GLOSSARY

ADDITIVE COLORS: Red, green and blue (RGB), the three primary colors employed by computer and television monitors.

ALIASING: In graphics, the approximation of a smooth curve by a flight of stairs where the steps are all one pixel high. Vertical and horizontal lines are never aliased, but diagonal lines must be. Also known as STAIRCASING and the JAGGIES.

ALPHA CHANNEL: An eight-bit channel, supported by many hardware and software systems, which is used for masking, transparency and other modifications of a graph.

AMBIENT LIGHT: Non-directional illumination that surrounds an object. In the real world, this is light that scatters off the walls and then bounces off the object to the eye.

ANALOG (VIDEO): Videotapes (and TV) in which the record or displayed signal is simply the strength of the signal detected by the camera. This is opposed to DIGITAL VIDEO, in which the camera signal is converted to numbers.

ANIMATION: A sequence of images which is intended to be played at many frames per second to create the illusion of continuous motion.

ANTIALIASING: A jagged line is "antialiased" by filling in some of the stairsteps with a lighter shade of the color of the curve; the grey padding of a black line, for example, makes the curve look smoother.

ARTIFACT: Visual errors or problems.

BITMAP GRAPHICS: In this representation of an image, the color for each pixel is specified. This term is sometimes restricted to images in which each pixel is either black or white so that only a single bit is needed for each pixel.

BIT BLT: See BLITTING.

BLACK LETTER : Ornate typeface of the kind used in the Gutenberg Bible, and continuing in Germany until the 1930's. Also called "Textura", "Old English", "Spire-Gothic", "Gothic" or "Fraktur". Used in science primarily for "symbol overloading" to distinguish a symbol indicated by $\mathfrak{a}$ from the Roman a.

BLITTING: Abbreviation for "bit block transfer". A raster operation that moves data from the FRAME BUFFER to the screen or from one part of the FRAME BUFFER to another.

BUMP MAPPING: Superposition of an imbossed pattern, created on a plane surface, onto a curved surface in three-dimensional space.

CAMERA-READY COPY: Text and illustrations which can be printed by photolithography without the need for typesetting or paste-up by the publisher.

CAPTION: Text that explains a figure and is set directly underneath it.

CHARTJUNK: Unnecessary elements of a graph, such as baroque frames, redundant labels, heavy grid lines, and other non-data figurations, which clutter a graph without increasing the information it presents. (Neologism of Edward Tufte.)

CLIPPING: This is the non-display (and often the non-computation) of parts of a data curve or other graphic object that extend beyond the frame of the graph or the field of view.

CLIP: Movie jargon for a short section of an animation, typically containing one scene or a portion of a scene; a clip is a portion of the film bounded by two "cuts" where the viewpoint shifts to a different camera, viewing angle, etc.

CLOSED SYMBOL: A symbol, such as a circle, triangle or square, which is filled with solid color.

CMYK: Cyan-Magenta-Yellow-Black, the basic SUBTRACTIVE COLORS used in printing.

CODEC: A protocol for compressing and then decompressing video files. Codecs are extremely important because all but the shortest video files require so much storage in uncompressed form as to be unmanageable; in addition, uncompressed files require too much processing to permit real-time display on older workstations. Video editors support several protocols each, which may be implemented either in software or on special hardware video cards inserted into the computer.

COLORMAP: An N x 3 array in which each row stores the red, green and blue intensities of a color; the row number is an index to that color.

COMPOSITE GRAPH: A single figure which is formed from several individual graphs, arranged side-by-side, one atop the other, or in a checkerboard or more elaborate pattern. Synonym: MULTIPANEL GRAPH.

COMPOSITOR: One who sets type. Synonyms are TYPESETTER and KEYBOARDER.

CROPPING: Cutting down a photograph or other image so to eliminate nonessential parts. Scanning software usually has the ability to crop an image to save computer storage.

CURTAIN: A set of vertical lines from the surface of mesh plot to a reference plane; this sometimes make the shape of the plotted surface easier to visualize.

DATA-INK: The non-erasable core of a graphic.

DATA-INK RATIO: $\frac{\text{data-ink}}{totalinkusedtoprintthegraphic}$. or equivalently, the proportion of a graphic's ink devoted to the non-redundant display of data-information, or equivalently, 1.0 - proportion of a graphic that can be erased without loss of data-information.

DATA-MINING: The process of digging understanding and essential information from a large data-base, such as the archives of a general circulation model of the atmosphere.

