featured article

Choosing Tools: Nine Metaphors of Four-Dimensional Cartography

Philip J. Gersmehl

Animated maps are now technically and economically feasible. Like other forms of cartography, map animation has some unique design considerations, which involve a variety of tradeoffs. Making these tradeoff decisions is easier if we acknowledge that different animation software packages seem to embody a number of different perspectives — a 'flipbook' style of animation, for example, is suited to different tasks than a 'stage-and-actor' or a 'model-and-camera' program. This paper contrasts nine different animation metaphors, with special attention to the degree to which a given tool allows a cartographer to make particular kinds of revisions.

INTRODUCTION

A speaker walks over to a control panel and flips a switch: "Let's look at a map that illustrates the process." The room darkens; the screen changes to deep violet; and a small green and blue globe appears, turning majestically on its axis and growing in size as the viewer appears to move slowly toward it. On cue, bright yellow dots highlight the poles; after attracting the viewer's attention, they fade to a dull tan, and lines of latitude and longitude appear. The globe then fades from sight, except for the grid-lines and the outline of North America. Slowly, the spherical grid mutates into a plane coordinate system, and as it does, one can see how the continent is distorted as the grid is flattened. Then the viewpoint begins to shift, first sliding to the left and then curving around in a broad arc and approaching the continent from the west. Seen from this oblique view, the continent begins to lose its planar appearance. Mountain ranges appear as the narrator reads their names: the green-and-tan Coast Ranges, the snow-covered Sierra Nevada, the isolated volcanoes of the Cascades, the block-faulted Bully Choops, the elongated Humboldt Range and its many cousins, and finally the Wasatch and the rugged Tetons. In forty-five seconds the cartographer has conveyed a vivid impression of half a dozen relationships that are very difficult to communicate with words, or even with diagrams on a flat piece of paper (unless, of course, the audience is a group of cartographers with active imaginations and extensive collections of mental maps). It may be true that impressions of animated images seldom persist if they stand alone, but with timely reinforcement an animated map is one of the best ways to communicate ideas about spatial relationships and their changes through time.

As recently as half a dozen years ago, most cartographers could only dream about adding motion to their maps. The twin constraints of time and money made animation an unaffordable luxury, except for those lucky enough to be producing maps for the Olympic games, television commercials, and other high-budget enterprises. In the last decade of the twentieth century, the problem of inaccessibility has given way to the much more pleasurable task of choosing among perhaps fifty reasonably affordable and effective computer programs that can be used to make animated maps. That choice, however, is complicated by the fact that the phrase 'computer animation' is really rather vague; it encompasses many different kinds of computer-assisted graphical motion, with an equally diverse set of potential uses in map production.

The purpose of this article is not to provide a comprehensive review of animation software. Although I am reasonably familiar with perhaps twenty packages, and will cite some of them when appropriate, the suite of available programs is vast and it changes almost monthly. My primary intent in this paper is to address a more fundamental question: the identi-

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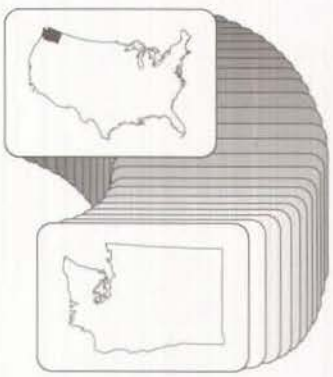
fication of design issues that are relevant to 'four-dimensional cartography' (a name that comes from the Einsteinian world-view, in which time assumes a dimensional status co-equal with the three perceived spatial dimensions of everyday experience (leaving aside, for the moment, some of the new and hopelessly counter-intuitive notions of superstrings and other n-dimensional world models)).

A 4-D cartographer has to deal with scale, data classification, visual hierarchy, and many other problems discussed at length in the literature of traditional print cartography. At the same time, the transientness and mutability of a television image can introduce some unique design issues and provide some unique ways of solving design problems. Successful communication of those solutions, however, requires a common vocabulary, a linguistic baseline that may be difficult to achieve because different animation programs may use different terms for the same action (or, even more confusing, use the same word to describe dissimilar concepts or actions). To help clarify this situation, it is helpful to view the field of map animation as a cluster of related but not identical notions, rather than a single seamless idea. In this paper, I use the term 'metaphor' to describe any one of these different views of the subject.

ANIMATION METAPHORS

To make their programs easier to master, most designers of animation software have elected to borrow jargon from a setting that they hope is more familiar to the user. Such a borrowing of conceptual vocabulary is a kind of metaphor, an implicit comparison whose purpose is to help clarify an idea. Describing various software vendors as adopters or proponents of different metaphors can make it easier to compare programs and choose the proper approach for a given mapping task. However, one should recognize the possibility of overlap (a heavy wrench, for example, could be used as a hammer; it would not necessarily be the most effective tool, but it could drive a nail into some kinds of wood). In my classes on four-dimensional cartography, I have found it useful to recognize at least nine distinct animation metaphors, described below in approximate order of increasing conceptual complexity. A given computer program seldom belongs exclusively in any single category; however, a typical program usually has a distinctive orientation that makes it possible to cite it as an example of a particular metaphor. With that caveat in mind, let us examine nine metaphors for map animation:

