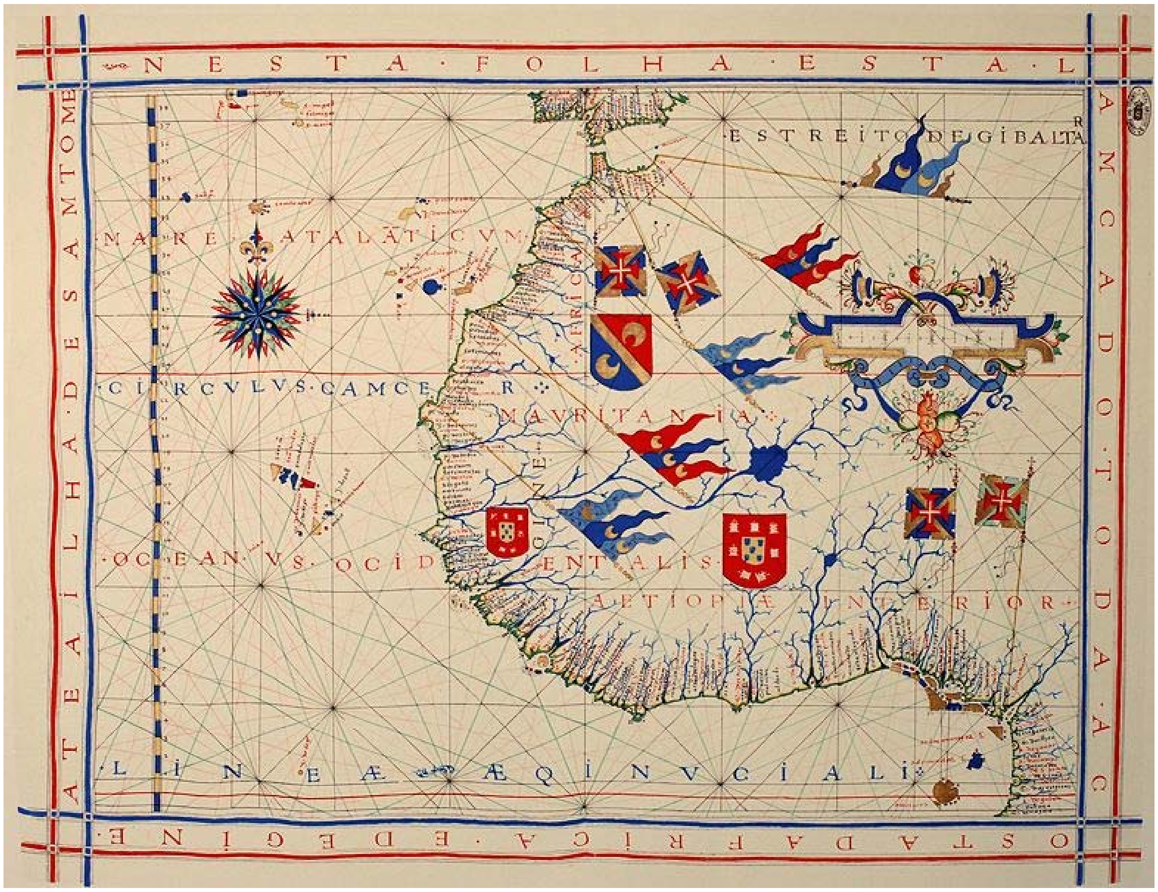
Various and diverse methods exist for the correction of electronic navigational charts.

Limitations

In 1973 the cargo ship *MV Muirfield* (a merchant vessel named after Muirfield, Scotland) struck an unknown object in waters charted at a depth of greater than 5,000 metres (16,404 ft), resulting in extensive damage to her keel. In 1983, HMAS *Moresby*, a Royal Australian Navy survey ship, surveyed the area where *Muirfield* was damaged, and charted in detail this previously unsuspected hazard to navigation, the Muirfield Seamount.

The dramatic accidental discovery of the Muirfield Seamount is often cited as an example of limitations in the vertical datum accuracy of some offshore areas as represented on nautical charts, especially on small-scale charts. A similar incident involving a passenger ship occurred in 1992 when the Cunard liner *RMS Queen Elizabeth 2* struck a submerged rock off Block Island in the Atlantic Ocean. More recently, in 2005 the submarine USS San Francisco (SSN-711) ran into an uncharted seamount about 560 kilometers (350 statute miles) south of Guam at a speed of 35 knots (40.3 mph; 64.8 km/h), sustaining serious damage and killing one seaman.

Map projection, positions, and bearings



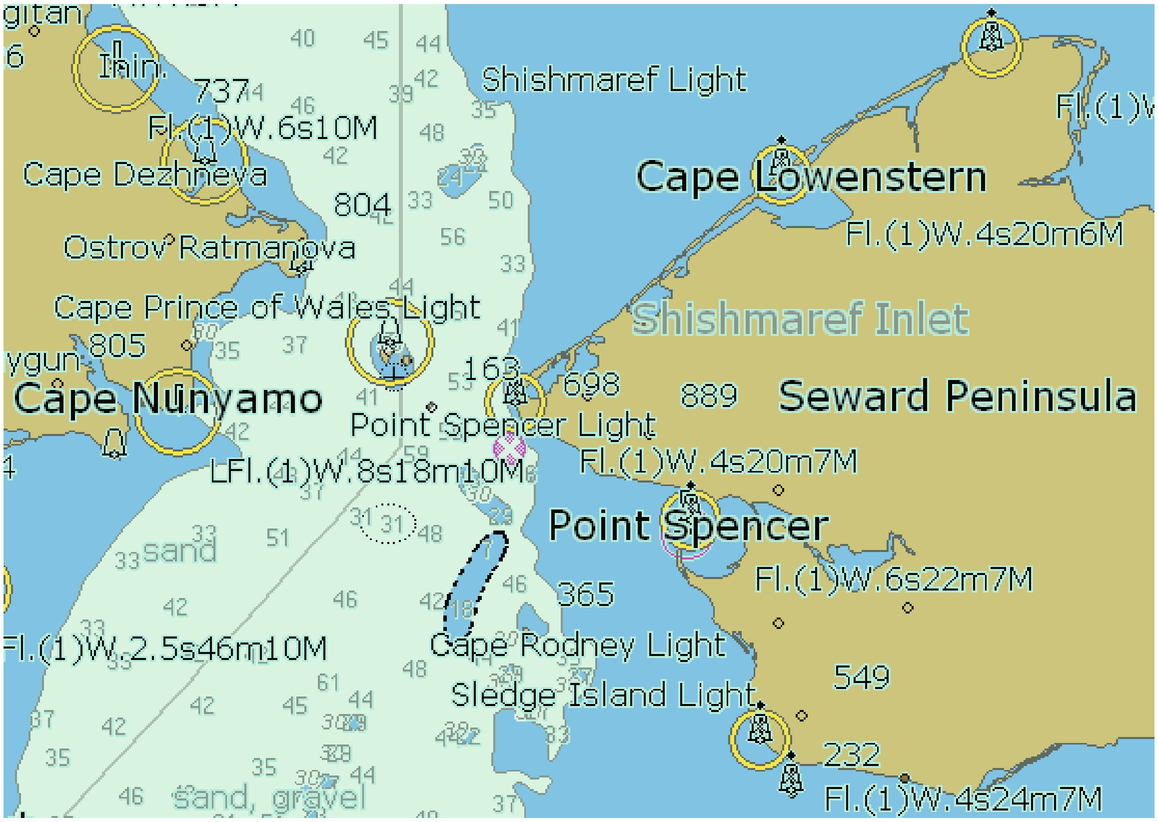
A pre-Mercator nautical chart of 1571, from Portuguese cartographer Fernão Vaz Dourado (c. 1520-c.1580). It belongs to the so-called *plane chart* model, where observed latitudes and magnetic directions are plotted directly into the plane, with a constant scale, as if the Earth's surface were a flat plane (Portuguese National Archives of Torre do Tombo, Lisbon)

The Mercator projection is almost universally used in nautical charts. There are however some exceptions for very large or small scales where projections such as the gnomonic projection may be used. Since the Mercator projection is conformal, that is, bearings in the chart are identical to the corresponding angles in nature, bearings may be measured from the chart to be used at sea or plotted on the chart from measurements taken at sea.