DEPTH-CUEING: This is a systematic reduction in the color intensity or gray intensity of objects with increasing distance from the eye. This cues the viewer that paler objects are farther away, mimicking the effects of haze, etc.

DESIGN VARIATION: Changes in the scale or other key elements of a graph or a series of graphs which create the spurious appearance of rises or falls in the data.

DIGITAL (VIDEO): TV/video in which the input from the camera is converted immediately to numbers so that numbers, rather than undigitized pixel intensities, are recorded onto tape.

DINGBATS: Small icons or pictorgraphs (letters, tiny boats or houses, crosses, stars, stop signs, etc.). Often organized into special dingbat fonts. Useful as clip art and stamps in scientific illustrations. Examples of dingbat fonts include Zapf Dingbats, Webdings, Wingdings, etc. Also called ORNAMENTS.

DIRECTIONAL LIGHT SOURCE: Light emanating from a localized source, usually idealized as a point source infinitely far away so that all rays from the source are parallel. Often shorted to LIGHT SOURCE.

DITHERING: In indexed color, where the index can identify only 256 shades of out of millions that the monitor is capable of displaying, appearance can be improved by ordering the hardware to average between these shades ("dither") so as to reduce abrupt transitions in color.

DOUBLE BUFFERING: A hardware trick for improving the speed and smoothness of animations. The contents of one part of the FRAME BUFFER are displayed on-screen while data is written to another section ("buffer") of the FRAME BUFFER; the roles of the two buffers are reversed when the update is completed. Speed is increased because two different data transfers are happening *simultaneously* instead of sequentially: CPU/memory-to-buffer, buffer-to-screen.

DOT GAIN: The amount by which a dot of printer's ink will spread after being deposited on the page. This is a major complication in printing grayscale images because the halftone dots that make up the image are each a little wider on the printer page than specified by the software.

DUB: Movie jargon for "copy". When an audio track is added in the studio to a video track which has been photographed on location, the audio track is said to be "dubbed" into the movie. When a computer animation is copied onto a VHS video-tape, the result is a "VHS dub".

DUCK, GRAPHICAL: A graphical atrocity, the moral equivalent of the convenience store in the shape of a duck. A neologism of Edward Tufte.

DUOTONE: The printing of a grayscale image by using inks of two different colors, such as black and light gray, or black and light red. The reason is that offset lithography can only reproduce about 50 shades of gray using a single color of ink. To obtain finer shadings of gray in a photograph, designers therefore use DUOTONES and sometimes even TRITONES (three inks) and QUADTONES (four inks) to reproduce grayscale photographs at high resolution.

[DYNAMIC RANGE:] The ratio of the largest intensity to the smallest intensity which can be detected by a scanner, photographic film, CCD or other image detector.

EIGHT-BIT COLOR: Synonym for INDEXED COLOR, which normally uses an 8-bit number as the color index.

ENCAPSULATED POSTSCRIPT (EPS): An image format which consists of two parts: a preview, which is a screen image for a particular class of computers, and a printer file, which is computed of Postscript vector graphics instructions. The Postscript language can also render bitmap images, albeit at the cost of a very large number of vector instructions, so EPS files may made from bitmap images. On a Macintosh, the preview is PICT, the default file class for Matlab images. On a Windows machine, a Macintosh EPS will display only a blank image, but will print correctly.

FLAT SHADING: When a surface is approximated as a union of polygons, each polygon is the colored uniformly over its entire face so that the color changes only at edges where polygons meet. Also called FACETED SHADING.

FLATTEN: In software that supports layers, FLATTENING refers to the combining of all the layers into a single layer. This is necessary, for example, to export a file from Photoshop or Illustrator, which both support layers, to the Encapsulated Postscript (EPS) format, which does not allow layers.

FLIPBOOK: A collection of sketches, each differing slightly from its immediate neighbors, which create the illusion of continuous motion when the pages are rapidly riffled. Cartoon animators draw sketches on punched paper so that they can slip them onto binder posts and then flip the sketches to check the effectiveness of the drawings as animation. For static visualization, it is often useful to combine a set of flipbook-style illustrates into a single, multipanel composite figure.

FONT: A complete assortment of letters, numbers and punctuation marks of one style and size. Fonts are usually specified by giving the font family name, point-size and style, as in Adobe Garamond 12-point Semi-Italic.

FRAME BUFFER: Display memory that stores a full frame (or more) of picture data. The number of bits-per-pixel determines the range of colors and graphical tricks that can be performed.