Slideshow

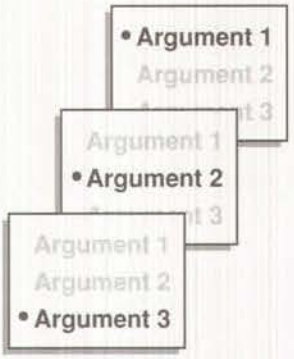


According to this metaphor, animation is an orderly but attention-grabbing sequencing of dissimilar still images — maps, photographs, diagrams, etc. Where a traditional slide show has blank-screen pauses between images, most computer programs for slideshow animation provide a variety of transitions from one image to another: fades, wipes, dissolve, pixellations, venetian blinds, insets, fly-aways, pagecurls, and many other effects with similarly evocative names. At their best, slideshow animations can be attractive, fast-paced, and easy to construct (albeit expensive in terms of the number of still images that are required for even a few minutes of rapid animation). Unfortunately for cartographers who prefer a wide selection of tools, good slideshow animation programs are like adjustable wrenches — they do many things reasonably well, and therefore they have already penetrated quite deeply into the business community, with a wide range of programs like Performer, Director, or Animagic on the Amiga, Grasp or Show Partner F/X on MS-DOS machines, and some uses of Hypercard on the Macintosh. For many users of business graphics, the words 'animation' and 'slideshow' are strict syno-

nyms, and the visual world is the poorer for it. A slideshow is, fundamentally, a sequence of dissimilar still images, and therefore it cannot accomplish the gradual change of scale or perspective that is one of the most seductive traits of a good animated map.

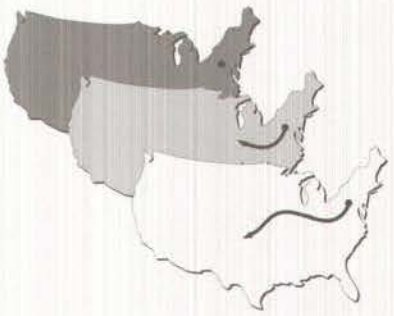
Teleprompter

In many educational settings, the metaphor of the teleprompter is more applicable than the slideshow. As proponents (and perhaps even slaves) of good outline form, many teachers view their material primarily as an orderly set of nested lists, and therefore a straightforward scrolling of key words or phrases can be a useful visual reinforcement for their spoken message. A slideshow program may have lists of words or phrases in its sequence of images, but the outlines tend to be static, whereas the user of a teleprompter program usually tries putting words and simple images on the screen in a more complex way, often in perfect synchrony with the spoken word. In a pinch, a colleague with a projector and a portable word processor can do a creditable job of providing simple teleprompter animation. In choosing a teleprompter program, look for a variety of backgrounds, fonts, and scrolling speeds or directions. The value of teleprompting is apparent in the fact that the market seems to be able to support dozens of these programs (usually described as 'title-writers' or 'character-generators').



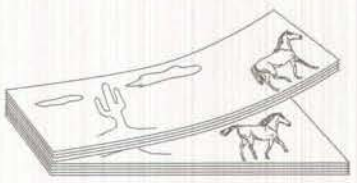
Pointer

If words are arranged on the screen so that their position is part of their message (i.e. as labels that appear on call to identify places on a background map), then the program is an example of the pointer metaphor, so called because the animation plays the role of a flashlight pointer in the hands of a live instructor. Perhaps the most well-known illustration of this category is the 'electronic tablet' used by some television sports announcers to help them analyze a play during a tape replay. A good pointer program should be able to handle text, a hierarchy of point and line symbols, and perhaps a selection of masks that cause background information to recede and thus help focus attention on the main message. Unfortunately for my simple taxonomy, the best of the pointer programs have become much broader and more sophisticated with recent updatings, and therefore it is probably fairer to note this metaphor only as a quick and often surprisingly effective way of using a more general-purpose program such as Autodesk Animator for the MS-DOS platform or Studio 1 for the Mac. A variant of the pointer metaphor is a simple tape recorder — a hardware-software package that transfers to videotape whatever the instructor (or another statistical or mapping program) is doing on the screen. Programs of this type include ColorSpace FX for the Mac, Instant Replay Professional or VGA Producer for MS-DOS machines, and a truly amazing assortment of software written for the Amiga.



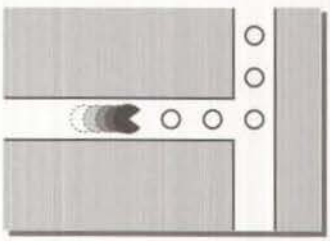
Flipbook

This metaphor has its root in a set of stapled cards that are held in one hand, bent slightly with the thumb of the other hand, and then released in rapid sequence. Each card has a slightly altered version of the previous scene, and, when flipped at the proper speed and viewed from the correct angle, the effect is like a motion picture (albeit a simple and short one). A good flipbook animation program should have an extensive set of easy-to-use image-modification tools and a mask or lasso tool that can surround and modify an irregular shape without resorting to pixel-by-pixel changes. Pageflipper or LightBox on the Amiga, Animator on the PC, and



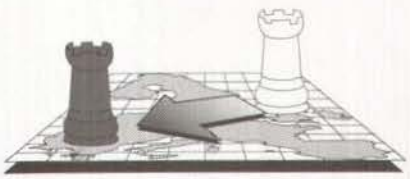
Studio 1 for the Mac have good flipbook capabilities. The latter has a demo animation of a robot assembly line that is a masterpiece of intricate optical illusion and suggestion. The TV character Max Headroom was a sophisticated Amiga flipbook, with an assortment of separate poses and color backgrounds that could be assembled in a sequence and synchronized to the narration. Even with that kind of shortcut, the flipbook technique is labor-intensive; each scene must be drawn (or at least assembled) in its entirety, and a convincing illusion of smooth motion usually requires about a dozen scenes per second. Image cloning and electronic modification can lessen this burden considerably, but with today's equipment the list of options is large, and the flipbook metaphor is seldom the easiest way to add motion to a map.

