

CS488/688

Glossary

University of Waterloo
Department of Computer Science
Computer Graphics Lab

August 31, 2017

This glossary defines terms in the context which they will be used throughout CS488/688.

1 A

1.1 affine combination:

Let P_1 and P_2 be two points in an affine space. The point $Q = tP_1 + (1 - t)P_2$ with t real is an affine combination of P_1 and P_2 . In general, given n points $\{P_i\}$ and n real values $\{\lambda_i\}$ such that $\sum_i \lambda_i = 1$, then $R = \sum_i \lambda_i P_i$ is an affine combination of the P_i .

1.2 affine space:

A geometric space composed of points and vectors along with all transformations that preserve affine combinations.

1.3 aliasing:

If a signal is sampled at a rate less than twice its highest frequency (in the Fourier transform sense) then aliasing, the mapping of high frequencies to lower frequencies, can occur. This can cause objectionable visual artifacts to appear in the image.

1.4 alpha blending:

See compositing.

1.5 ambient reflection:

A constant term in the Phong lighting model to account for light which has been scattered so many times that its directionality can not be determined. This is a rather poor approximation to the complex issue of global lighting.

Aliasing artifacts can be alleviated if the signal is filtered before sampling. Antialiasing involves evaluating a possibly weighted integral of the (geometric) image over the area surrounding each pixel. This can be done either numerically (based on multiple point samples) or analytically.

2 B

2.1 B-spline:

A piecewise polynomial function whose shape is controlled by a discrete set of values and which automatically maintains continuity between segments. See also Bézier splines.

2.2 backfacing polygons:

Polygons whose normal points away from the eye in screen space, after perspective, are considered backfacing. The enforcement of a polygon edge orientation is necessary to determine the polarity of the normal, usually via the right hand rule.

2.3 barrel distortion:

A distortion arising in lens and CRT technology.

2.4 barycentric coordinates:

The blending factors λ_i in an affine combination $Q = \sum_i \lambda_i P_i$ can be considered a coordinate system relative to the set of points $\{P_i\}$. For example, the 3 vertices of a triangle describe a barycentric coordinate system for the 2D affine plane in which the triangle lies. Because the blending factors are constrained by $\sum_i \lambda_i = 1$, $n+1$ coordinates are needed to parameterize an n -dimensional space.

2.5 Bézier splines:

A representation of a polynomial controlled by a discrete set of values that have a geometric relationship to the curve. See also B-splines.

2.6 bitblt:

Special purpose hardware for performing fast copying and logical operations on blocks of memory. Very useful in the support of windowing systems.

2.7 Bresenham's Algorithm:

Bresenham developed a fast algorithm which computes the raster representation of a line segment using only integer arithmetic. See also DDA.

2.8 bump mapping:

A form of texture mapping in which the normals of a surface are permuted. Can be used to simulate nonplanar surface texture.

A user interface widget composed of a portion of the screen which reacts to mouse clicks by issuing a callback or performing some other action, such as popping up a menu. Normally a button also changes its appearance when clicked, e.g. changes from a raised to a sunken relief mode.

3 C

3.1 callback:

A UI library can be organized so that particular functions get called when certain events are detected. These functions are called callback routines and are registered with the UI library during initialization by passing a function pointer (in C).

3.2 calligraphic display:

A display device which draws line primitives directly, i.e. by sweeping an electron beam along the path of a line segment. As opposed to a raster display.

3.3 cap polygon:

When an object in a surface representation is clipped, it may be desirable to generate a cap polygon to hide the hole and maintain the illusion of a solid model.

3.4 clipping:

Various operations in computer graphics require the removal of parts of objects or their primitives, typically through intersubsection with a convex polygon or halfspace.

3.5 colour map:

A colour map translates colour indexes stored in a frame buffer into display colour values, typically RGB values. This allows a degree of indirection which enables many tricks, as well as saving memory in the frame buffer while still providing a flexible choice of colours. See also LUT.

3.6 compensation table:

When gamma correction is used to compensate for the nonlinearity of a display device, it is usually implemented with a look-up table.

3.7 compositing:

To overlay pixels or images using an alpha channel to indicate relative opacity.