Positions of places shown on the chart can be measured from the longitude and latitude scales on the borders of the chart, relative to a map datum such as WGS 84.

A bearing is the angle between the line joining the two points of interest and the line from one of the points to the north, such as a ship's course or a compass reading to a landmark. On nautical charts, the top of the chart is always true north, rather than magnetic north, towards which a magnetic compass points. Most charts include a compass rose depicting the variation between magnetic and true north.

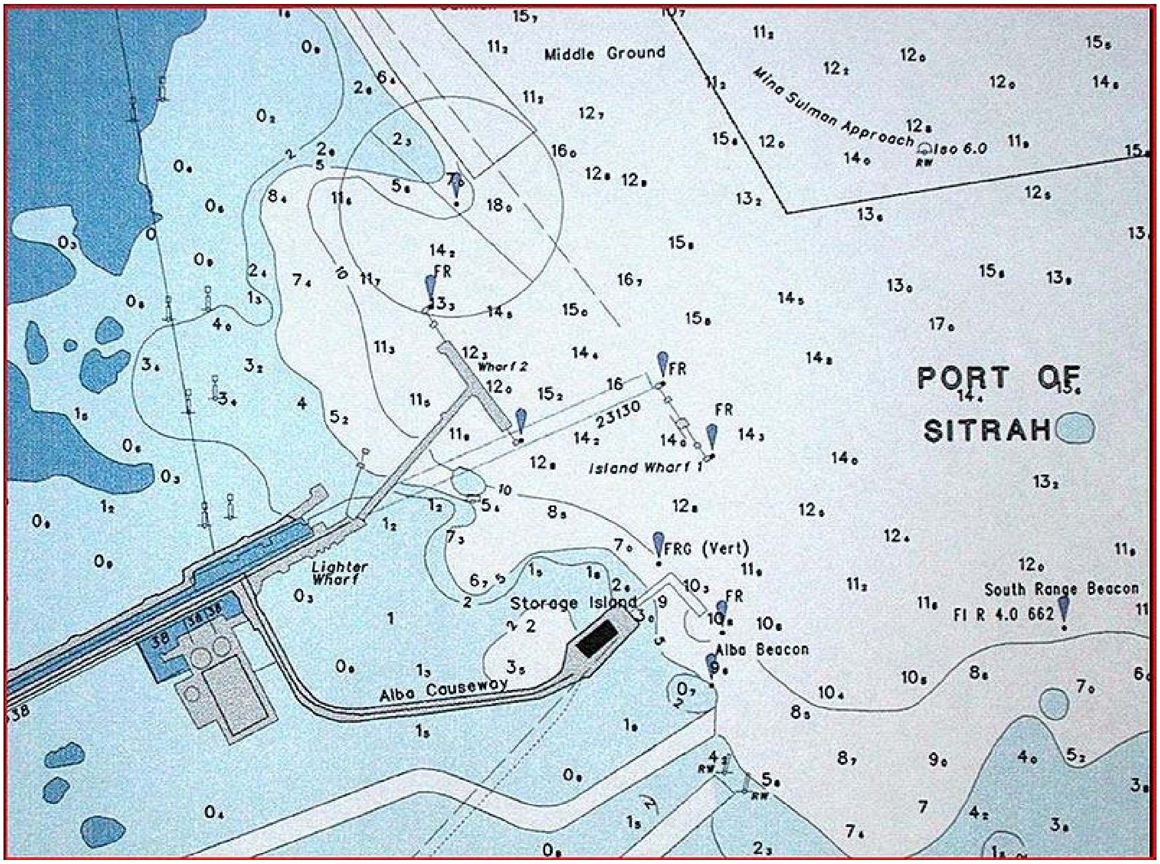
Electronic and paper charts



Portion of an electronic chart of the Bering Strait

Conventional nautical charts are printed on large sheets of paper at a variety of scales. Mariners will generally carry many charts to provide sufficient detail for the areas they might need to visit. Electronic navigational charts, which use computer software and electronic databases to provide navigation information, can augment or in some cases replace paper charts, though many mariners carry paper charts as a backup in case the electronic charting system fails.

Labeling nautical charts

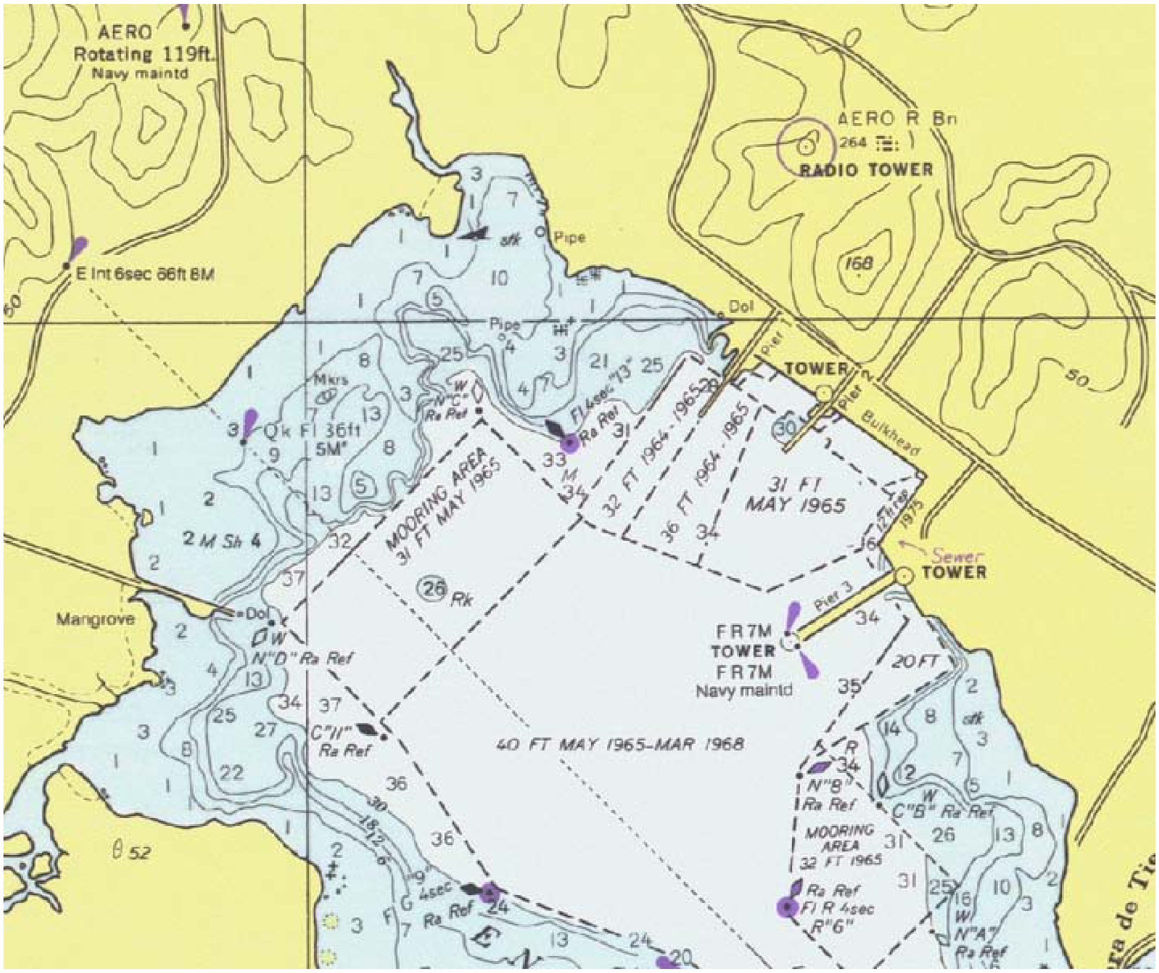


Automatically labeled nautical chart

Nautical charts must be labeled with navigational and depth information. There are a few software solutions in the market that do label placement automatically for any kind of map or chart.