Sprite



A number of popular early video games (e.g. PacMan) illustrate the sprite metaphor. Animations of this kind have an assortment of small and simple-to-draw objects moving along a restricted set of paths on the screen. MovieSetter on the Amiga, early versions of Videoworks for the Mac, and one component of Grasp for the PC use this metaphor, which can be effective for showing concepts that involve persistent or repetitive motion, such as population migration, nutrient flows, and traffic patterns. In more sophisticated sprite programs, the objects have a variety of states (e.g. left foot forward, both feet even, right foot forward, etc.) that can be alternated to add an illusion of complexity to the motion (and incidentally help to mask the squareness that helps to make sprite motion computationally efficient).

Stage and play

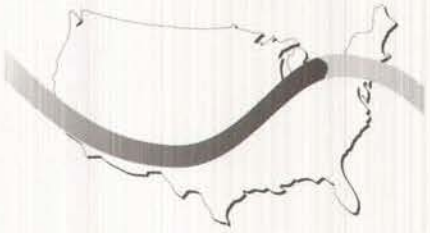


Later versions of the Macintosh program Videoworks (and its superset, Macromind Director) make extensive use of a Shakespearean metaphor: "All the world's a stage, and we are but players . . ." These programs structure an animated sequence as a stage with backdrops and actors (or *cels,* in a traditional painted animation variant of the metaphor). The backdrops are usually stationary throughout an episode, although the program may allow them to be panned sideways, zoomed in or out, faded, or traded with other backdrops. The actors, on the other hand, follow a more complex script that governs their appearance, motion, and relative position (a nicety that allows dominant actors to pass in front of others in a complex choreography). With this metaphor, a detailed animation of an event such as the Crusades might involve defining each army as an actor and a map of Europe as the stage. The difference between an actor and a sprite is the degree of allowable complexity and change — sprites maintain essentially uniform appearance and color, whereas actors can change in a variety of ways as they follow their scripts, which are usually described in stage terms, as opposed to the mathematical abstractions of a sprite program.

Color Cycling

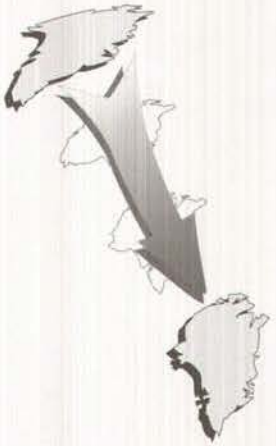
A hardware feature makes color cycling a uniquely efficient way of communicating motion along specified paths or across broad areas. In this kind of program, the animator uses a special 'brush' to lay down a specified series of colors with each stroke. After the image is finished, multiple frames are produced, with the colors automatically advanced one step along the designated series for each subsequent frame. When these frames are played back in rapid succession, waves of color appear to move down the paths. This metaphor has become common in the weather

segments of many television news programs. Its big advantages are efficiency of memory use and speed of construction. A good color-cycling program provides a range of brushes and color choices. With a program such as DeluxePaint for the Amiga, Macromind Director on the Mac, or Autodesk Animator on the PC, showing three or four complex paths of upper-air wind on a continental basemap takes less time than typing this paragraph. The learning curve for a color-cycling program with even a modest amount of color and brush flexibility, however, can be steep, because it is very easy to have a mismatch between the number of colors, the position of the brush, the length of the line, and the number of frames in the cycle, and the result can be a very jerky and uncommunicative animation.



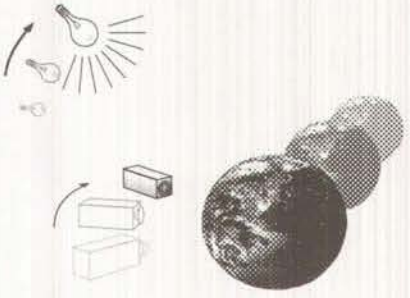
Metamorphosis

A metamorphosis program is designed to make it easy to change the shapes or other features of rather complex individual objects. Someone using this kind of program begins by defining an object with a series of points and placing those points in their appropriate starting and ending positions (say forty points showing the shape of Greenland on a cylindrical and an interrupted elliptical projection). The computer's job is to calculate the position of each point for each 'in-between' frame of an animation — much like the automatic creation of pages 2 through 29 between a given page 1 and page 30 of a flipbook. Fantavision, available for all three basic platforms, the Amiga, the Mac, and the PC, is the least expensive really interesting animation program around. It illustrates the principles of 'tweening' in a thoroughly entertaining way, and it can create some surprisingly sophisticated animated maps if provided with a detailed backdrop from a paintbox program. A number of other programs have tweening options. Animator adds 'tweenable' spline curves and polygons to a flipbook routine, whereas Swivel 3D and Super 3D for the Mac and a number of Amiga programs are able to make three-dimensional models 'tweenable.' In doing so, they cross the border into the domain of the last metaphor on my list.