GAMMA CORRECTION: This a look-up table which is used to connect the desired, perceived brightness of a pixel to the strength of the electric signal fed to the Cathode Ray Tube. The reason that "gamma correction" is necessary is that the response of the screen phospors to electricity (and also the response of the human visual system to light) are both *nonlinear*.

GOURAUD SHADING: A scheme in which the color of a polygon is not constant across the polygon, but rather is determined by interpolation from the vertices where the surface normals are computed. (Better but more expensive than FLAT ("FACETED") shading but cheaper and not as good as PHONG shading.)

GRAPHOS: Silly mistakes on a graph, analogous to typographical errors in text, such as mislabeling a curve or axis.

GRAYSCALE: This is an image which uses only a single color (usually black), but in varying intensities. Grayscale is usually approximated by dividing the images into many small blocks and printing various numbers of black dots in each block. Both book and newspaper printers and also laser printers are not able to print in various shades of gray directly.

GUI: Short for Graphical User Interface. This is a software package that allows the computer user to issue commands by clicking buttons, sliders and menus instead of typing in commands.

INDEXED COLOR: A scheme in which an image is represented by storing 8-bit numbers that are indices into a palette of 256 colors. This is more economical of storage than TRUE-COLOR in which 24 bits are stored for each pixel.

JAGGIES: See ALIASING.

KEY: A "high-KEY" image is one which is composed mostly of light tones ("snow image"); a "low-key" or "night" image is one composed primarily of dark greys and black.

KEYFRAME: In animation, a frame that is drawn or compressed very accurately; frames between keyframes are drawn by interpolating or "tweening" between the keyframes. (Used both in animation/drawing and also in video compression/decompression.)

LAYER: Many drawing and image-processing programs such as Photoshop and Illustrator allow a single figure to be split into logically distinct layers. This makes it easy to edit the background (in a "background" layer) without accidentally altering other parts of the figure.

LEGEND: A set of lines and symbols with labels which gives the relationship between a given line/marker style and the name of the quantity which is plotted using that line or marker style. The legend is often enclosed in a frame ("LEGEND BOX") to set it off from the rest of the graph. Deprecated in favor of direct labelling of curves whenever possible. (Occasionally, this term is used as a synonym for CAPTION although this usage seems to be fading.)

LIGHT SOURCE: See DIRECTIONAL LIGHT SOURCE.

LINE ART: This is a graphic artist's term for images which are drawn entirely in black lines, dashes, and curves of a single color (usually black!) and a single intensity (the darkest black the printer and screen can render). Woodcuts and copperplate engravings are line art.

LINE STYLE: Solid, dashed, dotted and dot-dashed are the usual line styles. The term may also be applied to distinguishing lines by width, as in thin lines and thick lines.

LOOKUP TABLE: See COLORMAP.

LPI: Lines-Per-Inch, the resolution of the halftone screens used to print images in offset printing. (Laser printers, in contrast, lay down individual dots and usually described by dpi, Dots-Per-Inch.)

[MATTE:] Adjective meaning "of dull luster", "without finish". More technically, an object has a "matte" finish if its light is reflected diffusely (Lambertian reflection) as opposed to specular or "mirror-like" reflection.

MOIRÉ PATTERN: Having a wave-like pattern, as on silk or metal. Such wave-like patterns can be formed on silk by "watering" it, which is a treatment that uses water and pressure to produce the pattern. Such patterns also form naturally or artificially on metal, such as the Damascus steel finish of fine sword blades made in the city of Damascus.

MOIRÉ VIBRATION: Areas shaded by dark, diagonal lines or wavy lines or other patterns that are distracting to the eye. Neologism of Edward Tufte.

MORPHING: Blending one shape into another, very different shape by interpolating between the two extremes and showing all the intermediates. Almost a synonym for TWEENING except that the keyframes in the latter are usually separated only by a fraction of a second of playing time.

MULTIPANEL GRAPH: A single figure which is formed from several individual graphs, arranged side-by-side, one atop the other, or in a checkerboard or more elaborate pattern. Synonym: COMPOSITE GRAPH.

NOMOGRAM: Literally, a graph that embodies a law. From the Greek $\nu o\mu os$, "law", and $-\gamma\rho\acute{\alpha}\mu\mu\alpha$, "something drawn or written". Such diagrams are often designed to be graphical calculators.

NORMAL (VECTOR): A vector which is perpendicular to a surface at a given point; identical with SURFACE NORMAL.