3.8 concave object:

A concave object has the property that for some points within its support, a line can be formed that passes outside its support. See also convex objects.

A convex combination is an affine combination $\sum_i \lambda_i P_i$ in which $\lambda_i \geq 0$ in addition to the affine combination constraint of $\sum_i \lambda_i = 1$. The barycentric coordinates for the interior of a triangle form a convex combination.

3.10 convex object:

A convex object has the property that any two points in its support can be joined by a line that consists of only points in its support. More generally, given any n points in a convex object, the set of all points formed by convex combinations of those points lie within the object. See also concave objects.

3.11 cross product:

Valid only in three dimensions, the cross product of two vectors forms a new vector perpendicular to both whose magnitude is equal to the sine of the angle between the vector pair, measured in the right-hand sense, multiplied by the product of their magnitudes.

4 D

4.1 DAC:

A digital to analog convertor is typically used to convert digital colour specifications in a frame buffer into analog signals for analog display devices (such as CRTs).

4.2 DDA:

The digital differential analyzer is an algorithm which computes the raster representation of a line segment using a finite difference evaluation of the line equation. The Bresenham algorithm is typically more efficient and accurate.

4.3 diffuse reflection:

A term in the Phong lighting model to account for light which is scattered equally in all directions.

4.4 distributed ray tracing:

See **stochastic ray tracing**.

4.5 dithering:

On a display device with a small number of quantization levels, spatial resolution can be traded for an apparent increase in the number of quantization levels by exploiting the spatial averaging property of the human visual system. Variations include ordered dithering and error-diffusion.

Direct memory access is a form of peripheral interfacing in which the peripheral manages its own data transfer to and from the system's main memory, thus offloading this work from the CPU.

4.7 dot product:

The dot product of two vectors is a scalar proportional to the cosine of the angle between them multiplied by the product of the magnitudes of the two vectors.

4.8 dragging:

Pressing a physical button, moving a **physical valuator**, and releasing the button, when it constitutes a composite action accompanied with visual feedback, is called dragging. Normally dragging is accomplished with a physical device that has both buttons and xy valuators, such as a mouse, pen, or trackball.

5 E

5.1 ECL:

Emitter-coupled logic. A particularly power-hungry and hot bipolar technology whose main advantage is speed. Logic states are represented by constant current flows down one of two alternate paths.

5.2 error diffusion:

A form of dithering in which quantization errors at one pixel are distributed to pixels that have not yet been quantized.

6 F

6.1 field (even/odd):

In interlaced video systems, a frame of video is divided into two fields. The even field contains all even scanlines, the odd field all odd scanlines. These are presented in sequence.

6.2 flicker:

If the refresh rate of a video or film system drops too low, annoying *flicker* will be apparent. The exact rate at which this occurs varies depending on the light level and the image; at low light levels a lower refresh rate can be used.

6.3 frame:

1. In n -dimensional affine geometry, a point and n vectors defining a coordinate system. In a barycentric coordinate system, $n + 1$ points can define a barycentric frame.
2. A UI widget meant to contain and organize other widgets.

6.4 frame buffer:**6.5 frustum:**

See viewing frustum.

6.6 fusion point:**6.7 function box:**

A hardware user interface device that has some collection of buttons and valuator (knobs, sliders).

7 G**7.1 gamma correction:****7.2 GKS:****7.3 Gouraud shading:**

Linear interpolation of colours defined at the corners of a polygon. For each scanline, the colours are first interpolated along the intersected edges and then along the scanline. For triangles, this interpolation technique corresponds to the use of barycentric coordinates and so is affine invariant. For general convex polygons is it not.

See also Phong shading.

7.4 gravity field:

In physically-based animation, a constant downward acceleration applied to all objects. Note that a constant downward force is incorrect, although it is sometimes used.

8 H**8.1 hemi-cube:****8.2 Hertz:**

A temporal frequency unit, equivalent to cycles per second.

8.3 HLS:**8.4 homogeneous coordinates:****8.5 horizontal retrace:****8.6 HSV:**

The hue-saturation-value colour system is an alternative to the RGB colour system.