Model and camera

The most flexible (and therefore almost always most demanding of computer hardware, designer foresight, and programmer knowledge) are the model-and-camera programs. These programs define objects as sets of three-dimensional coordinates for key vertices. They then construct the intervening surfaces, add texture to the surfaces, calculate highlights and shadows, define paths for movement of both object and camera, and then encourage you to go out for a long lunch while they render the commands for a three-second animation into visible form (unless, of course, you have a Silicon Graphics Personal Iris workstation or are using Wavefront on a Cray supercomputer, in which case you are obviously in the enviable position of being able to pay for the privilege of watching animations render in real time). Bell Labs has a powerful modeling program for MS-DOS computers with Truevision graphics adapters. Sold by a number of vendors under a variety of names, including Topas and Crystal 3D, this program provides broadcast-quality animation with millions of colors, multiple light sources, and realistic shadow and transparency effects. MacIvory for the Macintosh has similar capabilities with a somewhat gentler learning curve and a substantially higher cost (where have we heard that before?), but the Mac also has some simpler and less expensive modeling programs with changeable camera perspective, such as Swivel 3D and Super 3D. New Amiga-based modeling programs have been



appearing every month or two — well-reviewed ones include Opticks, Sculpt-Animate 4D, Turbo Silver, Caligari, and Zoetrope. Nine times out of ten, however, it is more cost-effective to use a modeling program only for short transitional effects, such as viewing a spinning globe from outer space, zooming in on a particular place, and then making a quick and hopefully imperceptible fade to a two-dimensional flipbook or tweening program for the rest of the story. A less costly variant of the camera metaphor involves moving the apparent viewpoint toward, away, or around a flat image. This kind of 'two-and-one-half-dimensional' optical illusion is able to provide a host of tilt and tumble effects that can give the viewer a refreshing new perspective on the world (or a serious case of vertigo-induced nausea, if the cartographer isn't careful).

CONCLUSION

The available animation programs provide plenty of choices, at a price. In that respect, they are much like print cartography, with digitizers and computer screens, airbrushes, scribers and photo-etched peelcoats, technical pens and stick-on patterns, and hand-drawn symbols all still useful for different kinds of maps. To help a cartographer choose the proper animation metaphor for a given task, it is helpful to ask a few basic design questions:

How can a cartographer attract or focus attention on a particular part of the map? In addition to the traditional variables of size, density, brightness, pattern, orientation, and complexity, animation affords a number of additional and potentially very powerful visual attractants, such as sudden appearance, vibratory motion, color change, flashing, and fringing of foreground objects or graying of the background information. Many of the basic principles revealed by psychophysical research can serve as a guide in choosing ways to depict specified ideas.

How can a cartographer design a hierarchy of backgrounds and objects in order to maintain an adequate amount of visual and auditory 'headroom' for the ones that should be emphasized? This question is complicated by the fact that one must keep brightness and color saturation within legal limits for broadcast (and contemporary American broadcast standards are notorious for their inability to handle strong reds and yellows, which are precisely the colors that cartographers like to use as attention-grabbers).

How can a cartographer ensure the variety and pace of information content necessary for successful television? The metaphor of a triage officer may be appropriate — one should lay out the entire story, define those topics that *must* be rendered within a particular metaphor, and use the proper tools for those topics. Then, consider the time-tested ideas of reinforcement and contrast in selecting graphic options for the intervening topics, where the range of acceptable tools is wider. In that context, it is always worthwhile to remember that television is not the only available medium; printed maps will continue to have a place, because the relatively low resolution and transitoriness of a televised image is simply not appropriate for some kinds of messages.

The final consideration for any cartographic project should be revisability. In print cartography, we use computer drawing programs partly because they make it possible to change area patterns much easier than with peelcoats and screens or stick-on film (and those tools became popular partly because they were easier to revise than ink, which in turn is easier to revise than gouged wood or fired clay). Within the suite of available animation tools, some metaphors make some kinds of revision much easier than others. For example, changing perspective is simple with a model-and-camera program and terribly time-consuming with a

color-cycling program; changing the color of an object throughout a four-second animation is very easy with a stage-and-actor program and frustratingly difficult with most flip-book programs. The selection of tools, therefore, usually depends on trying to strike a balance between the advantages of a given metaphor for a given subject and the costs of having to make the inevitable revisions within the constraints of the metaphor. In exploring those tradeoffs, we are just at at the beginning of a very long and exciting road into the future of four-dimensional cartography. ⌀

A Glossary Of Terms For Computer-Assisted Four-Dimensional Cartography

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Italicized words are also defined separately in this glossary.

Animatable property — Trait of an entity that can be changed during the sequence of an animation. Different computer programs have different lists of animatable properties, which typically include some combination of position, size, orientation, shape, color, blur, brightness, reflectivity, and transparency; see everything below!

Anti-aliasing — Using intermediate colors to smooth the jagged appearance of diagonal or curved lines; anti-aliased typefaces look much better than solid-color letters and numbers.

Arc — Move the *camera* around an *object*; this is really a combination of *track* and offsetting *pan* or *tilt*.

Apply — Add texture to a 2-dimensional area. See *texture-map* and *wrap*.

Area — Two-dimensional feature, bounded by three or more *lines* in the same *plane*.

Attention point — Place on a *scene* where a normal viewer usually looks first. English-reading people tend to look toward the upper left-hand corner, although a bright color, moving object, or striking shape can divert their attention elsewhere.