OBJECT-ORIENTED GRAPHICS: In this representation, a set of instructions is specified for each element of the image, such as "draw a blue line of 3-point thickness from (0.1, 0.1) to (0.8, 0.5)". A synonym for VECTOR-BASED IMAGE. This is the default mode of most scientific graphics programs and drawing programs, but not of painting and image-processing software.

OPEN SYMBOL: A symbol, such as a circle, triangle or square, which is shown only in outline without a fill.

ORNAMENTS: See DINGBATS.

ORTHOGRAPHIC: A species of perspective in which the "vanishing points" are at infinity so that the top of a cube, for example, is delineated by pairs of PARALLEL lines. In true perspective, the top of a cube would be a trapezoid

OVERLAY PLANE: High-end FRAME BUFFERS not only store an image, but also have additional space to store graphics which can be overlaid on top of the primary image. OVERLAY PLANES can accelerate graphics because a complicated primary image does not have to redrawn to superimpose text labels or arrows, or to overlay an animated figure that occupies a small part of the screen onto a complicated background that fills the screen.

PI CHARACTER/FONT: A character which is a symbol ("DINGBAT") rather than a letter, or a font full of such symbols.

PICTOGRAPH: Species of plot in which quantities are denoted by plotting various numbers of identical icons. For example, the rate of U-boat sinkings during different years of World War II could be shown by using say, 1 icon of a sinking ship for every ten ships sunk during a given year. Synonyms: VISUAL TABLE.

PHONG SHADING: A surface composed of polygons is shaded by computing SURFACE NORMALS at many points both at the vertices and face of a polygon, and then interpolating colors between those computed at each of the SURFACE NORMALS. (Superior but also more computationally intensive than FLAT ("FACETED") shading and PHONG shading.

PHOTOREALISTIC: Very sophisticated computer graphics which strives to make the screen or printed display look as realistic as a photograph. Rare (and rarely needed) in scientific and engineering visualization.

PICA: One-sixth of an inch, a typesetter's/book designer's unit of measurement.

PIXEL: The smallest picture element of a display; a screen cannot manipulate smaller pieces of an image. For example, a 1280 x 1032 display contains 1280*1032 pixels. The number of pixels in a display depends on the hardware.

PMT: "Photomechanical Transfer Print", a high-quality glossy reproduction of a figure. Journals and books often print figures by pasting a PMT onto a page from a phototypsetter, then making a photolithography plate from the result. Synonym: "stat".

POINT (UNIT OF SIZE): 1/72 of an inch or about 1/28 of a centimeter.

PROCESS COLORS: Cyan, magenta, yellow and black, the usual four colors of printing. Sometimes five or more inks are used for high-end printing; the extra inks are called SPOT COLORS.

PSEUDOCOLOR: Two different meanings in different contexts. First, a type of graph for displaying a function $z(x, y)$ by marking the location (x, y) with a color which is associated with values of z through a COLORMAP, for example, dark red for the peak, dark blue for the minimum, and green for intermediate values of z. Second, a synonym for INDEXED COLOR in which an image is represented by storing 8-bit numbers that are indices into a palette of 256 colors.

RASTER GRAPHICS: A form of graphic representation in which the color each individual pixel is specified. (See also BITMAP GRAPHICS.) The conversion of an OBJECT-ORIENTED (alias VECTOR-BASED) image to a pixel-based representation is said to be "RASTERIZING".

RGB: Red-Green-Blue, the three ADDITIVE COLORS employed by computer and television monitors.

RGB COLOR: See TRUE COLOR.

RECTO: Right-hand page. Many book designs specify that certain elements, such as the title page (always) and the first page of a chapter (in many book styles) must always be "recto".

REFLECTION MAPPING: Similar to TEXTURE MAPPING except that the texture is the reflection of external objects. A display of an automobile in a driveway might have the image of the house, driveway and lawn reflection-mapped onto the shiny, highly reflective car.

ROTOSCOPING: Drawing directly on invididual frames of film. Adobe Photoshop can import video in filmstrip format as a single file from Adobe Premiere, draw on individual frames, and then export the filmstrip back to Premiere for video rendering or export.

SANS SERIF: A font lacking serifs, such as Helvetica or Futura.

SCIAGRAPHY: The art of delineating shadows in drawing, or sketching objects with the correct shading. From Greek "$\sigma\kappa\iota\acute{\alpha}$", "shadow".

SERIF: A small stroke or line segment used to finish off the main stroke of a letter. Times Roman is a font with serifs; Helvetica is a serif-free or SANS SERIF font.