Details on a nautical chart

Pilotage information

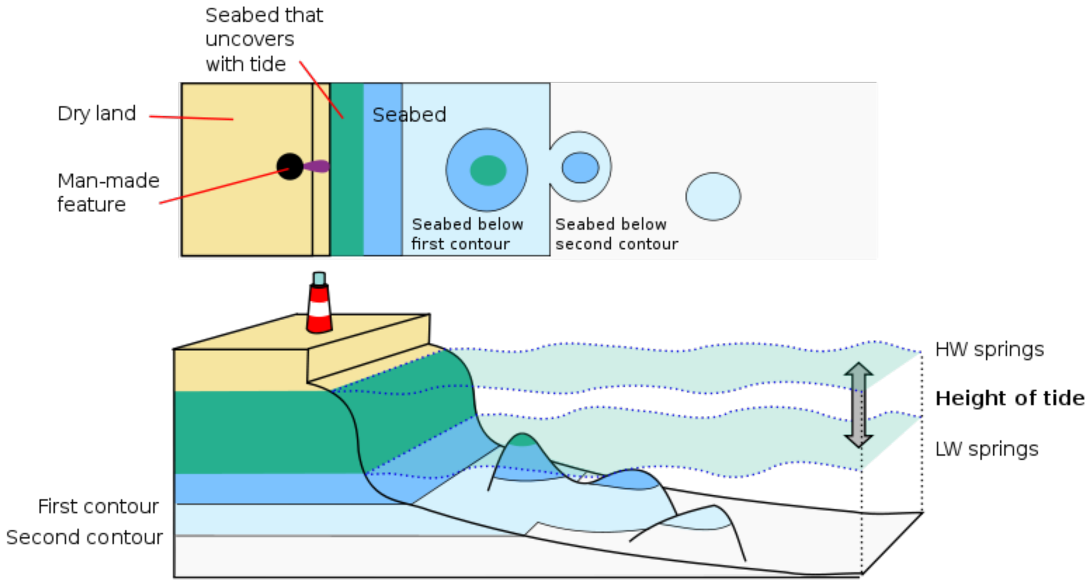


Detail of a United States NOAA chart, showing a harbour area

The chart uses symbols to provide pilotage information about the nature and position of features useful to navigators, such as sea bed information, sea marks and landmarks. Some symbols describe the sea bed with information such as its depth, materials as well as possible hazards such as shipwrecks. Other symbols show the position and characteristics of buoys, lights, lighthouses, coastal and land features and structures that are useful for position fixing.

Colours distinguish between man-made features, dry land, sea bed that dries with the tide and seabed that is permanently underwater and indicate water depth.

Depths



Use of colour in British Admiralty charts

Depths which have been measured are indicated by the numbers shown on the chart. Depths on charts published in most parts of the world use metres. Older charts, as well as those published by the United States government, may use feet or fathoms. Depth contour lines show the shape of underwater relief. Coloured areas of the sea emphasise shallow water and dangerous underwater obstructions. Depths are measured from the chart datum, which is related to the local sea level. The chart datum varies according to the standard used by each National Hydrographic Office.In general, the move is towards using Lowest Astronomical Tide (LAT), the lowest tide predicted in the full tidal cycle, but in non-tidal areas and some tidal areas Mean Sea Level (MSL) is used.

Heights are generally given using Highest Astronomical Tide (HAT) or Mean Sea Level.

The use of HAT for heights, and LAT for depths, means that the mariner can quickly look at the chart to ensure that they have sufficient clearance to pass any obstruction, without the need to do tidal calculations each time.

Tidal information

Tidal races and other strong currents have special chart symbols. Tidal flow information may be shown on charts using tidal diamonds, indicating the speed and bearing of the tidal flow during each hour of the tidal cycle.

Chapter 13

Technical Drawing

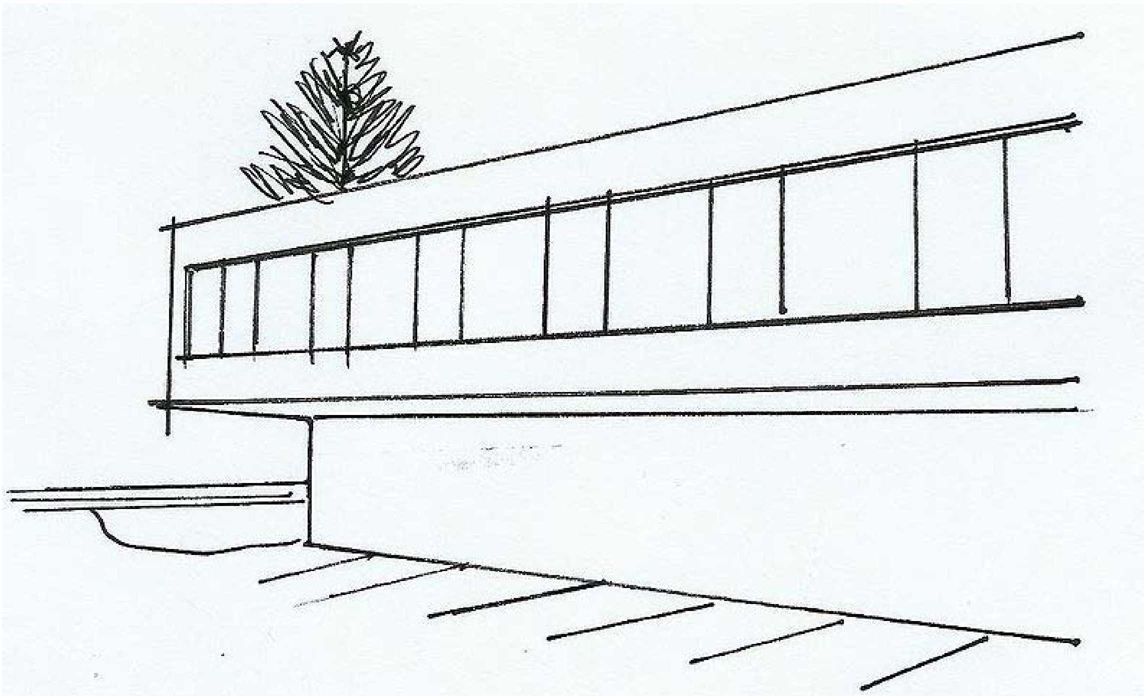
Drafter at work.

Copying technical drawings in 1973

Technical drawing, also known as **drafting**, is the academic discipline of creating standardized technical drawings by architects, interior designers, drafters, design engineers, and related professionals. Standards and conventions for layout, line thickness, text size, symbols, view projections, descriptive geometry, dimensioning, and notation are used to create drawings that are ideally interpreted in only one way.

A person who does drafting is known as a drafter. In some areas this person may be referred to as a drafting technician, draftsperson, or draughtsman. This person creates technical drawings which are a form of specialized graphic communication. A technical drawing differs from a common drawing by how it is interpreted. A common drawing can hold many purposes and meanings, while a technical drawing is intended to concisely and clearly communicate all needed specifications to transform an idea into physical form.