Axis — Line around which a 2D *object* is rotated to create a 3D object.

A/B roll — Editing system with two or more tape recorders *genlocked* together, which allows images to *dissolve* from one to another.

Backdrop — Fixed part of a *sprite* or *cel* animation; the backdrop does not change *position*, although it can *fade* in and out of view.

Bandwidth — Duration of an electronic *signal*; when bandwidth is fixed, one cannot increase color complexity without reducing *resolution*; when one notes that the bandwidth of a high-resolution full-color computer display is on the order of 90MHz, it is easy to see why something must be given up in order to translate the image into *NTSC* television, with its bandwidth of about 5MHz.

Bias — Tendency of a *spline* curve to anticipate or overshoot the direction it must take after passing a given *point*.

Bit-map — A shape described as a set of *pixels* of a specified color.

Blend — Make a smooth transition between colors by creating new colors with intermediate *hue*, *value*, and *chroma*.

Bluing — Transferring information to another *frame* with a specified guide color or *template* that is easy to erase later. Named for the non-reproducing blue pencil that print editors sometimes use to mark corrections on a camera-ready manuscript.

Blur — Residual image that occurs when *objects* move too fast for eye fixations.

Board — Additional electronics added to a basic computer to perform specific tasks; animation usually requires frame-grabber, image-manipulation, math-coprocessor, and video-out boards, although some manufacturers combine several functions on one board.

Brightness Color *value*, from dark to nearly white. See *luminance*.

Brush Basic drawing tool; can be as simple as a single *pixel* or as complex as a fragment of a detailed multi-color *scene*.

Buffer Dedicated area of computer memory to store a *cel* or *scene*.

CAD program Computer-aided design program. CAD programs are usually *vector*-oriented and have many *layers*.

Camera point Imaginary *position* of the observer with respect to a 3D model; see *arc, crab, dolly, lift, lower, pan, rotate, tilt, track, zoom*.

Card See *board*.

Cel Picture (of any size) stored in a *buffer* or placed in a *scene*.

Choropleth Map with areal units that are political entities (counties, states) or other arbitrary *areas* that are not necessarily related to the phenomena that are the primary topic of the map.

Chroma *Intensity* of a color, from gray through dull to bright (Caution: that is not the same as dark to light; see *value*). High-chroma reds and yellows are prone to *crawl* and should be avoided.

Chrominance Color *component* of a television signal.

Clear, Delete, Erase, Move, Swap, Transfer, Zap Different programs use different commands to empty the screen and/or memory *buffer*; know these commands, and beware, unless you like losing a day's work in a microsecond.

Clearance Freedom from copyright obligations. Ordinarily, one can copyright only the form of a map, not the data displayed on it. Putting information on another basemap with a different projection may be enough to provide clearance, but if your source contained information that was not in the original data set, you may be legally liable for copyright infringement. Caution: many publishers deliberately put minor errors into a map to trap copyright infringers, and therefore it is always best to check the original data.

Clone Duplicate an *object, cel*, or *keyframe*. Cloning and then manipulating the clone is often the fastest way to create two not-quite-identical objects or scenes for an animation sequence. See *flipbook*.

Color temperature A way of describing spectral colors in terms of the temperature of the object that would emit those wavelengths; blues are 'hotter' than reds. Fluorescent light is hotter than incandescent.

Color-cycling animation Giving the appearance of motion by systematically changing colors through a designated series. The illusion is of a wave of color moving down a line or through an area.

Colorize Add color to a black-and-white image.

Component Signal Television *signal* that separates *luminance* and *chrominance*. See *YC signal*.

Composite signal Television *signal* that includes *chrominance, luminance*, and sound.

Complement Color that, when added, tends to turn a color into gray. Such as red added to green, yellow to purple, etc.

Compress Increase animation speed by making fewer intermediate *frames* between *keyframes*.

Cooler Dimmer and more red in *hue* . See *color temperature*.

Copyblock Device attached to a port on a computer to prevent software piracy. Many of the standard animation programs will not run without a copyblock physically attached to the computer.

Copyright Legal ownership of intellectual property. See *clearance*.

CPU Central processing unit of a computer.

Crab (or track) Move the *camera position* from side to side.