9 I

9.1 image space algorithm:

9.2 inking:

9.3 ink jet:

9.4 in-line gun:

9.5 interlace:

9.6 interpolating spline:

A spline function which passes through its control points or values.

10.1 jaggies:

10.2 joystick:

10.3 just noticeable difference:

11 K

11.1 kerning:

11.2 keypad:

12 L

12.1 left-handed coordinate system:

12.2 ligature:

12.3 light handle:

12.4 light valve:

12.5 lightpen:

12.6 linear space:

12.7 liquid crystal light valve:

12.8 local control:

12.9 locator:

12.10 look-up table (LUT):

13 M

13.1 Mach bands:

An aliasing artifact that occurs with regular sampling of a pattern. The effect is lines and possibly a false pattern appearing on top of the regular pattern.

13.2 master object instancing:

A model may be placed more than one time in world space. In this case, an instance is a reference back to the master model. Changes to the master will be reflected in all instances.

13.3 menu:

A panel of related buttons in a user interface.

13.5 mouse:

14 N

14.1 normalized device coordinates:

14.2 NTSC:

14.3 Nyquist:

14.4 Nyquist frequency:

15 O

15.1 off-axis correction:

15.2 on-axis correction:

15.3 opponent colors:

15.4 ordered dithering:

15.5 orthographic projection:

15.6 outcodes:

16 P

16.1 PAL:

16.2 pan:

16.3 PDI protocol:

16.4 persistence of phosphor:

Once irradiated with an electron beam, a phosphor will glow for a short time, with an exponentially decaying intensity. Usually, in a CRT the decay is rapid, and persistence of vision is relied on to hide the scanning and interframe gaps.

16.5 persistence of vision:

The human visual system will retain for a short time an impression of an image, even if that image is only presented for a very short time. This simplifies the creation of the illusion of motion by presenting a sequence of frames in rapid succession. Most technologies cannot present images in sequence seamlessly, but must blank the screen. In video, *persistence of vision* is also used to hide the fact that the image is scanned temporally.

16.7 PHIGS:**16.8 Phong shading:**

Normals defined at the corners of a polygon are interpolated and applied to a lighting model (not necessarily the Phong lighting model) at each pixel. For each scanline, the normals are first interpolated along the intersected edges and then along the scanline. For triangles, this interpolation technique corresponds to the use of barycentric coordinates and so is affine invariant. For general (convex) polygons is it not. See also Gouraud shading.

16.9 phosphor:**16.10 phosphorescence:****16.11 physical input device:****16.12 physical output device:****16.13 pick:****16.14 pick id:****16.15 pincushion distortion:****16.16 pixel:****16.17 plasma panel:****16.18 predictive lightpen tracking:****16.19 pseudo-color:**

A method for shading an object where the colour represents some property of the surface.

17 Q**17.1 quaternions:**

A generalization of complex numbers, with three elements that sum to negative one. In computer graphics, unit quaternions are commonly used to represent rotations.

18.1 rack:

18.2 radiosity:

18.3 random dithering:

18.4 raster display:

18.5 RasterOP:

Short for Raster Operation. A copy or block logical operation for moving or combining blocks of pixels. May be implemented in hardware using a bitblt engine.

18.6 ray tracing:

A method for generating images by tracing the path of individual light rays through the scene.

18.7 read/modify/write cycle:

18.8 retrace:

18.9 RGB:

A colour system that approximates the spectrum of light with three colours, Red, Green, and Blue.

18.10 right-handed coordinate system:

18.11 rubber banding:

18.12 run length encoding:

19 S

19.1 scanline coherence:

19.2 Schlieren optics:

19.3 Schmidt optics:

19.4 scroll:

Vertical translation of the camera. Synonymous to crane. Can also be used in a UI context for the vertical movement of text or images, often under the control of a scrollbar.

19.6 segment:**19.7 segmented display list:****19.8 seven plus/minus two:****19.9 shadow mask:****19.10 shadow volume (or shadow polygon):****19.11 Sketchpad:****19.12 solid texture:**

A method for adding texture to an object where a texture/material function is defined over space. When shading a point on the object, the material for that point is determined by its location in 3-space.