SEMIOLOGY: The science of signs; the branch of medicine dealing with symptoms and by extension, the science and study of graphs. From the Greek $\sigma\eta\mu\epsilon\iota\sigma\nu$ "sign" and $\lambda\sigma\gamma\iota\alpha$ "discourse" or "doctrine".

SEPARATIONS, COLOR: The generation of four separate photolithography printing plates, one for each of the subtractive (CMYK) colors, in offset printing. Image-processing software usually has the capability to split an image into four separate files so that the separations can be controlled electronically.

SMALL MULTIPLIERS: To quote Tufte (1990), pg. 67: "Illustrations of postage-stamp size are indexed by category or a label, sequenced over time like the frames of a movie, or ordered by a quantitative variable not used in the single image. Information slices are positioned within the eyespan, so that viewers make comparisons at a glance — uninterrupted visual reasoning. Constancy of design puts the emphasis on changes in data, not changes in data frame." This type of multi-panel composite illustration must also be called a "Flipbook-on-a-Page" graph or a "Quantitative Storyboard".

SPECULAR REFLECTION: Mirror-like reflection.

SPOT COLOR: Special inks which are used for high-end printing to supplement the usual four PROCESS (CMYK) colors.

SPRITE: Graphic objects which are stored once in a movie file, and then duplicated or moved as needed. Early personal computer sprites were bitmaps were moved, without making big demands on the CPU, by blitting the sprite to the frame buffer. Modern sprites may either bitmap, vector, or 3D.

STAIRCASING: When a smooth curve passes diagonally across the pixels of the screen, the curve must be approximated by a flight of stairs, each step being one pixel high. Also known as the JAGGIES or ALIASING.

STILL: A single image, often taken from an animation, as opposed to the ANIMATION itself, which is composed of many frames.

STORYBOARD: A collection of sketches which narrate the plot, settings and characters of a movie.

SUBTRACTIVE COLORS: Cyan, magenta, yellow and black (CMYK), the four colors used in printing. These are also called PROCESS colors.

SURFACE NORMAL: A vector which is perpendicular to a surface at a given point. The surface normal of the vertex of a polygon is defined as the average of the normal vectors to each of the polygonal faces that meet at that vertex.

TESSELATE: To divide a complicated geometric object into the union of simpler ones to simplify calculations. For example, many graphics programs tesselate quadrilaterals, which may not be planar, into a pair of triangles, which are always lie in the plane defined by the three vertices.

TEXTURE MAPPING: Superimposing an image ("texture") defined on a plane onto a curved surface in three-dimensional space. The advantage of this method is that it is much easier to create a complicated texture on a plane than it is to color a complicated surface directly.

TRACK: Different components of a movie or animation, playing simultaneously, are "tracks". Most movies have both a video track and an audio track, but with the use of transparency masks, it is possible to layer a larger number of tracks in a single animation. Different species of images which are played at different times

may also be identified as distinct tracks, such as a video track which is followed a still-image track that freezes a single picture on the screen for a couple of seconds.

TRUE COLOR: An imaging scheme in which at each pixel, 8 bits are stored to represent the intensity of red, 8 additional bits are stored as the intensity of green, and a further 8 bits are a number which is the intensity of blue. Also called "24-bit" color or RGB COLOR.

TWEENING: In old-fashioned celluloid animation, a small subset of the cells were sketched by the animators; most of the drawings were produced by less-skilled artists called "tweeners", who interpolated between the KEYFRAMES created by the animators. Computer animation programs, notably Flash, use similar strategies to reduce the workload on animators.

TWENTY-FOUR-BIT COLOR: See TRUE COLOR.

VECTOR-BASED IMAGE: In this representation, a set of instructions is specified for each element of the image, such as "draw a blue line of 3-point thickness from (0.1, 0.1) to (0.8, 0.5)". Synonym for OBJECT-ORIENTED GRAPHICS.

VERSO: The left-hand side of a page. Book designs often specify that some elements must appear only a verso page. The copyright page, for example, is almost always "verso".

VISUAL TABLE: Species of plot in which quantities are denoted by plotting various numbers of identical icons. For example, the rate of U-boat sinkings during different years of World War II could be shown by using say, 1 icon of a sinking ship for every ten ships sunk during a given year. Synonyms: PICTOGRAPH.

VOXEL: The smallest resolvable box in three-dimensional graphics, analogous to PIXEL.

WATERFALL PLOT: A surface mesh plot in which only lines parallel to a single coordinate are drawn. Synonym: MESH PLOT, HORIZONTAL-ONLY.

WORD SLIDE: A slide or transparency that contains only words without figures.

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