Tendency for colors to smear across the line borders of objects; *chroma*-crawl in *NTSC* television is most obvious with red and yellow, intermediate with magenta and green, and relatively minor with cyan.	**Crawl**
Cathode ray tube, the screen on a typical TV or monitor.	**CRT**
Instantaneous replacement of one *scene* by another.	**Cut**
Repeating a sequence of *cels* or colors to simulate a repetitive motion (e.g. a person walking, a bird flying, or a movement along a path). See *color cycling*.	**Cycling**
Subtractive color description, naming colors in terms of standard printers' inks (cyan, magenta, yellow, and black).	**CMYK**
Digital elevation model, a file of the *XYZ coordinates* of *points* that can be used to define a surface.	**DEM**
Cause an entity or *scene* to gradually disappear and be replaced by another.	**Dissolve**
Achieve the visual appearance of an intermediate color by randomly scattering *pixels* of the endpoint colors. See *blend*.	**Dither**
Move the *camera position* closer or farther from an *object*; unlike *zoom*, dollying will alter the perspective as well as the size of the *scene*.	**Dolly**
Vector-oriented graphics program. See *CAD*.	**Draw program**
Time code designed to accommodate *NTSC bandwidth*.	**Drop frame**
Darkened fringe that appears to raise an *object* above its *background*; often used to enhance *figure-ground* of a map.	**Drop shadow**
Add additional audio or video to an existing videotape.	**Dub**
Digital video effects, such as *pageturns*, squashes, and tumbles, which can be used during editing to combine animations, *narration* shots, and live scenes (often called ADO, after an early trademark).	**DVE**
Where two *surfaces* of an object join. An edge is defined by a *line* or series of *points*.	**Edge**
Decrease the speed of an animation by adding *frames* between *keyframes*.	**Expand or stretch**
Create a 3D *object* by 'pushing' a 2D object 'upward' or 'downward' from the plane of the map and into the third dimension.	**Extrude**
Cause an entity to gradually disappear (fade out) or appear (fade in or on).	**Fade**
Half (every other *scanline*) of an *interlaced NTSC* TV image.	**Field**
Entity that we want viewers to see as a unit (as opposed to ground, the surrounding or background information that we would prefer the viewer to be aware of but not focus on).	**Figure**
Add a color or pattern to the *area* that is enclosed by a specified color or range of colors ('fill to border,' 'fill to line').	**Fill**
Animation that consists of a sequence of slightly different *scenes* that replace each other in rapid sequence.	**Flipbook**
Move an *object* across a *backdrop*.	**Float**
Combination of *camera* motion to simulate an airplane moving through, over, or around a 3D *model*.	**Flythrough, flyover, flyaround**
Family of letters and numbers with a specific graphic style and size. Font names and other terms in animation are usually the same as in conventional cartography.	**Font**

Frame Single *image* (about 1/30th of a second in US television). Consists of two *interlaced fields* in *NTSC* television.

Frame-grabber Device to capture a *scene* from a tape deck or video camera and translate it so that it can be manipulated by a computer.

Genlocked Two or more sources (tape recorders, computers, or cameras) that are driven by the same synchronization clock and therefore can be overlayed or faded from one to another. See *A/B roll*.

Gouraud shading Creating lighted, shadowed, reflective, and *texture-mapped surfaces* on a 3D model. More realistic and time-consuming than *Phong shading*.

Grade, gradient Arrange a gradual sequence of colors between two specified colors. *Dithering* helps to eliminate a 'banded' look.

HAM (hold-and-modify) Obtaining a larger number of apparent colors by holding one *field* and modifying the *palette* before displaying the intervening *scanlines*.

Headroom The range of color that is available for emphasis. Making background colors too *intense* can limit headroom.

Hide Cause an *object* or *scene* to disappear. *See show*.

Highlight 'Hot spot' of light reflection, even from a dull surface.

Hit (hitpoint) Critical instant in an animation, such as when a window breaks, when audio and video should be perfectly synchronized.

Hotter Brighter and more blue in hue (radiometric definition). More intense white, red, or yellow and therefore more prone to *crawl* (television definition).

Hue Spectral characteristic (wavelength) of a color, from violet through blue, green, yellow, orange, red. See *subcarrier phase*.

HVC (HLS) Color description in terms of hue, *value (luminance* or *brightness)*, and *chroma (saturation)*.

Image *Scene* as displayed on a TV screen.

Intensity A fuzzy word that can mean *brightness* or *chroma (saturation)*. See also *headroom*.

Interlaced *NTSC* television has a nominal 525-line image that is made up of two *fields*. Every even-numbered line belongs to one field and every odd-numbered line to the other, and the two fields are displayed alternately. The persistence of one image while the other is being refreshed helps to eliminate perceptual flicker. Most computer displays are non-interlaced, and translating a computer image to television is therefore a non-trivial electronic problem.

Isoline Line separating areas of higher *value* (mathematical definition) from areas of lower value on a map.

Jitter Single-*pixel* shifting of points and thin lines, usually due to fluctuations in tape speed or electrical current.

Join Combine two animation sequences, often with a specified *transition* effect.

Jog-shuttle wheel Tape-deck control for playing television frames at any desired speed, from fast to very slow, forward or reverse.

Kerning Adjusting the spacing between particular sets of letters to improve overall appearance (e.g. by moving a lower-case o so that it fits partly underneath the horizontal arms of the uppercase F in the word 'Ford').

Key, keying Color (often but not always in the *superblack* range) that can be used to indicate areas of a scene that should be replaced with other information from the *keysource* during editing.

Keyframe Reference *frame*, showing *positions* and characteristics of *objects* at a particular time in an animation.