Methods



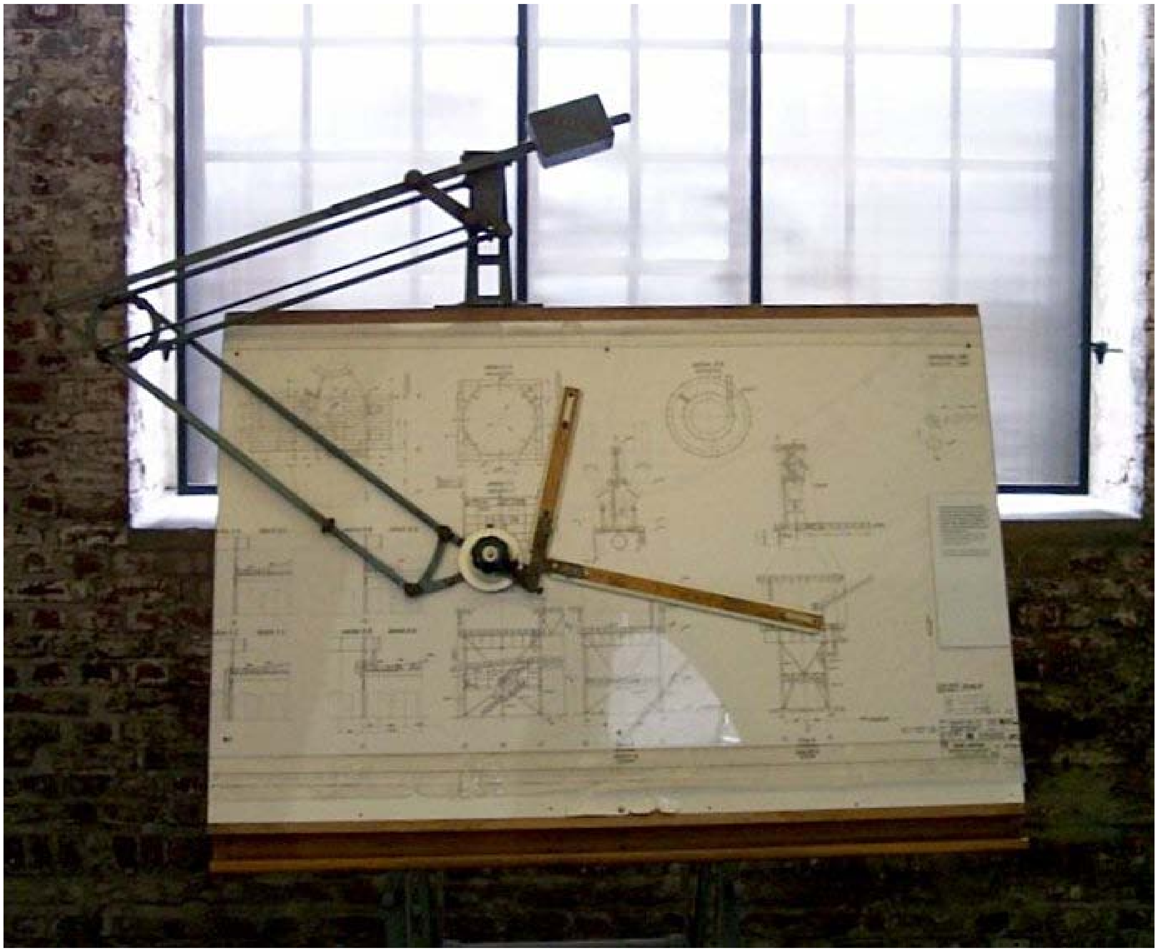
Sketch for a government building.

Sketching

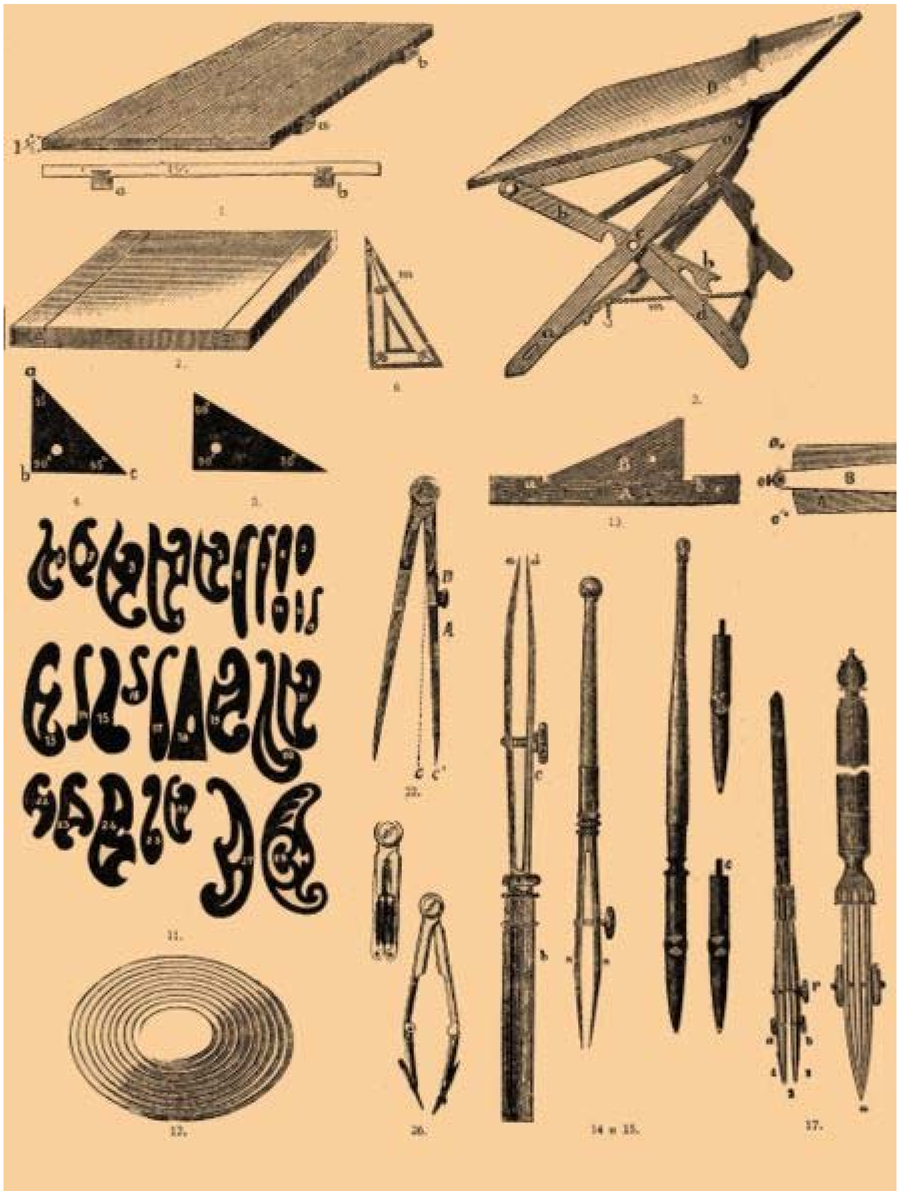
A sketch is a quickly executed freehand drawing that is not intended as a finished work. In general, a sketch is a quick way to record an idea for later use. Architect's sketches primarily serve as a way to try out different ideas and establish a composition before undertaking a more finished work, especially when the finished work is expensive and time consuming.

Architectural sketches, for example, are a kind of diagrams. These sketches, like metaphors, are used by architects as a mean of communication in aiding design collaboration. This tool helps architects to abstract attributes of hypothetical provisional design solutions and summarize their complex patterns, hereby enhancing the design process.