19.13 specular reflection:

A term in the Phong lighting model to account for light which is scattered more strongly in the mirror direction (or close to the mirror direction) than it is in other directions.

19.14 SRL output:**19.15 staircasing:**

A form of aliasing which manifests itself as steps on line segments and polygon edges, or along any sharp contrast edge. Also called jaggies in this context. Staircasing may occasionally refer to false edges induced by a low number of intensity levels during quantization.

19.16 stochastic ray tracing:

A form of ray tracing where the ray directions are randomly perturbed as a means of anti-aliasing the image.

19.17 storage tube:**19.18 storage grid:****19.19 stroke:**

A single line segment primitive in a calligraphic display list.

19.20 stroke font:

A font composed of letters described by collections of strokes, i.e. line segments. This representation has the advantage of being independent of a raster, and so geometric transformations and device independence are possible.

19.21 structured display list:
A **display list** which may refer to other display lists in a hierarchical fashion, and usually allows database operations to read and modify its contents.

19.22 subjective spot size:

19.23 surface of rotation:

A 3D surface created by sweeping a 2D curve about an axis of rotation.

20 T

20.1 tablet:

20.2 texture mapping:

A method for adding detail to a surface by mapping an image onto the surface.

20.3 tracker:

20.4 trackball:

An input device where a rotational direction is specified by rolling a sphere in the desired direction.

20.5 transformed display list:

20.6 turntable:

21 U

21.1 UIMS:

A User Interface Management System. Allows the creation and subsequent modification of a user interface at a high level, visually or through a declarative special-purpose language.

22 V

22.1 viewing frustum:

A truncated pyramid that represents the volume which is visible to the eye under perspective, after near and far plane clipping.

The canonical viewing frustum has sides which have slopes of plus or minus 1.

22.2 viewing transformation:

A transformation which converts from 3D World Coordinates to 3D View Coordinates.

A section of a screen to which the output of a rendering system is mapped. See also window and viewport transformation.

22.4 viewport transformation:

23 W

23.1 wheel of reincarnation:

What goes around, comes around. Also, in graphics, the tendency for “obsolete” issues and algorithms designed to address them to arise again and again in new contexts.

In general, the balance between memory, CPU, and I/O is constantly shifting and this effects the choice of algorithms as the pendulum swings back and forth.

For example, suppose an efficient integer algorithm to perform some rendering task has been developed, deployed, but eventually dropped in general rendering systems in favour of a more general floating point algorithm as floating point performance increased. This integer algorithm may be reincarnated later as a special-purpose hardware algorithm, since integer arithmetic units take less space than floating-point units.

23.2 window:

Two meanings, which are easily confused:

- Under a windowing system UI such as X Windows, a window is a portion of the screen which acts as a virtual input and output device, and has its own device coordinate system.
- In 3D graphics, a window is a portion of the 2D projected view space which is mapped to a viewport on the output device.

The 3D terminology was developed before windowing systems were popular, hence the confusion. An X window should be thought of as a “display device” in the 3D context.

23.3 window edge coordinates (WEC):

During clipping, it is useful to convert to a coordinate system relative to the clipping edge.

23.4 window coordinates:

Under X Windows, each window has its own virtual device pixel coordinates, relative to the window origin.

23.5 world coordinates:

A space in which an entire scene is described independent of the position of the viewer.

23.7 write through:

A cache system in which reads are cached but writes go directly to global memory.

24 X

24.1 X Windows:

A device independent 2D graphics and UI windowing system that functions across a network.

25 Y

25.1 yaw:

Rotation of the camera about the camera's vertical axis; this term is borrowed from aeronautics. Yaw is a synonym of pan.

26 Z

26.1 z-buffer:

A raster which stores, for every pixel in an image, the depth of the point on the object which is closest to the screen at that pixel. Used in **hidden surface removal**, and almost universal in hardware rendering.

26.2 z-depth:

In **eye space**, the distance from the camera to a point on an object.

26.3 zoom:

A change in perspective caused by decreasing the **Field of View** that causes the apparent size of objects to increase. A **dolly** should be used instead for most applications in animation. A *zoom* in a 2D context typically refers to the magnification of an image through interpolation.