Portion of a scene that we would like to replace all areas of a given color (chromakey) or brightness (luminance key). Keying is a powerful tool for live video (e.g. the news where it can cause a map to replace a green patch on the wall behind a person sitting at a desk).	**Keysource**
Source of illumination in a *scene*. Lights may be described by *position, intensity,* width, color, and motion.	**Lamp (Light)**
Conceptual group of objects in a computer drawing program (see *CAD*). Logically similar to overlays or flaps in conventional cartography.	**Layer**
Raise the *camera* relative to an *object*, without changing the aim of the camera. The object will appear to move downward in the scene.	**Lift**
Source of illumination for a *surface* of an *object*.	**Light**
Increase the *value* of a color.	**Lighten (brighten)**
One-dimensional feature, defined by two or more *points*. Lines can exist within the *plane* of a map (two dimensions) or extend into the third dimension.	**Line**
Lower the camera relative to an object. Opposite of *lift*.	**Lower**
Lightness of a *pixel* or *scene* (see *value*).	**Luminance**
Area or color that is protected from alteration by *brushes* or other drawing *tools*.	**Mask**
Changing shape between *keyframes*. See *morph*.	**Metamorphosis (anamorphing)**
Set of regulations for communicating performance information (when a key is pressed or released, volume is changed, a drum is hit, a door slammed, etc.) to electronic musical instruments or sound-effects machines. MIDI *time-code* and *SMPTE* time-code are different, but translatable.	**MIDI (musical instrument digital interface)**
Combine separate audio and video tracks to produce a final output for broadcast or video-taping.	**Mix (mixdown)**
Computer-aided 3-dimensional drawing program, usually *vector*-based.	**Modeling program**
Single shape of an object that changes its shape between *frames*. See *metamorphosis* and *tweening*.	**Morph**
Voice-over or *talking head*. A favorite animator's trick is to *cut* to narrator in order to get out of an awkward projection, cluttered map, or other tight spot!	**Narration**
Closeness to another color. Having *RGB* or *HVC* numbers that are within a specified range.	**Nearness**
National Television Standards Committee, issuer of rules about *bandwidth, brightness,* color *intensity,* and *frame* speed.	**NTSC**
Set of *points* that define an entity in two or three dimensions. The points are then used to locate *edges, surfaces,* colors, etc.	**Object**
Degree to which an *object* prevents you from seeing other objects through it. Opposite of *transparency*.	**Opacity**
Apparent change in perspective that gives an illusion of 3-D motion in a 2-D series of images. These usually are described with commonsense terms such as lean, squash, spin, tilt, tumble, whirl, etc.	**Optic move**
Conventional adjustment for non-square home television screens. See *safe area*.	**Overscan**
Graphic routine to substitute one *scene* for another: these usually have fairly intuitive names, such as horizontal wipe, cross-fade, dissolve, flip-over, fly-away, page-curl, shatter, shrink-down, tilt-down, venetian blind, etc.	**Pageturn**
Computer-aided color or monochrome image-creation program. Paintbox programs are usually *raster*-based.	**Paintbox program**

PAL The European equivalent of *NTSC*.

Palette Graphic display of colors that can be selected at a given time. 6-bit color allows selection of 4 levels of red, green, and blue, for a total of 64 colors; 16-bit color allows 32 levels of each, for about 32,000 colors; 24—bit color has a palette of 16.7 million colors; and 32-bit color adds gray-scale information for better definition.

Pan Turn the *camera* sideways while it stays in the same *position*.

Pantone Color description in terms of pre-mixed printers' inks.

Pedestal Darkest legal level of blackness in an *NTSC* television image. *Superblack* is reserved for *keying* and other information.

Phong shading Creating simple lighted and shadowed surfaces on a 3D model. Less realistic but quicker than *Gouraud shading*.

Photo-realism Having enough colors and detailed enough resolution to be visually indistinguishable from a live image.

Pixel A single point of light on a television screen or computer graphic image. A pixel has *position*, color, and *intensity*.

Point Non-dimensional feature, with x, y, and z coordinates in 3D space. Most computer drawing programs use a series of named points to define *lines*, *surfaces*, and *volumes*.

Position Mathematical description of location in real or conceptual space. *XYZ coordinates*.

Posterize Produce a simpler and often stronger image by reducing the number of colors in a scene and making them more intense.

Preview Display a *model* with shaded *surfaces* but not full *rendering*.

Radiosity Total illumination of a surface in a *ray-tracing* program. It includes light from all sources, both direct from *lights* and reflected from other *objects*.

Raster Horizontal line of *pixels* on a TV screen.

Ray-tracing Mathematically following the motion of light from various sources to the objects in a *scene*. Sophisticated ray-tracing programs are able to produce *highlights*, shadows, and several generations of reflections from objects of varying *reflectivity*.

Reflectivity Degree of reflection from a surface. Reflectivity terms are usually intuitive and include dull, satin, iron, glass, silver, mirror, etc.

Render Display a 3D model with fully colored, *transparentized*, *highlighted*, and shadowed surfaces.

Replace Substitute a color for another specified color or range of colors. Replacements can be global or selective (under a *brush*).

Resolution Number of *pixels* per *image* or screen. A Macintosh or IBM-VGA monitor has a resolution of 640 horizontal pixels by 480 vertical; the resolution of standard NTSC television is about 330 distinguishable vertical lines (theoretically 660 pixels) by 486 horizontal scan lines (nominally 525, but they use *overscan* to accommodate non-square home television receivers).

RGB Color description in terms of *CRT* colors: Red, Green, Blue. A *signal* that sends those three messages separately. See *composite*.

Rotate Create a 3D *object* by 'spinning' a 2D object around a specified *axis*. When you spin a camera clockwise or counter-clockwise around the axis of its lens; the *scene* in the *frame* spins the opposite way.

Rotoscoping Breaking a smooth motion (i.e. a person walking) into a sequence of still images. Named for an early film technique.

RS-170A NTSC specifications for color, *chroma*, *overscan*, *pedestal*.