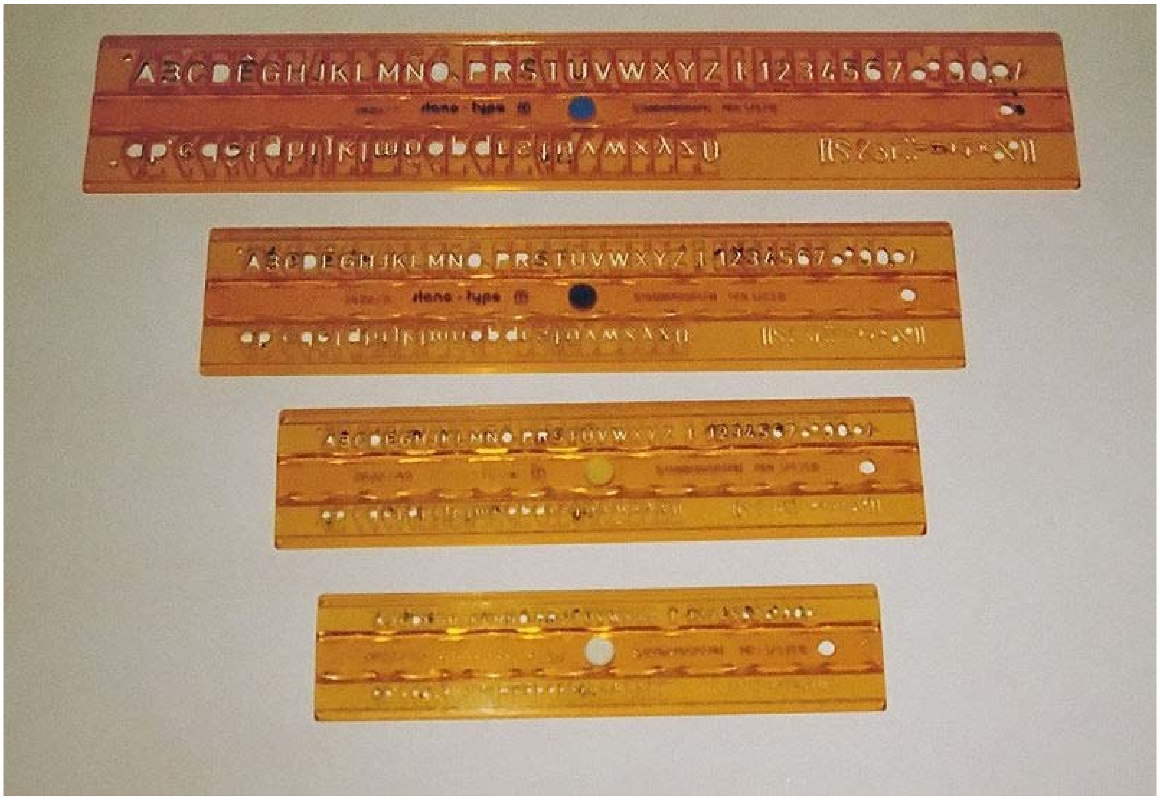
Manual or by instrument



A drafting table.



Technical drawing instruments.



Stencils for correct technical lettering.

The basic drafting procedure is to place a piece of paper (or other material) on a smooth surface with right-angle corners and straight sides—typically a drawing board. A sliding straightedge known as a *T-square* is then placed on one of the sides, allowing it to be slid across the side of the table, and over the surface of the paper.

"Parallel lines" can be drawn simply by moving the T-square and running a pencil or technical pen along the T-square's edge, but more typically the T-square is used as a tool to hold other devices such as set squares or triangles. In this case the drafter places one or more triangles of known angles on the T-square—which is itself at right angles to the edge of the table—and can then draw lines at any chosen angle to others on the page. Modern drafting tables (which have by now largely been replaced by CAD workstations) come equipped with a drafting machine that is supported on both sides of the table to slide over a large piece of paper. Because it is secured on both sides, lines drawn along the edge are guaranteed to be parallel.

In addition, the drafter uses several tools to draw curves and circles. Primary among these are the compasses, used for drawing simple arcs and circles, and the French curve, typically a piece of plastic with complex curves on it. A spline is a rubber coated articulated metal that can be manually bent to most curves.

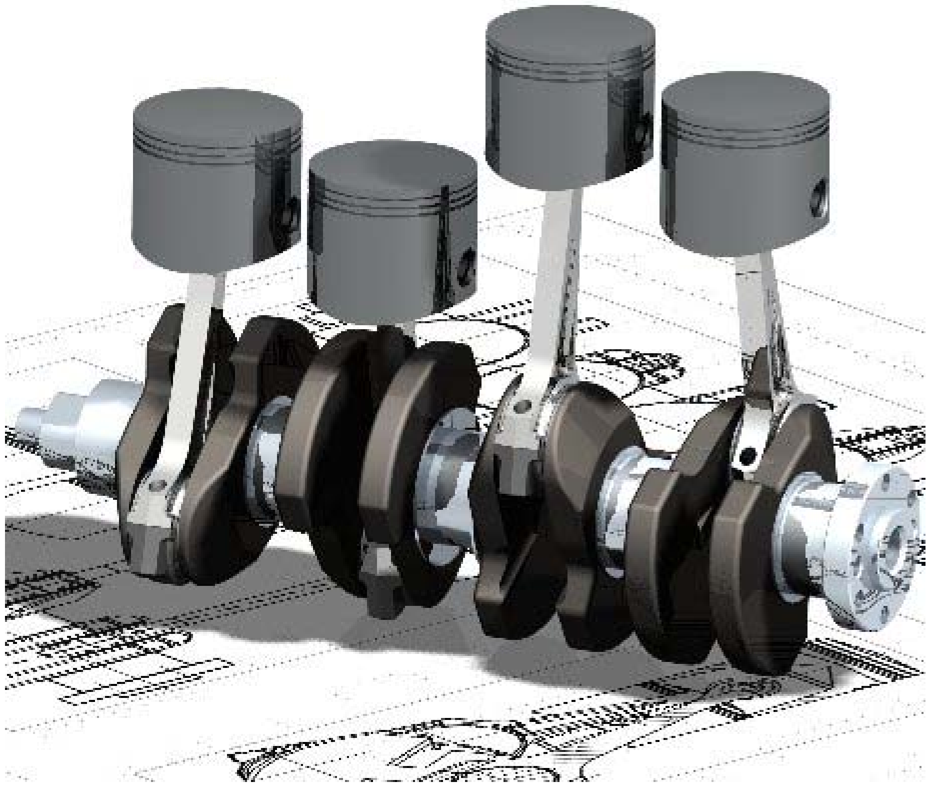
Drafting templates assist the drafter with creating recurring objects in a drawing without having to reproduce the object from scratch every time. This is especially useful when using common symbols; i.e. in the context of stagecraft, a lighting designer will typically draw from the USITT standard library of lighting fixture symbols to indicate the position of a common fixture across multiple positions. Templates are sold commercially by a number of vendors, usually customized to a specific task, but it is also not uncommon for a drafter to create their own templates.

This basic drafting system requires an accurate table and constant attention to the positioning of the tools. A common error is to allow the triangles to push the top of the T-square down slightly, thereby throwing off all angles. Even tasks as simple as drawing two angled lines meeting at a point require a number of moves of the T-square and triangles, and in general drafting can be a time consuming process.

A solution to these problems was the introduction of the mechanical "drafting machine", an application of the pantograph (sometimes referred to incorrectly as a "pentagraph" in these situations) which allowed the drafter to have an accurate right angle at any point on the page quite quickly. These machines often included the ability to change the angle, thereby removing the need for the triangles as well.

In addition to the mastery of the mechanics of drawing lines, arcs and circles (and text) onto a piece of paper—with respect to the detailing of physical objects—the drafting effort requires a thorough understanding of geometry, trigonometry and spatial comprehension, and in all cases demands precision and accuracy, and attention to detail of high order.

Although drafting is sometimes accomplished by a project engineer, architect—or even by shop personnel such as a machinist—skilled drafters (and/or designers) usually accomplish the task and are always in demand to some level.



An oblique view of a four-cylinder inline crankshaft with pistons.

Computer aided design

Today, the mechanics of the drafting task have largely been automated and accelerated through the use of computer-aided design systems (CAD).

There are two types of computer-aided design systems used for the production of technical drawings" two dimensions ("2D") and three dimensions ("3D").

2D CAD systems such as AutoCAD replace the paper drawing discipline. The lines, circles, arcs and curves are created within the software. It is down to the technical drawing skill of the user to produce the drawing. There is still much scope for error in the drawing when producing first and third angle orthographic projections, auxiliary projections and cross sections. A 2D CAD system is merely an electronic drawing board. Its greatest strength over direct to paper technical drawing is in the making of revisions. Where as in a conventional hand drawn technical drawing, if a mistake is found, or a modification is required, a new drawing must be made from scratch. The 2D CAD system allows a copy of the original to be modified, saving considerable time. 2D CAD systems can be used to create plans for large projects such as buildings and aircraft but provide no way to check the various components will fit together.

3D CAD systems such as Pro/ENGINEER first produce the geometry of the part, the technical drawing comes from user defined views of the part. Any orthographic, projected and section views are created by the software. There is no scope for error in the production of these views. The main scope for error comes in setting the parameter of first or third angle projection, and displaying the relevant symbol on the technical drawing. 3D CAD allows individual parts to be assembled together to represent the final product. Buildings, Aircraft, ships and cars are modeled, assembled and checked in 3D before technical drawings are released for manufacture.

Both 2D and 3D CAD systems can be used to produce technical drawings for any discipline. The various disciplines; electical, electronic, pneumatic, fluidic, etc., have industry recognised symbols to represent common components.

BS and ISO produce standards to show recommended practices but it is up to individuals to produce the drawings. There is no definitive standard for layout or style. The only standard across engineering workshop drawings is in the creation of orthographic projections and cross section views.

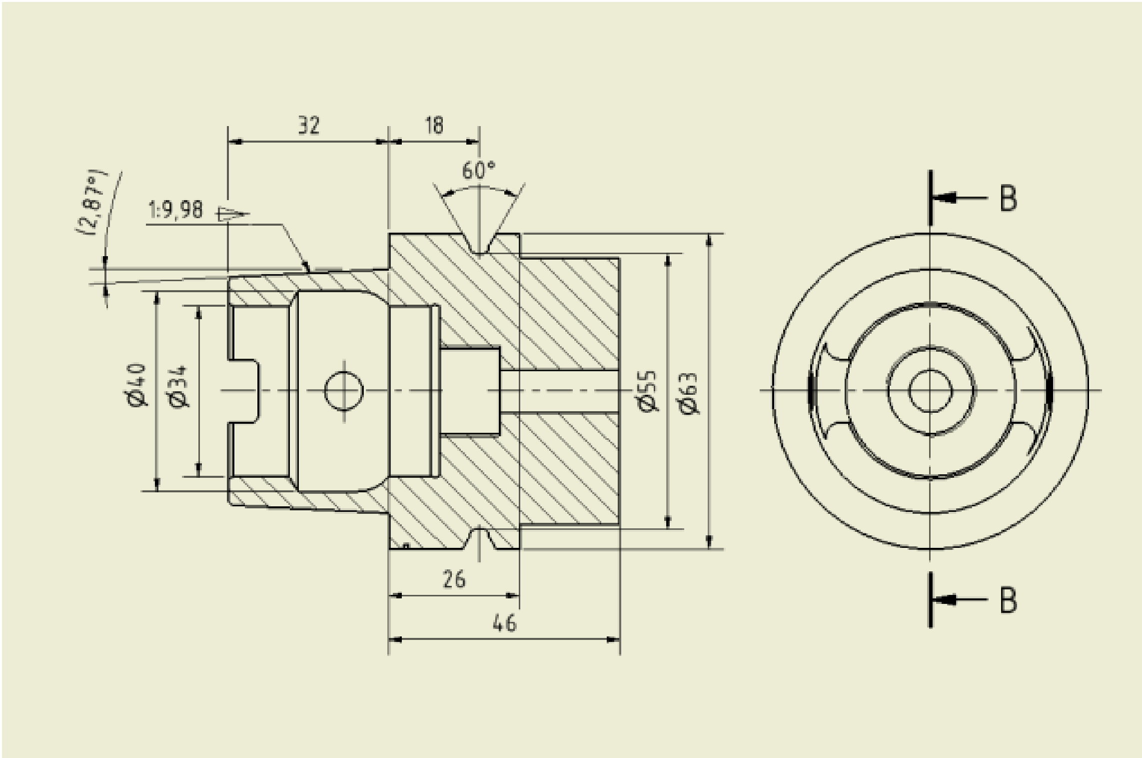
Drafting can represent two dimensions ("2D") and three dimensions ("3D") although the representation itself is always created in 2D (cf. Architectural model). Drafting is the integral communication of technical or engineering drawings and is the industrial arts sub-discipline that underlies all involved technical endeavors.

In representing complex, three-dimensional objects in two-dimensional drawings, the objects can be described by at least one view plus material thickness note, 2, 3 or as many views and sections that are required to show all features of object.

Applications for technical drawing

Architecture

The art and design that goes into making buildings is known as architecture. To communicate all aspects of the design, detailed drawings are used. In this field, the term plan is often used when referring to the full section view of these drawings. Architectural drawings describe and document an architect's design.



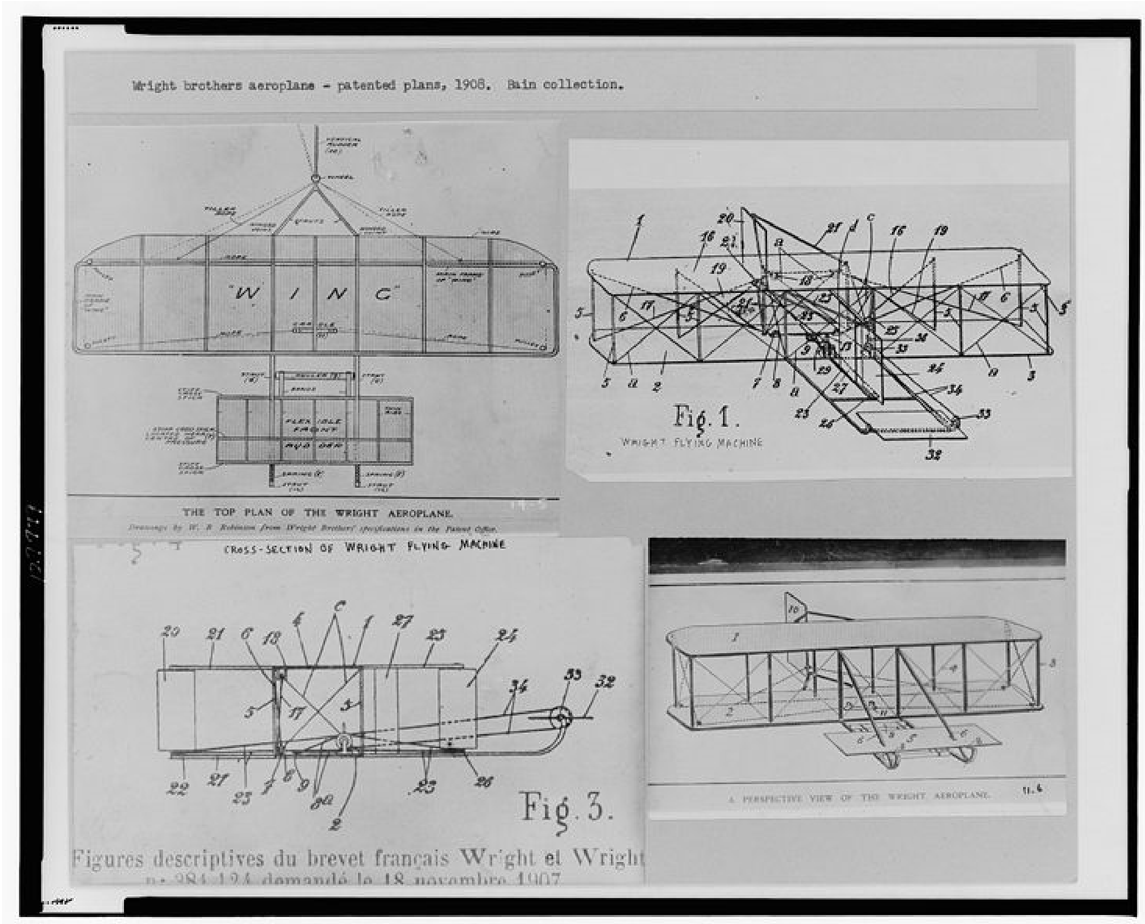
Engineering drawing of a Machine tool part.

Engineering

Engineering can be a very broad term. It stems from the Latin *ingenerare*, meaning "to create". Because this could apply to everything that humans create, it is given a narrower definition in the context of technical drawing. Engineering drawings generally deal with mechanical engineered items, such as manufactured parts and equipment.

Engineering drawings are usually created in accordance with standardized conventions for layout, nomenclature, interpretation, appearance (such as typefaces and line styles), size, etc.

Its purpose is to accurately and unambiguously capture all the geometric features of a product or a component. The end goal of an engineering drawing is to convey all the required information that will allow a manufacturer to produce that component.



Wright brothers Patent drawing, 1908.