Safe area	Area near the center of a television image, visible on TV sets with non-square picture tubes. See *overscan*.
Saturation	*Chroma* or color *intensity*, from dull gray to intense color.
Scan	Create a row of illuminated pixels across a TV screen. Enter an image into a computer memory by analyzing it one scan-line at a time.
Scanline	A single horizontal row of *pixels* on a video screen.
Scene	Collection of *objects* and *backdrop*. An *image* of a scene is what the viewer sees on the video screen at a given instant.
Shadow	Darkening due to interposition of another *object* between an entity and a *light* source.
Show	Cause an *object* or *scene* to appear.
Signal	Series of electrical pulses that define *image* and sound. See *component*, *composite*, and *NTSC*.
SMPTE	Society of Motion Picture and Television Engineers. 'Simptee Time Code' is a standard way of describing time (hour, minute, second, frame) for audio and video *mixing*.
Solarize	Alter an image by reducing the number and realism of the colors. Usually, muted colors are replaced by ones with more *chroma*.
Spline	Smooth curve fitted through a series of precisely located but potentially movable *points*.
Sprite	Object that moves through a scene without changing its shape. Sprites may cycle through several alternative shapes (e.g. PacMan).
Stillstore	Equipment that stores maps, photographs, and other still images and displays them on call, often with appropriate digital effects *transitions*.
Storyboard	Series of sketches that show the general sequence of events in an animation. A good storyboard has *timecode*, *keyframe* characteristics, and *transition* effects.
Subcarrier phase	Method of describing color *hue* as an angle on a 360-degree scale. See *vectorscope*.
Superblack	Colors darker than the *NTSC pedestal* (about 5 on a 64-level gray scale). These are indistinguishable from black on a standard television screen and therefore have no visual function, but they do provide a place to transmit *keying* and other information.
Surface	Area defined by several *edges* of an *object*.
Swivel point	Place where a subpart is attached to a primary *object* (e.g. a knuckle where a finger is attached to a hand).
Talking head	Scene with a *narrator* speaking directly to the camera.
Template	Guide for painting a scene. See *bluing*.
Tension	Amount of straightening of a *spline* curve. Full tension will make a series of straight lines out of the curve.
Texture mapping	Painting an *object* with a picture stored in a *buffer*.
Tilt	Turn a camera up or down while it stays in the same *position*.
Time base corrector	Device to improve synchronization and thus reduce *jitter* and *chroma-crawl*.
Time code	Temporal position of a *frame*, in hours, minutes, seconds, and *drop* or non-drop frames. See *SMPTE* and *MIDI*.
Timegraph	Graph showing *keyframes* and other events in an animation sequence. A *storyboard* is a diagram of intent, whereas a timegraph is a record of result.

Toggle A program feature that can be shifted between two states and exists in one or the other at all times (e.g. draw or erase, *mask* or write, *keycolor* or image, alter *palette* or not, etc.). One must learn what features are toggled in a given program and check them frequently to avoid accidentally doing something that is not intended.

Tool *Brush*, eraser, paint-roller, *blender*, or other device to alter the appearance of an *object*, *backdrop*, *cel*, *scene*, or other graphic element.

Track Move the *camera* point from side to side. See *crab*.

Transition Replacing one scene with another with a *cut*, *dissolve*, *wipe*, *key*, or more complex effect. See *pageturn*.

Transparency Degree to which an *object* allows you to see other objects through it. A 100% transparent object is invisible.

Tweening Creating intermediate stages between *keyframe*. The computer calculates intermediate values for any designated *animatable properties*.

Undo Program command to cancel the last action. To avoid extreme mental anguish, one must quickly learn what kinds of actions can be undone in a particular computer program (and develop a habit of saving work before performing any non-undoable action).

Value Brightness of a color, from dark to nearly white (graphics definition). Data number associated with a *point*, *line*, or *area* (mathematics definition).

Vector Line connecting two *points* in 2D or 3D space.

Vectorscope Instrument to display color on a radial graph with *hue* as direction (*subcarrier phase*) and *saturation* or *chroma* as distance from the center. Used to test whether colors meet *NTSC* specifications.

Vertex Point where several *lines* come together. The vertex is the most information-rich point in its general region of an *object*.

Virus Insidious program that gets into a computer and makes it do things you don't want it to do, such as writing obscenities on the screen, deleting files, or trashing the hard disk. To protect our departmental computers from viruses, we insist that you never (NEVER) put any floppy disk that contains a boot track or an executable program (a file or group of files ending in .EXE or .COM) into any departmental computer at any time for any reason.

Voice-over Spoken words that accompany a map or other image on the screen. See *narration*.

Weaken Reduce the *chroma* of a color (say yellow) by adding its *complement* (purple). The color becomes grayer (de*saturated*).

Wipe Substitute one *image* for another as a *line* or *object* moves across the *frame*. Wipes can have different directions and speeds. See *transition*.

Wireframe Display a 3D model with a few *lines* that outline the major *edges* of an object.

Wrap Add texture by painting a 2-D image onto the surface of a 3-D object. See *texture-map* and *apply*.

XYZ coordinates Mathematical description of spatial *position*.

X-move Moving an *object* left or right within the *plane* of the screen.

Y-move Moving an *object* up or down within the *plane* of the screen.

YC signal Television signal that sends *chrominance* and *luminance* information separately. YC is one kind of *component* signal.

Z-move Moving an *object* toward or away from the viewer.

Zap Cause a *point*, *line*, *object*, *scene*, or *buffer* to disappear from the screen or computer memory. See *clear*.