Related fields

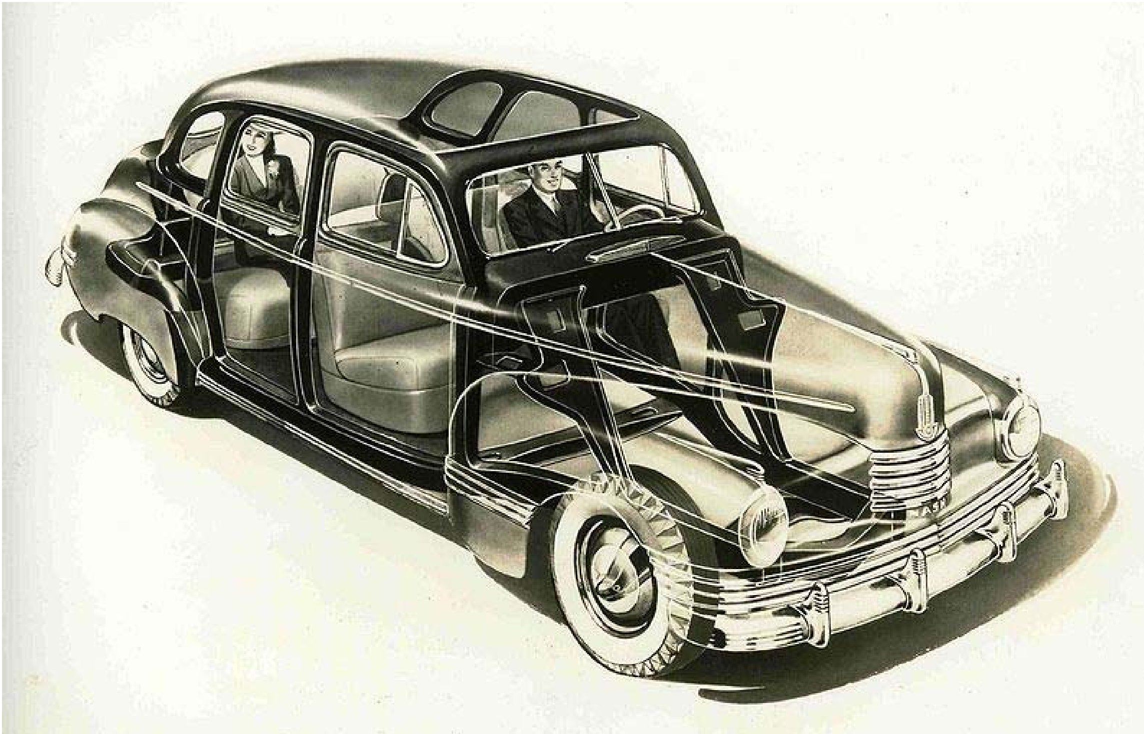
Illustration of a drum set.

Technical illustrations

Technical illustration is the use of illustration to visually communicate information of a technical nature. Technical illustrations can be component technical drawings or diagrams. The aim of technical illustration is "to generate expressive images that effectively convey certain information via the visual channel to the human observer".

The main purpose of technical illustration is to describe or explain these items to a more or less nontechnical audience. The visual image should be accurate in terms of dimensions and proportions, and should provide "an overall impression of what an object is or does, to enhance the viewer's interest and understanding".

According to Viola (2005) "illustrative techniques are often designed in a way that even a person with no technical understanding clearly understands the piece of art. The use of varying line widths to emphasize mass, proximity, and scale helped to make a simple line drawing more understandable to the lay person. Cross hatching, stippling, and other low abstraction techniques gave greater depth and dimension to the subject matter".



Cutaway drawing of a Nash 600.

A cutaway drawing is a technical illustration, in which surface elements a three-dimensional model are selectively removed, to make internal features visible, but without sacrificing the outer context entirely.

The purpose of a cutaway drawing is to "allow the viewer to have a look into an otherwise solid opaque object. Instead of letting the inner object shine through the surrounding surface, parts of outside object are simply removed. This produces a visual appearance as if someone had cutout a piece of the object or sliced it into parts. Cutaway illustrations avoid ambiguities with respect to spatial ordering, provide a sharp contrast between foreground and background objects, and facilitate a good understanding of spatial ordering".

Technical drawings (the document)

Types of technical drawings

The two types of technical drawings are based on graphical projection. This is used to create an image of a three-dimensional object onto a two-dimensional surface.

Two-dimensional representation

Two-dimensional representation uses orthographic projection to create an image where only two of the three dimensions of the object are seen.

Three-dimensional representation

In three-dimensional representation, also referred to as pictorials, all three dimensions, of the three dimensions of an object, are visible.

Views

Multiview

Multiview is a type of orthographic projection. There are two conventions for using multiview, first-angle and third-angle. In both cases, the front or main side of the object is the same. First-angle is drawing the object sides based on where they land. Example, looking at the front side, rotate the object 90 degrees to the right. What is seen will be drawn to the right of the front side. Third-angle is drawing the object sides based on where they are. Example, looking at the front side, rotate the object 90 degrees to the right. What is seen is actually the left side of the object and will be drawn to the left of the front side

Section

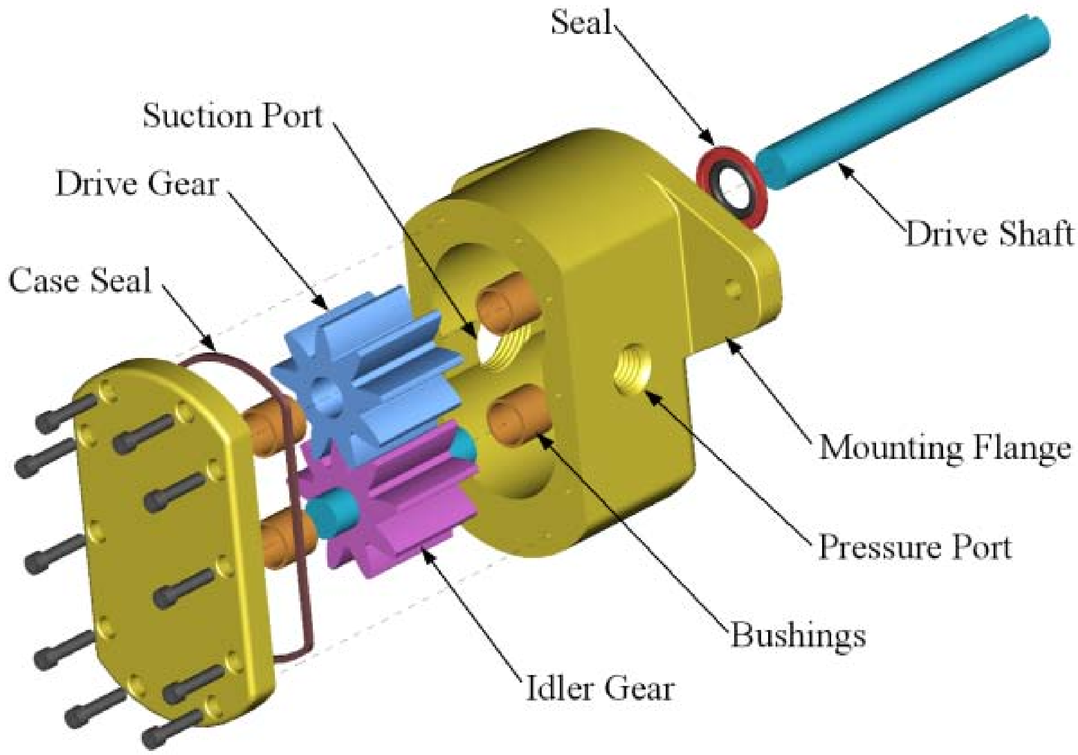
While multiview relates to external surfaces of an object, section views show an imaginary plane cut through an object. This is often useful to show voids in an object.

Auxiliary

Auxiliary views utilize an additional projection plane other than the common planes in a multiview. Since the features of an object need to show the true shape and size of the object, the projection plane must be parallel to the object surface. Therefore, any surface that is not in line with the three major axis needs its own projection plane to show the features correctly.

Pattern

Patterns, sometimes called developments, show the size and shape of a flat piece of material needed for later bending or folding into a three dimensional shape.



Gear pump exploded view.

Exploded

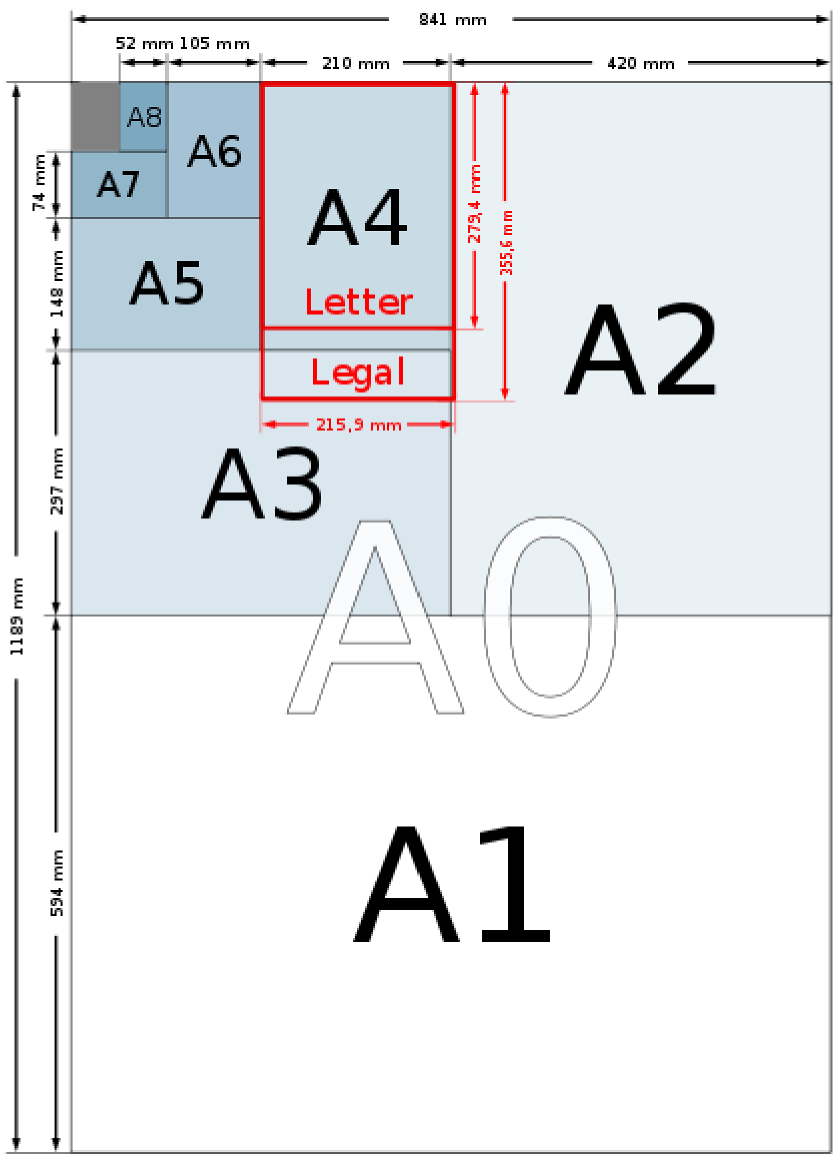
An exploded view drawing is a technical drawing of an object that shows the relationship or order of assembly of the various parts. It shows the components of an object slightly separated by distance, or suspended in surrounding space in the case of a three-dimensional exploded diagram. An object is represented as if there had been a small controlled explosion emanating from the middle of the object, causing the object's parts to be separated an equal distance away from their original locations.

An exploded view drawing (EVD) can show the intended assembly of mechanical or other parts. In mechanical systems usually the component closest to the center is assembled first, or is the main part in which the other parts get assembled. This drawing can also help to represent disassembly of parts, where the parts on the outside normally get removed first.

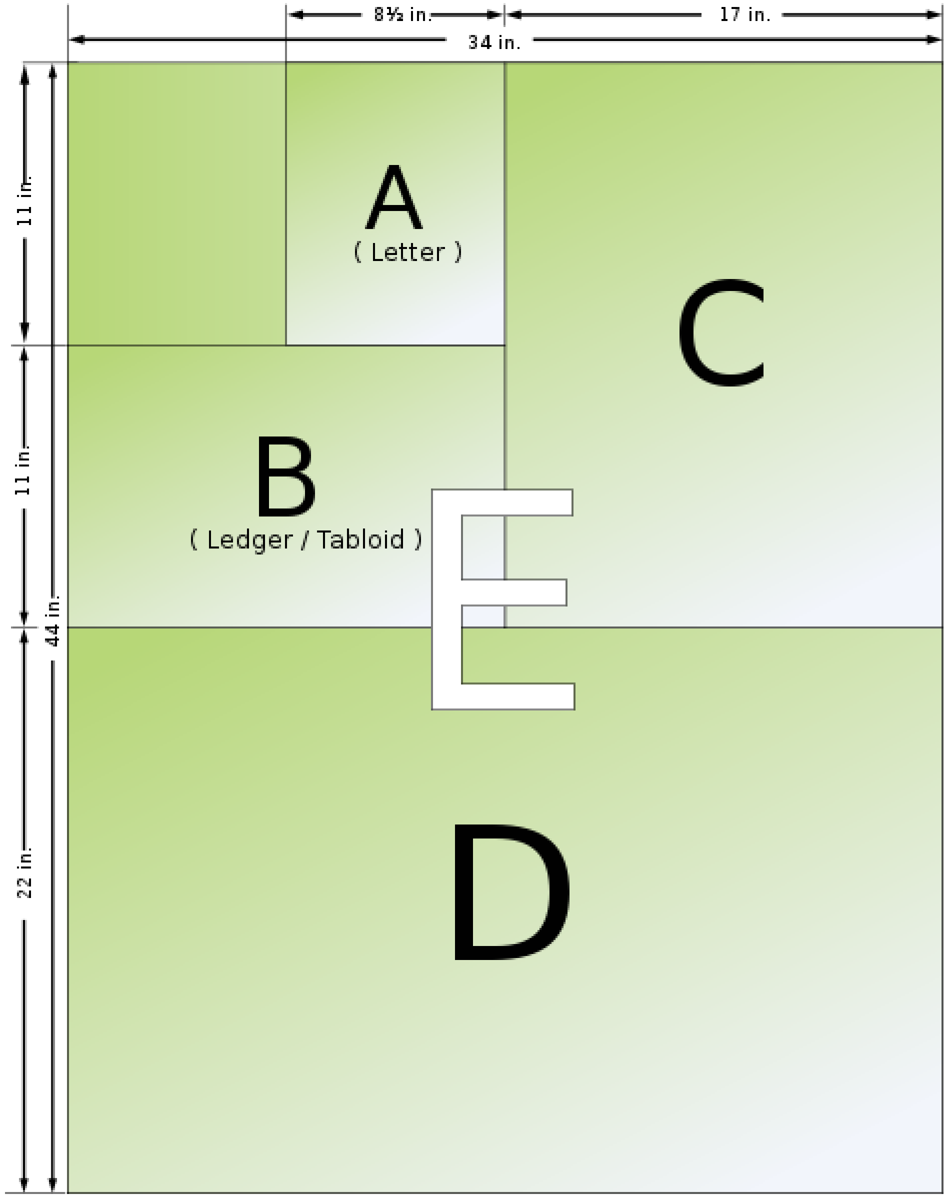
Standards and conventions

Basic drafting paper sizes

There have been many standard sizes of paper at different times and in different countries, but today there are two widespread systems in use: the international standard (A4 and its siblings) and the North American sizes.



ISO "A series" used in most of the world



North American paper sizes

Patents

The applicant for a patent will be required by law to furnish a drawing of the invention whenever the nature of the case requires a drawing to understand the invention. This drawing must be filed with the application. This includes practically all inventions except compositions of matter or processes, but a drawing may also be useful in the case of many processes.

The drawing must show every feature of the invention specified in the claims, and is required by the patent office rules to be in a particular form. The Office specifies the size of the sheet on which the drawing is made, the type of paper, the margins, and other details relating to the making of the drawing. The reason for specifying the standards in detail is that the drawings are printed and published in a uniform style when the patent issues, and the drawings must also be such that they can be readily understood by persons using the patent descriptions.

Sets of technical drawings

Working drawings

Working drawings are the set of technical drawings used during the manufacturing phase of a product. In architecture, these typically include civil drawings, architectural drawings, structural drawings, mechanical systems drawings, electrical drawings, and plumbing drawings.

Assembly drawings

Assembly drawings show how different parts go together, identify those parts by number, and have a parts list, often referred to as a bill of materials.